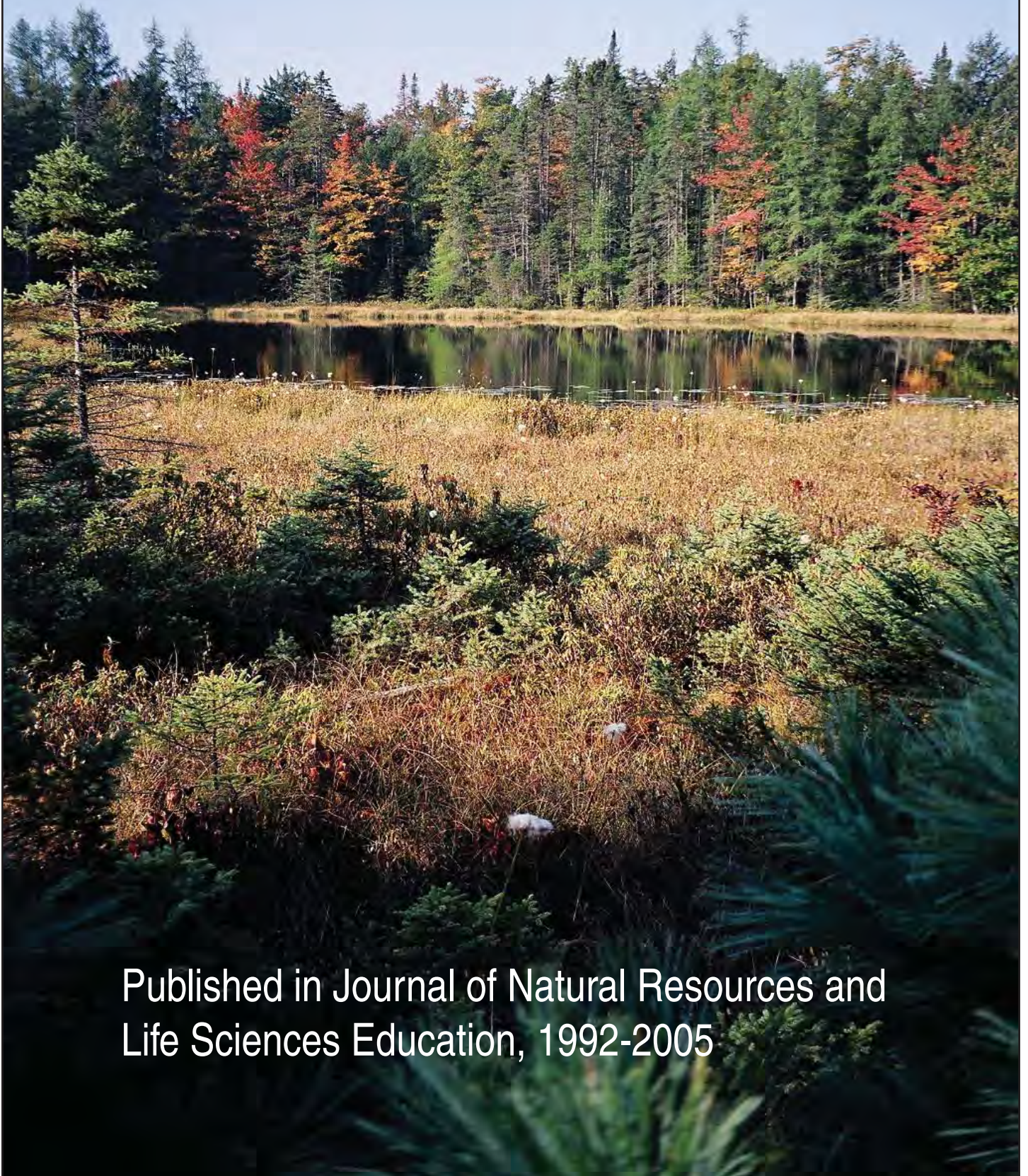


# Case Studies



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*Cover caption:* Molly Bog in Stowe, VT, is a University of Vermont Natural Area and a classic example of a northeastern kettlehole bog. Photo by Melissa Hayden, formerly of the Department of Plant and Soil Science, University of Vermont, Burlington.

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# Preface

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Steve Simmons

Former Harvard University business professor Charles Gragg wrote an article in the 1940s with an intriguing title: "Because Wisdom Can't Be Told." Gragg maintained that one of the most important outcomes in American higher education, in addition to offering technical, scientific and disciplinary knowledge, is to instill wisdom within students. He argued that for such an outcome to be attained, university education must involve much more than a "teacher talks, students listen" model and should include more interactive, problem-based and student-centered teaching. He noted that wisdom is formed when students are placed in an environment where they are called upon to make thorny decisions about situations where reasonable people—even experts—disagree as to the correct course of action. Of course, this concept of wisdom also carries ethical implications and any educational technique intended to help students acquire wisdom should incorporate that dimension as well.

Gragg's Harvard Business School of the 1940s was already well down the road to developing curricula where decision case studies were one of the preferred pedagogies, precisely because they presented environments for students where wisdom, as well as technical and disciplinary knowledge, was called for in order to resolve a case dilemma.

Since 1992, the American Society of Agronomy, through its *Journal of Natural Resources and Life Sciences Education*, has published decision cases that describe a wide array of real-world situations of interest to teachers within agriculture, natural resources, and the life sciences. This booklet contains cases that specifically consider decisions around dilemmas involving agricultural management and sustainability with the environment. They were published in the journal between 1992 and 2005.

Each case contains an "Interpretive Note" that provides readers with the authors' insights as to the educational objectives for the case, as well as descriptions of how that case has been used in the past. Of course, teachers who use these cases may well find that they can address other objectives or applications than those originally intended by the authors. The audiences for these cases also vary greatly—from secondary students through adult extension clientele. Most cases also provide questions within the "Interpretive Note" that can help teachers begin to develop lesson and discussion plans.

I trust that users of the cases in this booklet will, like me, find them to be an excellent resource for constructing worthwhile educational environments, and particularly those that foster attainment of such higher-order outcomes as Charles Gragg's acquisition of wisdom. In helping teachers who are new to decision cases understand the unique dimension that is involved in teaching with cases, I sometimes cite an analogy to an orchestra conductor. A case teacher, like an orchestra conductor, leads a process, but she or he does not play the instruments. Case teaching creates a vital relationship between a teacher and the students, one that values and utilizes students' expertise, experiences, and insights as much as the teacher's. Finally, as you teach ("conduct the orchestra") in your classes involving the excellent cases contained in this booklet, please do not forget to enjoy the music.

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# ARTICLES

The following three articles fall into a new and distinct category of contributions published in the *Journal of Natural Resources and Life Sciences Education*. They are called Case Study articles. Interest in providing problem-solving and decision-making experiences in education has sparked interest in the adaptation of decision cases for publication in this journal. Although decision cases have long been used in colleges of business, they have only recently been adapted to natural resources, life sciences, and agriculture. Guidelines have been developed to describe the format for publication of decision cases in the *Journal of Natural Resources and Life Sciences Education*. Prospective authors will find it helpful to see pages 2-3 in this issue for guidelines in manuscript preparation to ensure minimum editorial delay.

## Mueller Farm: Lupin as an Alternative Crop for On-Farm Protein Production<sup>1</sup>

S. R. Simmons,\* D. Putnam, and D. Otterby

### ABSTRACT

The decision whether to grow an alternative crop is often complex and of much contemporary relevance as producers seek to diversify and buffer their farming operations against increasing costs and volatile commodity prices. In recent years, white lupin (*Lupinus albus* L.) has been proposed as an alternative crop for on-farm production of dairy protein supplement in the North Central USA. This case considers a situation faced by a Central Minnesota dairy producer in 1991 as he decided whether to attempt to grow lupin as a protein supplement on his farm. The producer had previously made three attempts to produce lupin in 1988-1990. These attempts had been unsuccessful because of a combination of drought and weed problems. The case was developed as a format for stimulating in-depth consideration and discussion of factors involved in alternative crop adoption. The case hinges on two questions; whether lupin can be successfully grown on the farm and whether lupin can supply adequate protein for the farm's high-producing dairy herd? The case also illustrates how human factors can be important in many production decisions through consideration of the producer's determination and perseverance in the face of adversity. In deliberating the case decision, students need to integrate both agronomic and ruminant nutrition factors. The case has been class-tested twice with students rating it "good" to "very good" for its effectiveness at familiarizing them with issues and factors associated with alternative crop adoption.

**E**NHANCING CROP DIVERSITY within agricultural systems is of much current interest. At the level of the individual farm, a producer who desires to enhance diversity must assess the feasibility and advantages/disadvantages of adopting a specific alternative crop. This case was developed to provide students with insight into the crop adoption decision process.

<sup>1</sup>Teachers who intend to use this case for classroom or extension education purposes may request a copy of the full *Case Teaching Note* from the corresponding author.

### THE CASE

In baseball, it's three strikes and you're "out." Dairy farmer Jeff Mueller was beginning to feel like "Casey" after taking his third strike. For 3 yr he had attempted to produce lupins (*Lupinus* spp.) as a participant in a university-sponsored project evaluating the feasibility of growing and feeding white lupin (*Lupinus albus* L.) as an alternative protein supplement for dairy cattle (*Bos taurus*). By all accounts this experience was less than satisfactory.

Like most dairy farmers in the 1980s, Mueller felt the pressure of rising production costs. A significant portion of his production expenses went each year to purchasing protein supplements to add to his ration to sustain his herd's high level of milk production. He was eager to find ways to reduce these costs and the prospects of producing a high-protein feed crop on his own farm that could replace all or part of his purchased supplement was very appealing. Such a crop should provide him with a "buffer" from the uncertainties of volatile protein supplement prices? Thus, when Mueller was asked by his county agent in 1988 to participate in an on-farm research trial designed to evaluate lupin as an alternative protein supplement for dairy, his response was enthusiastic.

Mueller had never before grown lupins, but he had heard of other farmers in his central Minnesota area who had, and some reported good success. For example, a *Minneapolis Star and Tribune* newspaper account (Peterson, 1987) described one dairy farmer who had grown

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S.R. Simmons and D. Putnam, Dep. of Agronomy and Plant Genetics, 411 Borlaug Hall, Univ. of Minnesota, 1991 Upper Buford Circle, St. Paul, MN 55108; and D. Otterby, Dep. of Animal Science, Univ. of Minnesota. Contribution of the Dep. of Agronomy and Plant Genetics, Univ. of Minnesota. Minnesota Agric. Exp. Stn. Journal Series paper no. 19 108. Received 13 May 1991. \*Corresponding author.

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6.1 ha (15 acres) of lupin for the first time in 1987 and obtained a yield of 1850 kg/ha (68 bu/acre). This reportedly provided more than enough protein supplement to supply that farmer's 60-cow herd. He claimed to have reduced his protein supplement expenses by two-thirds just by substituting lupin for the soybean [*Glycine max* (L.) Merr.] meal he had been purchasing. The article further noted that the lupin seed could be fed directly without processing and that the crop was easy to plant and harvest. "They're easy to combine, super easy," reported the farmer. He also remarked in the article that the crop's tolerance to low temperatures meant that he could plant and harvest lupins earlier than soybeans. As a summary assessment the farmer stated, "You have to sell the soybean at whatever price they offer, and then buy back the meal for whatever cost they want to charge. We figured there had to be a better way."

Such logic made sense to Mueller, and although he did not produce soybean on his farm, he did pay nearly \$20 000 each year for soybean and other protein supplements. The prospect of growing lupin to eliminate or reduce this expense, as well as his dependence on external suppliers, was very attractive.

By participating in the university-sponsored project, Mueller knew he would have direct access to university specialists who could answer his questions and help him understand this new crop. The university also offered to provide no-cost lupin seed and inoculum to cooperators, which was no small factor since Mueller knew that lupin seed cost was high (Exhibit 1).

There was some uncertainty in 1988 regarding how many years the project might run, which meant that Mueller's commitment was on a year-by-year basis. Thus, he knew that he could "opt out" of participating in the project in future years if things didn't work out. "I can't lose," he thought.

What a difference 3 yr had made. By December 1990, most of Mueller's earlier enthusiasm for lupin was gone. Severe drought in his first year (1988), coupled with serious lambsquarters (*Chenopodium album* L.) and common ragweed (*Ambrosia artemisiifolia* L.) problems, had resulted in very little harvestable yield. As he agreed in 1989 to participate in the project for a second year, Mueller reasoned, "Surely the drought will let up and I'll be all right." But ragweed and lambsquarters infestations in his field that year were even worse than in 1988, and when coupled with sporadic dry periods during the season, essentially no yield was obtained in 1989. On the heels of such discouraging results, Mueller was reluctant to participate in the trial again, but his desire to "see this thing through" plus extra financial support from the university for the 1990 growing season favored his participation. However, damage and reduced stand caused by a hail storm soon after emergence in May forced Mueller to disk under this 1990 lupin crop, again obtaining no seed yield.

After his 3-yr experience with lupin, Mueller was understandably discouraged. "I hear reports of farmers in my area having success with lupins, but that sure hasn't been my experience. I can't figure out why they can do it and I can't. It just doesn't seem worth the hassle. Maybe I

**Exhibit 1. Estimated production cash costs for lupin and soybean in central Minnesota (Putnam et al., 1989).†**

Expense	Lupin	Soybean
	dollars/ha (dollars/acre)	
Seed	91.40 (37.00)	22.20 ( 9.00)
Fertilizer	28.70 (11.60)	28.70 (11.60)
Herbicide	43.00 (17.40)	43.00 (17.40)
Fuel	23.70 ( 9.60)	23.70 ( 9.60)
Repairs and maintenance	41.00 (16.60)	41.00 (16.60)
Interest on cash expense	9.90 ( 4.00)	9.90 ( 4.00)
Total	237.70 (96.20)	168.50 (68.20)

† Expenses do not include fixed costs such as land, machinery, and taxes.

should look into other options for reducing protein supplement costs such as enhancing the quality of forages produced on the farm or experimenting with growing and feeding roasted soybean."

### The Decision

Mueller's 3-yr effort to produce and feed lupins had not been successful. He hadn't grown enough seed to be able to adequately assess how his cows would perform with lupins in their ration. His interest in becoming more self-sufficient for protein on his farm was still strong and his nature was to "continue the fight." "After all," Mueller reasoned, "many of my problems with the lupins, such as the drought and hail, could have happened to any crop." But with no new herbicides coming available for ragweed or lambsquarters control, Mueller knew that production of weed-free lupins on his farm would be a real challenge in the future. He did not look forward to further disappointment and failure. The university project had ended and there was no more financial support forthcoming. From now on he was on his own.

The 1991 cropping season was approaching and Jeff knew that he had to decide soon whether to continue his efforts to produce and feed lupins on his farm. If he chose not to do so, he needed to assess his other options for reducing protein supplement expenses. If he did continue to grow lupin, he had to find a way to assure that the unsuccessful experiences of 1988 through 1990 were not likely to be repeated.

### Background on the Farm

Jeff Mueller's farm was located in central Minnesota west of Little Falls near the community of Swanville. He went into partnership with his father on the family Holstein dairy farm in 1979 following graduation from high school. At that time their herd was approximately 50 cows, but when Mueller's brother also joined the partnership in 1986, the herd was expanded to 100 milking cows, a relatively large herd by Minnesota standards (Exhibit 2). Mueller, his father, and his brother each owned their land separately but they managed it as a single unit. Their combined owned acreage was 204 ha (505 acres) of which 144 ha (355 acres) was tillable. Mueller, himself, owned 38 ha (95 acres) of tillable land and 59 ha (145 acres) of woodland and meadow. The family also rented additional land area for production of corn (*Zea mays* L.) and hay.



**Exhibit 2. Selected Minnesota state average dairy statistics, 1988.†**

	All DHI	Non-DHI	DHI (Holstein only)
Herds reported	6233	10 399	5589
Cows per herd	53	45	54
Production—kg/cow (lb/cow)	7589 (16 716)	4755 (10 473)	7702 (16 965)
Butterfat (%)	3.7	3.8	3.7
Feed cost per cwt— \$/kg (\$/cwt)	0.10 (4.52)	0.13 (6.10)	0.10 (4.50)

† Source: Minnesota Dairy Herd Improvement Association.

The terrain in the area of the Mueller family farm was gently rolling with occasional small peat bogs and depressions. The original vegetation was northern hardwood forest and oak (*Quercus* sp.) savannah. The tillable soils on the farm were predominately sandy loam (Typic Fragiocrepts and Aeris Fragiaqualfs), and peat over loamy till (Terric Borosaprists), and were poorly to well drained (Exhibit 3). They also were somewhat rocky, which hampered tillage, cultivation, and harvesting operations. Soil pH tended to be moderately acidic with low levels of exchangeable K and low to high levels of P.

Climatic conditions were very important for determining the cropping systems in the region. Soybean was seldom grown because of the relatively cool growing season temperatures, especially at night. For example, average July minimum temperatures in the country were less than 16°C (60°F) (Erickson et al., 1979). Average daily maximum temperatures in July were about 28°C (about 82°F). Growing season length was also somewhat short with a 12 May average date of last frost in the spring and a 26 September average first frost date in the fall. Such conditions were well-suited to a cool-season legume such as lupin. Annual precipitation on the Mueller farm averaged 660 mm (26 inches) with a summer precipitation (June–August) of 305 mm (12 inches). Although the total amounts of precipitation received in the area of the Mueller family farm were adequate for lupin, the sandy soils caused drought conditions to readily occur during dry periods, as in 1988. Some lupin producers in the area had successfully produced lupin under irrigation, but Mueller did not currently have the capacity to irrigate.

### Crop Management

Alfalfa (*Medicago sativa* L.) and corn were the main crops typically grown in rotation on the Mueller family farm, with 4 to 5 yr of alfalfa alternated with 3 to 4 yr of continuous corn. Field pea (*Pisum arvense* L.), spring triticale (*X Triticosecale* Wittmack), or oat (*Avena sativa* L.) were used as companion crops for establishing the alfalfa. Alfalfa was also sometimes direct-seeded on level fields using a preplant-incorporated herbicide for weed control in the establishment year. Alfalfa was either chopped at bud stage for haylage or cut for hay. Corn was harvested both for grain and silage. Crop area on the farm in 1989–1990 (including rented land) was approximately 121 ha (300 acres) of corn, 40 ha (100 acres) of alfalfa, 12 ha (30 acres) of oat underseeded with alfalfa, 49 ha (120 acres) of grass hay, 49 ha (120 acres) of pasture, and the 2 ha (5 acre) lupin trial.

**Exhibit 3. Characteristics of soils on Mueller Farm (Erickson et al., 1979).**

Landscape unit designator†	Root zone texture	Substratum	Drainage	pH	P	K
LLWL	sandy loam	sandy loam	well	5.2–6.5	m–h‡	low
LLPL	sandy loam	sandy loam	poor	5.0–6.2	m–h	low
SP	peat	sandy loam	poor	6.0–7.8	low	low

† Designators taken from Soil Landscapes and Geomorphic Region map.  
‡ m–h = medium to high.

Typically, Mueller liked to use a moldboard plow and disk for primary and secondary tillage on his farm. Atrazine and alachlor (Lasso) were the main herbicides used for weed control in his corn. Nitrogen, P, and K were usually applied as starter fertilizer, with the remaining N applied later as a sidedress. Weed problems on the farm varied somewhat depending on weather conditions from year to year, but common weed species included common lambsquarters, redroot pigweed (*Amaranthus retroflexus* L.), and common ragweed.

Mueller had planted his lupin trial in all years with a grain drill. Phosphorus and K fertilizers were applied prior to planting. Metolachlor (Dual) herbicide, applied preplant-incorporated, was used for weed control in all years. Metolachlor and pendimethalin (Prowl) were the only two herbicides registered for use on lupin in 1988 and 1989, and neither provided adequate control of lambsquarters or common ragweed. Although sethoxydim (Poast) herbicide became registered for use on lupin in 1990, it was ineffective for control of these weeds. There was interest in seeking registration for linuron (Lorox) and imazethapyr (Pursuit) use on lupin, which would have provided some additional control options for lambsquarters (linuron) and ragweed (imazethapyr). However, the small area of lupin in the USA reduced industry's enthusiasm for seeking a label. In addition, research trials with imazethapyr indicated that lupin injury was likely when used on sandy loam soils, which appeared to nullify any weed control benefits (Gunsolus and Weins, 1991). Some producers had grown lupin as a row crop with 51 to 76 cm (20 to 30 inches) row spacings to preserve their options for cultivating, although research had shown that seed yields of narrow-row (drilled) lupin were at least 30% higher than wider rows (Putnam and Hardman, 1988).

### Herd Management

The Dairy Herd Improvement (DHI) rolling herd average milk production for the Mueller farm in December 1990 was 9437 kg (20 787 pounds) per cow. The herd average had increased steadily since 1987 (Exhibit 4) and was considerably higher than the state DHI average for Holsteins of about 7718 kg (17 000 pounds) (Exhibit 2). Mueller's production goal was to move the herd average to 10 896 kg (24 000 pounds) within the next few years. To reduce production costs, the Muellers began in 1989 to purchase protein supplements in bulk and to mix their own ration using the total mixed ration (TMR) concept. Even with bulk purchasing, however, protein supplement expenses in 1990 totaled approximately \$20 000. A typi-

**Exhibit 4. Dairy herd improvement rolling herd summary for Mueller farm, 1987 to 1990.**

Date	Total cows milked	Milk	Fat	Protein
	no.	kg/cow (pounds/cow)	— g/kg —	
December 1987	95	8010 (17 644)	0.34	0.31
December 1988	95	8485 (18 689)	0.36	0.31
December 1989	96	8940 (19 691)	0.36	0.31
December 1990	100	9437 (20 787)	0.37	0.32

**Exhibit 5. Typical daily ration per cow for Mueller farm in 1990.**

Component	Amount	
	kg/cow	(pounds/cow)
Alfalfa hay	3.2	(7)
Alfalfa/grass haylage	9.5	(21)
High moisture shelled corn (rolled)	9.5	(21)
Oat (rolled)	1.4	(3)
Whole cotton seed†	1.4	(3)
Soybean meal	0.4	(1)
Linseed meal	0.2	(0.5)
Roasted soybean	0.2	(0.5)
Corn distiller's grains	0.2	(0.5)
Meat and bone meal	0.2	(0.5)
3:1 (Ca/P) mineral, vitamin, and salt premix	0.2	(0.5)
Blood meal	0.1	(0.25)

† Cotton, *Gossypium hirsutum* L.

cal daily diet for a cow in the Mueller herd in 1990 is shown in Exhibit 5. The ration was determined in consultation with the local feed mill in Swanville where forages were routinely tested and their analysis taken into account in balancing the ration. Dry cows were maintained on corn silage, mineral supplement, and grass hay.

A factor in Mueller's decision was his lack of knowledge and experience with using lupin in his herd's ration. He had hoped to produce enough lupin seed in his 1988–1990 trials to experiment with feeding them, but the lack of production allowed no opportunity to do so. Recent university trials (Guillaume et al., 1987; May et al., 1991) had provided conflicting information regarding the use of lupin in rations of lactating dairy cows. In an earlier trial (Guillaume et al., 1987), a total of 45 Holstein cows had been fed diets consisting of 50% forage (corn silage, alfalfa silage) and 50% protein concentrate. In one diet, soybean meal supplied 34% of the total crude protein, whereas in the other ground lupin seed made up 38% of the protein. Cows fed lupins consumed significantly less dry matter, although the reasons for this reduced intake were not clear. Lupin-fed cows also tended to produce less milk, although the differences were not significant within the statistical precision of the experiment. In situ disappearance of N, an indicator of relative protein degradation in the rumen, was substantially higher for lupin than for soybean meal, especially during the first few hours (Exhibit 6). Overall crude protein from soybean meal was estimated in the study to be 71% degraded, whereas lupin protein was 80% degraded. This was of importance because excessive protein degradation could be detrimental to high-producing cows since rumen microbes would be incapable of synthesizing sufficient quantities of essential amino acids. The results of the trial suggested that lower milk production for lupin-fed cows might be due, in part, to reduced intake and excessive

**Exhibit 6. Dry matter and N disappearance of soybean meal and ground lupin seeds from dacron bags suspended in the rumen of lactating Holstein cows (Guillaume et al., 1987).**

Protein supplement	Dry matter disappearance						N disappearance					
	Time in rumen, h											
	2	4	8	12	16	24	2	4	8	12	16	24
	g/kg											
Soybean meal	4.4	5.2	7.1	8.2	8.8	9.7	3.3	4.1	5.9	7.5	8.4	9.4
Lupin seeds	5.1	6.1	7.8	8.5	8.8	9.3	7.2	7.9	8.4	9.3	9.4	9.7

protein degradation. These researchers cautioned that further investigation was needed to confirm these results.

In the later trial (May et al., 1991) there was no evidence of reduced intake for cows fed diets in which up to 100% of the soybean meal had been replaced by ground lupin seed. In fact, diets with 75% lupin replacement gave substantially higher fat-corrected milk production than diets containing only soybean supplement. The researchers attributed this to the higher fat (energy) content of the lupin-containing diets. Further studies confirmed that lupin seed protein was more degradable in the rumen than soybean meal, possibly to an even greater extent than indicated in the earlier study. Although the later study was more positive regarding the prospect of using lupin in dairy diets, Mueller was still concerned about the impact of lupin on a high-producing herd like his.

## Summary

Two issues played on Jeff Mueller's mind as he weighed the prospect of again growing lupins on his farm in 1991: (i) whether he could successfully produce lupin considering the constraints he faced, particularly with weed control; and (ii) whether lupin would make a suitable protein source for his herd considering its current production level and future goals. The Mueller family farm was one of the most highly regarded dairies in central Minnesota. Mueller had received in 1990 a Minnesota Department of Agriculture competitive grant to conduct on-farm testing of alternative cover crops for forage production, which was indicative of his innovative and resourceful approach to crop management. The installation of the total mixed ration system in 1989 was another indication of the progressive approach that the Muellers took in the management of their herd and in the reduction of production expenses. Steady improvement of herd productivity, coupled with his goal for continued enhancement of production, placed utmost importance on having access to high performance rations that included adequate quantities of quality protein. Mueller needed to decide whether to consider lupin as a viable crop for his farm's future.

## TEACHING NOTE

### Case Objectives

The overall objective for this case is to provide students with problem analysis and decision-making experience typical of that faced by farmers seeking to diversify their

**Table 1. Student assessment of learner outcomes attainment for the Mueller Farm decision case in AnPI 5060 in 1991 (n = 8).**

Learner outcome	Unsatisfactory	Poor	Fair	Satisfactory	Good	Very good	Excellent	frequency of response, no.	
Improved capability to analyze dairy operation for protein need	0	0	1	1	1	4	1		
Improved capability to consider prospects and options for producing alternative crops	0	0	0	2	3	3	0		
Increased familiarity with principal production procedures and constraints for lupin	0	0	0	0	4	3	1		
Improved capability to integrate agronomic and animal production factors within single decision focus	0	0	0	1	0	4	3		

operations and to reduce production expenses. The case provides insight into the process of alternative crop adoption. Upon completion of the case students will have:

1. Improved their capability to analyze a dairy operation with respect to its need for a protein supplement
2. Improved their capability to consider the prospects, options, and risk factors for producing alternative crops
3. Become familiar with principal production procedures and constraints for lupin, a representative new and uncommon crop
4. Considered the integration of agronomic and animal production factors within a single decision focus

#### Use of the Case

This case was originally developed during 1989 for use in 1990 in the interdisciplinary "capstone" course (AnPI 5060) in the animal and plant systems major at the University of Minnesota. The case was revised and updated in 1991 and again used in the course in that year. Almost all students in this course had prior coursework in agronomy/horticulture and soil science. Few had coursework in animal science. The case was assigned to groups of three or four students. To enhance authenticity, exhibit information was provided to the students, whenever possible, in the form of original sources. For example, Exhibit 4 was provided in the form of actual DHI herd summary sheets obtained from Mueller. Similarly, students were provided an actual copy of the article by Guillaume et al. (1987) for Exhibit 6. Groups were given a period of about 5 d to deliberate the case outside of class prior to making a presentation of their decision and supporting rationale in class. The entire class then participated in an instructor-guided discussion of the case, decision options, and issues. Faculty or staff representing animal science and plant/soil sciences participated in the general case discussion.

The earlier version of the case was evaluated in 1990 as part of the overall course using a 1-7 rating scale (1 = unsatisfactory, 2 = poor, 3 = fair, 4 = satisfactory, 5 = good, 6 = very good, and 7 = excellent). Its' overall rating was "very good" based on a response from 10 students. Three students rated the case "excellent," four rated it "very good," one rated it "good," and one "satisfactory." In 1991, the revised case was evaluated by the students on a learner-outcome basis using the same

rating scale as 1990. Eight students experienced the case and their evaluations are summarized in Table 1. The case was particularly effective for improving the students' capabilities to integrate agronomic and animal production factors within a single decision focus. This is consistent with the primary purpose for developing this particular case and using it in the animal and plant systems major capstone course. The most common criticism of the case was that students felt they had incomplete or inadequate information on which to base a decision. Some students also expressed that the case seemed complex with many factors and options to consider. The case was specifically selected for development precisely because, as an alternative crop in Minnesota, lupin is poorly understood and researched. Similarly, the decision is complex and includes factors other than technical or scientific considerations. Nevertheless, crop managers must often base decisions on incomplete or inadequate information and human factors; thus, the case in its incompleteness and complexity represents an accurate documentation of reality. Some students also expressed concern that their personal background limitations in agronomy hindered their abilities to relate to the case. Because deliberation of the case was a group effort, the opportunity was provided to capitalize on the synergies of cooperative learning. Each group was deliberately constituted to maximize the diversity of the students, particularly in relation to course and agricultural backgrounds.

#### Issues in the Case

The case centered around two central questions:

1. Could Mueller successfully grow lupins on his farm?
2. Could Mueller effectively utilize lupins as a protein supplement for his dairy herd?

The desirability of reducing feed expenses was clear in 1990, but whether production and feeding of lupin would provide a meaningful reduction in those expenses was problematic. One difficulty was the unknown production capability for lupin on the Mueller farm. The failures of the 1988-1990 lupin crops resulted in no yield performance record being available for the farm.

A critical constraint for producing lupin on the Mueller farm was weed control. The outlook was not bright for overcoming this problem since no herbicides were labeled or likely to become labeled in the near future to control common ragweed and common lambsquarters in lupin.

The option of planting in wider rows and cultivating could have been considered, but yield potential would be reduced and weeds within the row might still not be controlled. The possibility that Mueller might be tempted to use off-label herbicides in this situation prompted important ethical and legal considerations in the case. Developing capacity to irrigate was also considered, especially in light of the drought experience in 1988.

An important agronomic and economic issue in the case was the availability and cost of lupin seed. Mueller was provided complimentary seed during the years of his participation in the university project, but that option was no longer available after the 1990 season. Lupin seed costs were high, approximately \$86 to \$99/ha (\$35-\$40 per acre), and the number of seed suppliers was limited. Although the possibility existed for Mueller to produce his own seed each year, his past lack of success with weed control and the likelihood of seed-borne diseases made this option less attractive.

Although extension literature available at the time of the decision indicated that lupins could replace at least 65% of the meal supplements in dairy cow diets, the extent of this replacement for the Mueller herd was not known. Furthermore, research had raised questions as to whether lupin-fed cows might have lower intake or suffer from inadequate by-pass protein, which would have been particularly unsatisfactory for high producing herds. The high level of production of Mueller's herd, coupled with his short-term goal of producing 10 896 kg (24 000 pounds) per cow, clouded the issue as to the extent to which lupin could replace protein supplements on his farm. The case provides a springboard for more in-depth consideration of ruminant nutrition analytical techniques (in situ, in vitro) as well as discussions of the importance of protein degradability. The case is a good one for discussing difficulties encountered when making decisions where information is incomplete or contradictory.

The individual qualities of Mueller were also important issues influencing the case decision. His desire to be less dependent on external protein supplement suppliers and expenses was central to the case. His record of past innovation suggested that he was not one to back down from a challenge. The decision depended greatly on the

strength of Mueller's determination and desire to persevere through the difficulties that he would encounter in future efforts to produce and feed lupin on the farm. Whether Mueller would invest the time, effort and expense to develop the capability to produce lupin was a question.

#### ACKNOWLEDGMENT

Special appreciation is expressed to Mr. Jeff Mueller for his generous cooperation in providing information needed to develop this case. Appreciation is also expressed to Dr. Melvin Stanford, Mankato State University, and former assistant JoAnn Barbour for their constructive critique and assistance while researching and writing this case.

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# Dick and Sharon Thompson's "Problem Child": A Decision Case in Sustainable Agriculture

R. Kent Crookston\* and Melvin J. Stanford

## ABSTRACT

In December of 1989, Dick Thompson was wondering what to do about the K deficiency problem that had persisted in his ridge-tilled corn (*Zea mays* L.). He and his wife, Sharon, owned and operated a 121-ha (300-acre) crop and livestock farm near Boone, IA. From 1967 until 1986 they had farmed organically. By 1986, however, K deficiency in their corn had become so serious that they felt they either had to use chemical K or "go broke." Soil K levels were high. "Potassium has become such a problem for us, that we refer to it as our 'problem child'," said Thompson. The case has 12 exhibits, which include Thompson's own illustrated notes that trace his struggles with K in a variety of ways. His notes include the history of manure management, the nutrient status of his crops and soils, fertilizer experiments conducted on the farm, plus results and reports of farmers and scientists from Iowa, neighboring states, and Canada. After reviewing and considering all these factors, Thompson still wondered why the K stress persisted and what he should do about it. The case focuses on this decision. The decision requires consideration of the issue of organic vs. chemical farming, plus the validity of soil testing philosophies and associated fertilizer recommendations common to Thompson's location and time. The decision also requires an evaluation of Thompson's ridge-tillage as well as manure/nutrient-management systems. Objectives of the case are for students to analyze and discuss these issues and to propose and defend a course of action for Thompson regarding his K fertility program. The case has been used successfully in a senior-level integrative course in animal/plant systems.

THE THOMPSON FARM in Boone, IA, was well-known nationally for its sustainable agriculture practices, including soil conservation, crop rotation, and low chemical inputs. Dick Thompson worked hard to improve his farm, and he kept good records. Despite success in many areas of his farming, Thompson was concerned about K deficiency in his ridge-tilled corn. This issue provides a focus that adds interest and purpose to the study of the farm from the viewpoint of the farmer, who must decide what to do about the K problem.

## THE CASE (ABRIDGED)<sup>1</sup>

On the night of 11 Dec. 1989, Dick Thompson was wondering what to do about the K deficiency problems that had persisted in his ridge-tilled corn (*Zea mays* L.).

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R.K. Crookston, and M.J. Stanford, Dep. of Agronomy and Plant Genetics, 411 Borlaug Hall, 1991 Upper Buford Circle, Univ. of Minnesota, St. Paul, MN 55108. Paper 19 077 of the Scientific Journal Series, Minn. Agric. Exp. Stn. Supported in part by the Northwest Area Foundation, West 975 First National Bank Building, St. Paul, MN 55101-1373. Received 13 May 1991. \*Corresponding author.

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He and his wife, Sharon, owned and operated a 121-ha (300-acre) crop/livestock farm near Boone, IA. They had farmed conventionally up until 1967, when they stopped using chemical pesticides and fertilizers altogether. "We weren't satisfied with the way we were farming back then," explained Thompson. "We were probably okay financially, but we just didn't feel right inside. There was definitely a spiritual aspect to our decision."

Thompson was a compulsive innovator and creatively altered his farm operations from year to year, finding ways to maintain profitability while reducing off-farm inputs. He considered ridge tillage a key to his field operations. In his numerous research briefs and annual reports, he was eager to share his enthusiasm for the ridge-till system. News about the Thompson's innovative on-farm research began to spread and articles about their farming practices appeared in news articles and farm magazines across the country. In 1984, the Thompsons found it necessary to organize a field day to formalize visits of curious farmers and scientists who dropped by to check out their practices. For the 1990 growing season, the Thompsons were planning two field days.

The Thompsons' farming system had not escaped without problems, however. "The single most persistent problem we have faced is potassium," Thompson commented in late 1989. In the early part of the 1989 growing season, symptoms of K deficiency had in fact been evident in many ridge-tilled fields in Iowa and Minnesota. "Potassium has become such a problem for us, that we refer to it as our 'problem child'," said Thompson.

He could trace his struggles with K in a variety of ways. One way was to review the history of waste management on his farm. During the winters of 1967 to 1975, Thompson field-applied manure from his cattle (*Bos taurus*) and hog (*Sus vittatus*) operations on top of the snow. His corn yields during that period slipped from 7.52 to 5.33 Mg ha<sup>-1</sup> (120-85 bushels acre<sup>-1</sup>); no reason for the reduction in yield was identified. In 1975, he decided to try composting the manure. He liked the compost, especially since it seemed to help reduce weeds in his fields. By 1982, however, he began seeing subtle indications of K deficiency in his corn. He read about problems of nutrient loss and/or poor nutrient release from compost. He also read that the average yield advantage was 32% for spring-applied manure.

In 1984, Thompson abandoned composting and proceeded with spring manure application. His Buffalo

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<sup>1</sup>This is an abridgement of a more complete case. The complete case consists of 8 pages of text, 18 pages of illustrated exhibits, and a 7-page interpretive note. For a copy of the complete text, contact the corresponding author.

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**Abbreviations:** ISU, Iowa State University; PFI, Practical Farmers of Iowa.

ridge-till planter followed the spreader the very same day. The sweep moved the top few centimeters of soil off the ridge, taking the manure, the cover crop, and the weed seeds to the center between the rows and covering all these materials with soil. Corn was planted in the driest (but still moist), warmest, and most weed- and residue-free area of the field. The biggest problem was that manure hauling slowed down planting by 50%.

In 1984, he also began accepting deliveries of sewage sludge from the Boone municipal sewage treatment plant. "I didn't need the sludge," Thompson said. "It's low in potassium by itself, but I felt that it should be used, so we're figuring out how to make best use of it."

In 1986, Thompson constructed a concrete bunker to store both his manure and sewage sludge. Cement kiln dust was added to the sludge in 1989 as a stabilizing agent and to reduce the pathogen counts; the kiln dust also contained some K.

He started soil testing on his farm in 1967. In 1984, a tissue analysis program was initiated. Both soil and leaf tissue analysis were continued annually from 1984. In 1967 the farm's soil K had been 236 kg ha<sup>-1</sup> (211 pounds acre<sup>-1</sup>); by 1989 it had increased to 448 kg ha<sup>-1</sup> (400 pounds acre<sup>-1</sup>). Corn ear leaf K had not increased. Visible leaf K symptoms first showed up in the Thompsons' corn in 1985. "The year 1986 was a key decision year for me," he remembered. "I felt I was faced with the decision to either use chemical K or go broke. I was a certified organic grower, and it meant losing my organic status if I used chemical K, but it was obvious that K was limiting my yields so much that I had to do something."

In 1986, Thompson decided to abandon his organic status and applied 34 kg ha<sup>-1</sup> (30 pounds acre<sup>-1</sup>) K as either KCl or K<sub>2</sub>SO<sub>4</sub> to his corn with the planter. He also began adding starter N with the planter (28% N urea solution). By 1989, ear-leaf N was 3.36%, which was considered ideal, but his ear-leaf K was only 1.43%. In 1988, the banded K rate was increased to 67 kg ha<sup>-1</sup> (60 pounds acre<sup>-1</sup>) in an attempt to achieve the desired K leaf tissue level of 1.75%. However, the problem still existed.

In spite of persistent K problems, the Thompsons were doing well financially. According to his calculations, production costs of corn following soybean [*Glycine max* (L.) Merr.] on their farm were \$519.24 ha<sup>-1</sup> (\$210.22 acre<sup>-1</sup>) for 1989. Iowa State University (ISU) figures for Iowa corn production costs at his yield level were \$768.99 ha<sup>-1</sup> (\$311.33 acre<sup>-1</sup>). When Thompson's production costs per unit area and yield levels were used to calculate costs on a weight basis, his costs were \$57.09 Mg<sup>-1</sup> (\$1.45 bushel<sup>-1</sup>) compared to an ISU figure of \$84.26 Mg<sup>-1</sup> (\$2.14 bushel<sup>-1</sup>). Net return to management was \$288.82 ha<sup>-1</sup> (\$116.93 acre<sup>-1</sup>) for Thompson, but only \$39.08 ha<sup>-1</sup> (\$15.82 acre<sup>-1</sup>) from ISU statewide estimates.

On 11 Dec. 1989, Thompson attended the annual meeting of the Practical Farmers of Iowa (PFI) held at the Starlite Village Inn in Ames. There was a general concern among the PFI cooperators that ridge-tilled corn

**Exhibit 1. Summary of enterprise data for the Thompson Farm.†**

Category	Description
Farm size	282 acres of tilled cropland, 50 cows, 90 sows
Labor and management practices	The farm's diversified operation spreads labor requirements throughout the year. It is managed and operated by Dick and Sharon Thompson and their son, with one full-time hired man who takes care of the swine. Dick Thompson spends considerable time doing on-farm research.
Livestock management practices	The farm has a 50-cow foundation herd of cattle (Angus-Hereford cows and exotic breeds of bulls); it also has a 90-sow, farrow-to-finish hog operation (1300-1400 pigs finished/year).
Marketing strategies	Most crops and livestock are sold through ordinary commercial markets with no price differential for methods of production. The exception is about 15% of beef animals, which are sold directly to individuals at a \$0.10/pound premium, less the transportation cost to the locker/slaughter plant.
Weed control practices	Ridge tillage and high plant populations, in conjunction with crop rotation and cultivation with rotary hoe, disk hillers, and sweeps, are used. Small grains in the rotation disrupt weed reproductive cycles. If rain delays cultivation and weeds threaten crops, postemergence herbicides will be used.
Insect and nematode control practices	No particular pest problems were reported. Crop rotations and ridge tillage, plus a diversity of plant species, are credited for this situation.
Disease control practices	No antibiotics are used except to treat illness. Various measures are used to build resistance in the hog herd (for example, probiotics, transfer of manure from farrowing units to gestation pen). Cattle are not vaccinated. The farmer limes the pens to keep the pH unfavorable to pathogens, and uses isolation, sunlight, and special feed rations (for example, steamed rolled oat) to prevent scours and other diseases.
Soil fertility management	Municipal sludge and manure (18 tons/acre) are applied to corn and soybean. Urea (30 pounds N) is applied to corn and oat at planting; 30 pounds K <sub>2</sub> O is applied to corn and soybean at planting. The farmer uses 5- to 6-yr rotations with corn, soybean, oat, meadow, and green manure in various combinations.
Irrigation practices	None
Crop and livestock yields	Corn yields are 130-150 bushels/acre vs. the county average of 124; soybean, 45-55 bushels/acre vs. 40; oat, 80-100 bushels/acre vs. 67; hay, 4-5 tons/acre vs. 3.4. Pigs are finished and sold. The average number of pigs sold per sow is 14.4-15.6 vs. an average of 14.8 for a group of 270 Iowa Swine Enterprise Record members.
Financial performance	Municipal sludge is provided free of charge; only a limited number of farms can receive this free resource. Costs are kept low by the use of on-farm resources, such as N <sub>2</sub> fixation and labor. Corn and soybean production costs are lower than for conventional farms. Farm cash flow is adequate to meet operating costs without borrowing, to maintain and enhance the capital stock of machinery and facilities, and to support the farm family.

† Adapted with permission from National Academy Press (1989). Due to the nature of Case Study articles, units are reported as in the original document—usually English units. Other contributions in the Journal should use SI units.

yields were being affected by K stress. A report handed out during the meeting contained the following:

Why does this problem occur, and what can be done about it? Soil scientists around the Midwest have offered several partial explanations to the first question. The problem appears to be worse in dry years and in reduced tillage systems. In reduced tillage, K leaching from the residue of the previous crop remains close to the soil surface instead of being stirred back into the tillage layer of soil. The same is true for broadcast applications of K. In dry conditions, crop roots do not grow well in this surface soil, and K ions are also less able to diffuse through the soil to the roots.

Some researchers around the Midwest have seen evidence that crops in reduced tillage respond more strongly to band applications of K than they do to broadcast treatments. This is corroborated by PFI cooperator Richard Thompson, who ridge-tills. If the goal is to place the nutrient where the plant can get it, then where, exactly, is that? The answers may depend on a number of factors, including the weather, but cooperators have turned their attention to the problem.

As Thompson drove home from the PFI meeting that night, he was genuinely puzzled. He had not only achieved what was considered excellent K levels in his soil, but he had added more K with the planter than was normally recommended, and yet his leaf tissue tests still registered considerably less K than ideal for corn. Particularly puzzling was the fact that his corn yields had not responded to extra K that year. He wondered just how much K he was going to have to add to get those leaf percentages up to recommended levels. He was confident that he had just about the best manure handling system in the country. Potassium losses during storage had to be minimal.

The headlights of his pickup truck zeroed in on the garage wall. He was home; it was time for bed. His problem child would still be there in the morning. In fact, it would still be around next spring.

## CASE EXHIBITS<sup>2</sup>

1. Summary of enterprise data for the Thompson farm, reprinted with permission from *Alternative Agriculture*, 1989. Included with this article (Exhibit 1).
2. The Thompson's rotation at a glance, reprinted with permission from *The New Farm*, May/June 1989. Included with this article (Exhibit 2).
3. How to farm on ridges, reprinted with permission from *The New Farm*, July/August 1984. Illustrations of planting equipment in relation to soil and plants, with descriptions of the procedures involved in ridge tilling.
4. Charts and dialogue regarding the benefits of ridge tillage, from an undated "Thompson On-Farm Research—1989 Summary." A list of "Positive Attributes of Ridge-Till," plus a cross-section of the

<sup>2</sup>Case exhibits are available in their entirety in the complete case. In this abridged case, only Exhibits 1, 2, and 8 are provided in their entirety.

## Exhibit 2. The Thompsons' rotation at a glance.†

Here's a look at the 5-yr rotation the Thompsons use on about 200 of their 300 acres. An additional 80 acres is in a 6-yr rotation: corn-soybean-oat-meadow-meadow-meadow.

### CORN-soybean-corn-oat-hay

Yield goal: 150 bushels/acre  
Seeding rate: 26 000/acre; 120-d corn in 36-inch rows.  
Tillage: No spring tillage; ridge-planted into fall-built ridges  
Fertility: 15 tons manure/sludge per acre applied in spring, plus commercial K starter banded with planter; hairy vetch killed by planter and cultivator  
Weed control: two rotary hoeings, two cultivations  
Cover crop: 30 pounds hairy vetch, 20 pounds oat, 15 pounds grain rye; seeded into standing corn in early Sept.

### Corn-SOYBEAN-corn-oat-hay

Yield goal: 50 to 60 bushels/acre  
Seeding rate: 175 000/acre; late Group II soybean in 36-inch rows  
Tillage: None; ridge-planted  
Fertility: 15 tons manure/sludge per acre applied in spring  
Weed control: two rotary hoeings, two cultivations  
Cover crop: 30 pounds hairy vetch, 20 pounds oat, 15 pounds grain rye; seeded into standing soybean in early Sept.

### Corn-soybean-CORN-oat-hay

Yield goal: 150 bushels/acre  
Seeding rate: 26 000/acre; 120-d corn in 36-inch rows  
Tillage: None; ridge-planted  
Fertility: 15 tons manure/sludge per acre applied in spring, plus commercial K starter banded with planter; hairy vetch killed by planter and cultivator  
Weed control: two rotary hoeings, two cultivations  
Cover crop: None; ridges left to trap snow

### Corn-soybean-corn-OAT-hay

Yield goal: 80 to 120 bushels/acre  
Seeding rate: 4.25 bushels/acre; drilled  
Tillage: Offset-disk twice; harrow after planting  
Fertility: 120 pounds K<sub>2</sub>O/acre  
Weed control: Clip stubble in Sept.  
Cover crop: Hay mix seeded with oat

### Corn-soybean-corn-oat-HAY

Yield goal: 5 tons/acre  
Seeding rate: 5 pounds alfalfa, 2 pounds red clover, 1 pound alsike slover, 2 pounds timothy, 2 pounds orchardgrass  
Tillage: None  
Fertility: 60 pounds K<sub>2</sub>O/acre  
Weed control: None  
Cover crop: Hay offset-disked twice in Sept. Ridges built later in fall; seeded with 30 pounds hairy vetch, 20 pounds oat, 15 pounds grain rye

† Adapted with permission from Regenerative Agric. Assoc. (1989). Due to the nature of Case Study articles, units are reported as in the original document—usually English units. Other contributions to the Journal should use SI units.

- rows, and a graph showing 7200 to 9000 kg (8–10 tons) of soil loss with conventional corn-soybean tillage in Boone County and 900 to 3600 kg (1–4 tons) of soil loss (depending on rotations) with ridge-tillage on the Thompson farm.
5. Selections from promotional brochures for the 1990 Field Days at the Thompson Farm in Boone, IA. Shows location, schedule, and list of demonstrations.
6. Soil test results, 1967–1989 from "Thompson On-Farm Research—1989 Summary." Four charts showing various soil levels of K, Ca, P, and Mg, which all increased with bunker storage of manure and sludge. One chart shows soil pH level over time in the 6.7 to 7.9 range.
7. Corn leaf tissue analysis results, 1984–1989; and 5-yr nutrient budget, 1984–1989, from "Thompson On-

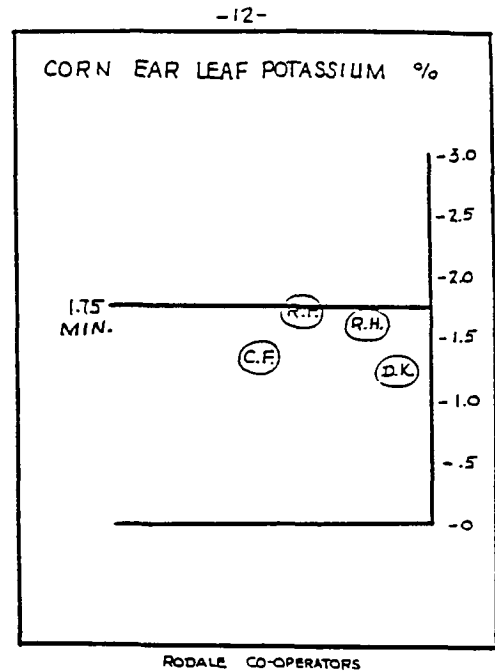
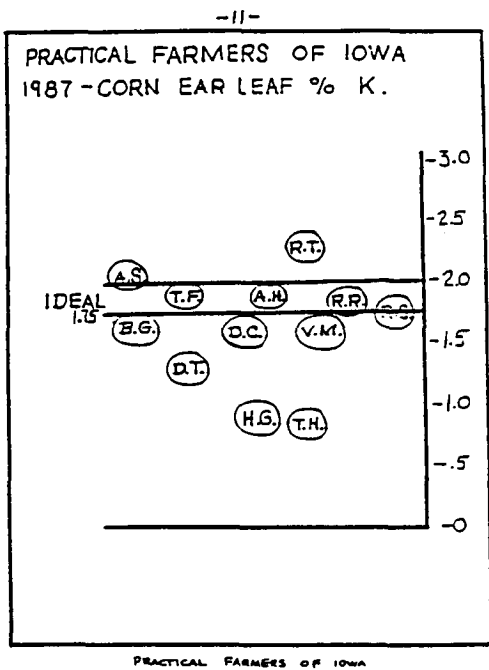


Exhibit 3. Potassium section of Thompson on-farm research—1987 Summary. “Potassium, The Problem Child”: One-half of the PFI farms were below the minimum standard when it comes to ear leaf K (Chart 11). All four of the Rodale Farms were below the 1.75% (Chart 12) (continued).

Farm Research—1989 Summary.” First chart shows corn leaf tissue percent for N, Ca, and Mg near or above ideal but K below ideal. Second chart shows inverse relationship between K and Ca or Mg, and between K and N. Third chart shows N ear leaf percent above ideal range in past 3 yr. Fourth chart shows soil nutrient budget of N and P with a positive balance, and K with a large positive balance.

8. Selected charts and dialogue from the potassium section of “Thompson On-Farm Research—1987 Summary.” Page 1 of Exhibit 8 is included with this article (Exhibit 3). Page 2 has three charts and a discussion of K and manure. Page 3 has two charts and a discussion of nutrient balance and K. Page 4 gives Thompson’s “Fertilizer Recommendations” for farmers without manure.
9. Selected charts and dialogue from the K section of “Thompson On-Farm Research—1988 Summary.” Page 1 has three charts showing K uptake at three different farms (Thompson, ISU, and Canada). Page 2 has three charts from Illinois and Wisconsin showing effects of banding, broadcast, and tillage on K uptake.
10. Potassium section of “Thompson On-Farm Research—1989 Summary.” Two pages of charts showing soil and leaf K, with discussion of purchased K.
11. Net returns per acre for corn, soybean, oat (*Avena sativa* L.), and hay production, from “Thompson On-Farm Research—1989 Summary.” Four charts, Thompson and ISU compared. Thompson’s costs are lower in all crops.

12. Detailed corn production costs (Thompson vs. Iowa State University), from “Thompson On-Farm Research—1989 Summary.” One chart. Thompson’s costs are much lower.

### INTERPRETIVE NOTE

#### Case Objectives

An important objective of this case is to introduce students to Dick and Sharon Thompson, a remarkable farm couple whose philosophy and practices made them famous in American low-input agriculture. The Thompsons had an unusual commitment not only to conduct environmentally safe farming, but also to help others do the same. The eventual objective is to have students offer suggestions toward a resolution of the K deficiency problem. Extensive exhibits allow students to focus on several specific aspects of the Thompson’s farming operation, and should also help them to evaluate and perhaps challenge some of those operations and/or the philosophies behind them. Upon completing the case, students should:

1. Have wrestled with one of the principal debates within “organic” or low-input farming circles, i.e., the use of processed or synthesized nutrients.
2. Have considered the validity of soil testing philosophies and associated fertilizer recommendations common to Thompson’s location and time.
3. Have evaluated Thompson’s ridge tillage system, weighing his promotion of it against possible shortcomings.
4. Have evaluated the economics of Thompson’s nutrient (specifically K) management program.



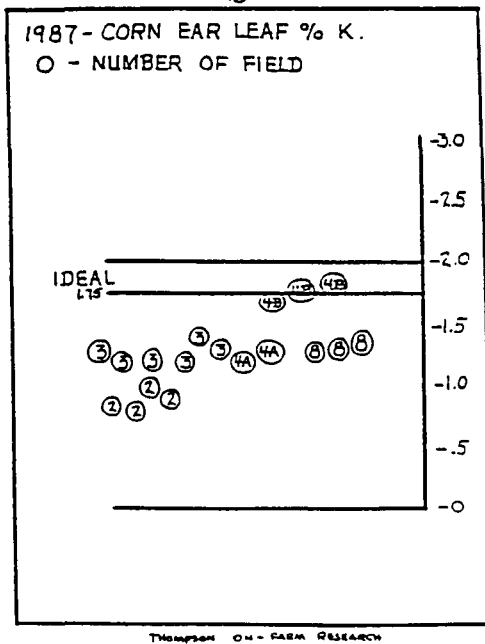


Exhibit 3, continued. The Thompson farm had only one field that was even close to the minimum mark (Chart 13).

5. Be able to defend a course of action for dealing with the K problem. The choice is to defend Dick's course of action or an alternative.

#### Use of the Case

This case could be effectively used by students or professionals interested in sustainable agriculture, manure management, corn management, and soil management (particularly ridge tillage and soil fertility). Students with varied backgrounds could make good use of the case, but technical training in crop and soil science and exposure to low-input or sustainable agricultural philosophy is expected.

Particular attention should be given to the exhibits containing selections from several "Thompson On-Farm Research Summaries." These consist of notes illustrated with charts and graphs that document experiments conducted by the Thompsons on their farm and results obtained therefrom. Few, if any, farmers in the world have so documented their practices. Students should be encouraged to ask themselves why Thompson prepared each chart, and to identify the important message behind each—paying particular attention to his convictions and recommendations.

This case has been classroom-tested several times with excellent results. Senior undergraduate students in the integrative animal/plant systems course at the University of Minnesota have responded well to the discussion questions. Their recommendations have been defended orally by group and in writing individually.

#### Issues in the Case

The authors believe the following questions will direct case users to the key issues in the case. The authors' insights into these issues, and possible answers to each question, are provided in the full interpretative note. References to specific exhibits (see "Case Exhibits") have been retained, even though the text of most of these exhibits are not provided in this abridged format. Review of the exhibits and the authors' insights in the complete interpretative note will indicate the depth of responses expected from the students.

1. What do you think was causing the K problem on the Thompson farm? How would you confirm this?
2. Evaluate Thompson's observation (Exhibit 10, paragraph 2) that "we may have discovered the answer here for the potassium uptake problem but didn't know it. It may take some liquid potassium under the seed along with dry potassium off to the side to reach early potassium uptake in the plant."
3. How do you react to Thompson's suggestion that low K levels in his corn leaf tissue and soil were the result of too high Mg and Ca levels in the soil (Exhibit 9, charts 37, 38, 39, and accompanying dialogue)?
4. For almost 20 yr, the Thompsons had been certified organic farmers. By 1986 Thompson found that he was questioning the "organic" notion that KCl was hard on the environment. What do you think caused him to start questioning? How would you evaluate the Thompson's farming practices regarding their impact on the environment?
5. How would you evaluate the economics of Thompson's nutrient (specifically K) management?
6. How relevant is the Thompson farming system for other farmers?
7. What recommendation would you have for Thompson and why?

Soil physical data were not provided by Thompson and are not included in the case. Students could be encouraged to consider the importance of compaction as well as tillage, and a discussion of these points is included in the full Teaching Note.

The authors recommend that the article by Olson et al. (1982) be read in conjunction with this case. It is particularly important for consideration of above questions 2 and 3.

#### REFERENCES

- National Research Council. 1989. Alternative agriculture. National Academy Press, Washington, DC.
- Olson, R.A., K.D. Frank, P.H. Grabovski, and G.W. Rehm. 1982. Economic and agronomic impacts of varied philosophies of soil testing. *Agron. J.* 74:492-499.
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# Stratton Farm: A Case of Conservation Compliance

Larry J. Grabau\* and Mark V. Kane

## ABSTRACT

In 1990, most producers faced decisions regarding strategies for enhancing soil conservation as a result of the mandate to develop a conservation compliance plan in conjunction with the 1985 U.S. Farm Bill. This case study features the decision faced by a Simpson County, Kentucky, grower in 1990 as he considered how his cropping system should be modified to address the problem of erosion control. In considering the plan, the grower also faced the difficult issue of whether to continue to raise tobacco (*Nicotiana tabacum* L.), as well as the question of cropping system diversification. The case objectives were to improve skills in group problem solving, as well as written and oral communication. The case provides cropping and yield histories, soil mapping units, economic considerations, and equipment availability. Each of the three problems is stated in language that precludes a single right answer, thus evaluation depends on the instructors' assessment of the strength of the arguments presented in each team's written and oral reports. Student response has been quite favorable, with the frequent comment that the case helped them to see the usefulness of learning crop production principles.

THE 1985 FARM BILL required that growers managing erosion-susceptible lands present a comprehensive plan for controlling soil erosion. This plan had to be approved by 1992, and in full operation by 1994. Like many other growers across the country, the producer in this case faced the dilemma of how he could continue to manage his sloping fields and still be in compliance with the law. Further, while he was an award-winning tobacco (*Nicotiana tabacum* L.) grower, many across the nation were questioning the morality of producing a crop that was known to be detrimental to the health of its consumers. Finally, this grower had for many years been interested in producing a diverse array of crops in order to minimize risk of economic disaster in poor growing seasons. His conservation compliance plan thus provided an opportunity to simultaneously assess each of these critical issues.

## THE CASE

By his own assessment, Mike Stratton was doing well in his farming operation in 1990. He worked hard and had developed an outstanding reputation in his region of the state. However, factors beyond his control were complicating his life. On the one hand, inadequate or irregular rains had sharply reduced yield of his grain crops in

several seasons. Although he could have invested in irrigation equipment to reduce such drought problems, favorable long-term rainfall histories made local lenders unwilling to finance such a venture. On the other hand, Stratton faced government regulation of his business practices. Because he had grown burley tobacco for several years, and had established government base hectares for corn (*Zea mays* L.), wheat [*Triticum aestivum* (L.) em Thell], and barley (*Hordeum vulgare* L.), he was used to dealing with the federal government. Now, however, the government had gone a step farther: they were no longer simply telling Stratton how much area of which crops he could grow, they were regulating how he managed those crops. Complaining to the nearest government official might have seemed attractive, but Stratton knew he needed to comply with the new regulations to continue to market his burley and dark air-cured tobacco. Further, he had to develop an acceptable conservation compliance plan by 1992, and have it in place by 1994, so he had to move quickly.

In addition, he faced another troubling thought: what if the government decided to reduce tobacco production allotments due to the outcry of the medical community? Was it really okay for him to be raising a crop that was known to seriously damage the health of its users? Maybe he needed to rethink his cropping system; maybe he needed to plan ahead to increase the diversity of his cropping system. He had heard that canola (*Brassica campestris* L.) had done well in other parts of the state; maybe it would do well for him, too. As Stratton regarded these difficult decisions, he knew that mere hard work would no longer bring him the success it had in the past.

## Historical and Personal Background

Mike Stratton graduated from Simpson County High School in 1978. From 1978 through 1987, he worked on a salary basis for Mr. Harvey Clendening, the owner of 233 ha southeast of Franklin, KY, near the Tennessee border. In 1988, Stratton and Mr. Clendening agreed to terms that gave Stratton a bigger stake in the operation. He was purchasing all of the farm's equipment on a 7-yr, no interest arrangement. During that time, Clendening would receive one-third of the produce, whereas Stratton would get two-thirds, but would pay all of the crop production expenses. Clendening trusted Stratton with all management decisions, and was thus not involved in any day-to-day or year-to-year decision making. Stratton and his wife Kristie hoped to begin purchasing the land in 1995, after they had paid for all of the equipment. Because they planned to purchase the land at some point in the future, they had a vested interest in minimizing soil erosion. The Strattons did not work extensively at off-farm jobs. Kristie helped with occasional farm tasks, but she was not involved in management decisions, and devoted

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ed most of her time to homemaking and caring for their 5-year-old daughter, Audra. Stratton had hired a full-time employee to help with field work in November 1988, and intended to keep a person in that supporting role indefinitely. Stratton's father produced a substantial amount of burley and dark air-cured tobacco on nearby land, and helped with labor management for these crops. For example, when alfalfa (*Medicago sativa* L.) and burley tobacco harvests fell at the same time in 1989, Stratton baled hay while his father supervised tobacco workers.

The farm had concentrated on production of grain and tobacco crops since 1981. Prior to that time, the farm included a 68 cow (*Bos taurus*) registered Holstein dairy enterprise. When a partner in the dairy left in 1981, the cows and milking equipment had been sold, but the existing tie-stall barn, silos, and feedlots remained in relatively good condition. Stratton had no interest in re-establishing the dairy enterprise, because he felt that his expertise in crop production gave him an advantage in that facet of farming.

### Cropping System Components

1. *Land and Crops.* Exhibits 1 and 2 show the two blocks of land, here described as Farms A and B, respectively, which made up Clendening's holdings. In addition, soil mapping units are shown on Exhibits 1 and 2. The total area of Farm A is 132 ha, of which 97 ha was in crop production. Field sizes and cropping histories are as shown in Exhibit 3. It is noteworthy that fields 4a and 4b were previously handled as strips of corn or full-season soybean [*Glycine max* (L.) Merr.] alternating with winter wheat or winter barley followed by double crop soybean. In spite of the benefits of strip cropping for erosion control, Stratton felt that this was too much trouble to manage. Exhibit 2 shows fields of Farm B with 70 ha of cropland (31 ha were in woodlands), and Exhibit 4 gives field sizes and cropping history for this farm. Although he intended to have a 5 crop/3 yr rotation involving barley/soybean in Year 1, wheat/soybean in Year 2, and corn in Year 3, Exhibits 3 and 4 reveal that this intended cropping system had been frequently disrupted. For ex-

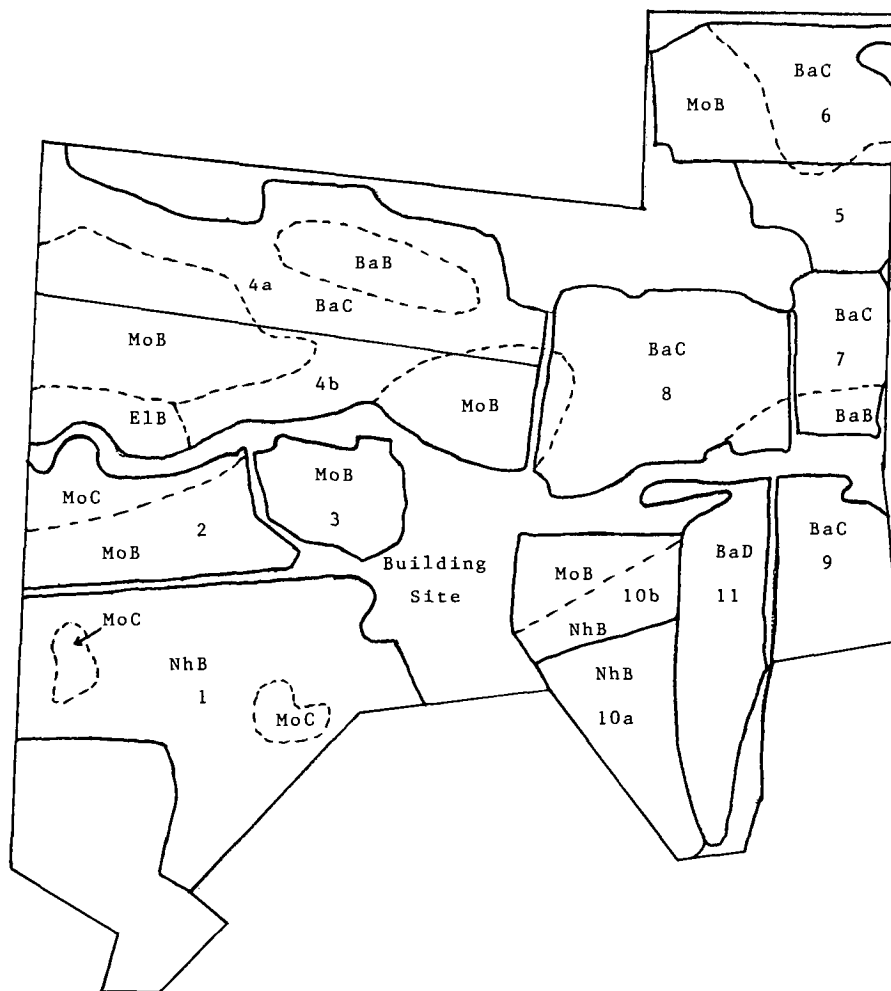
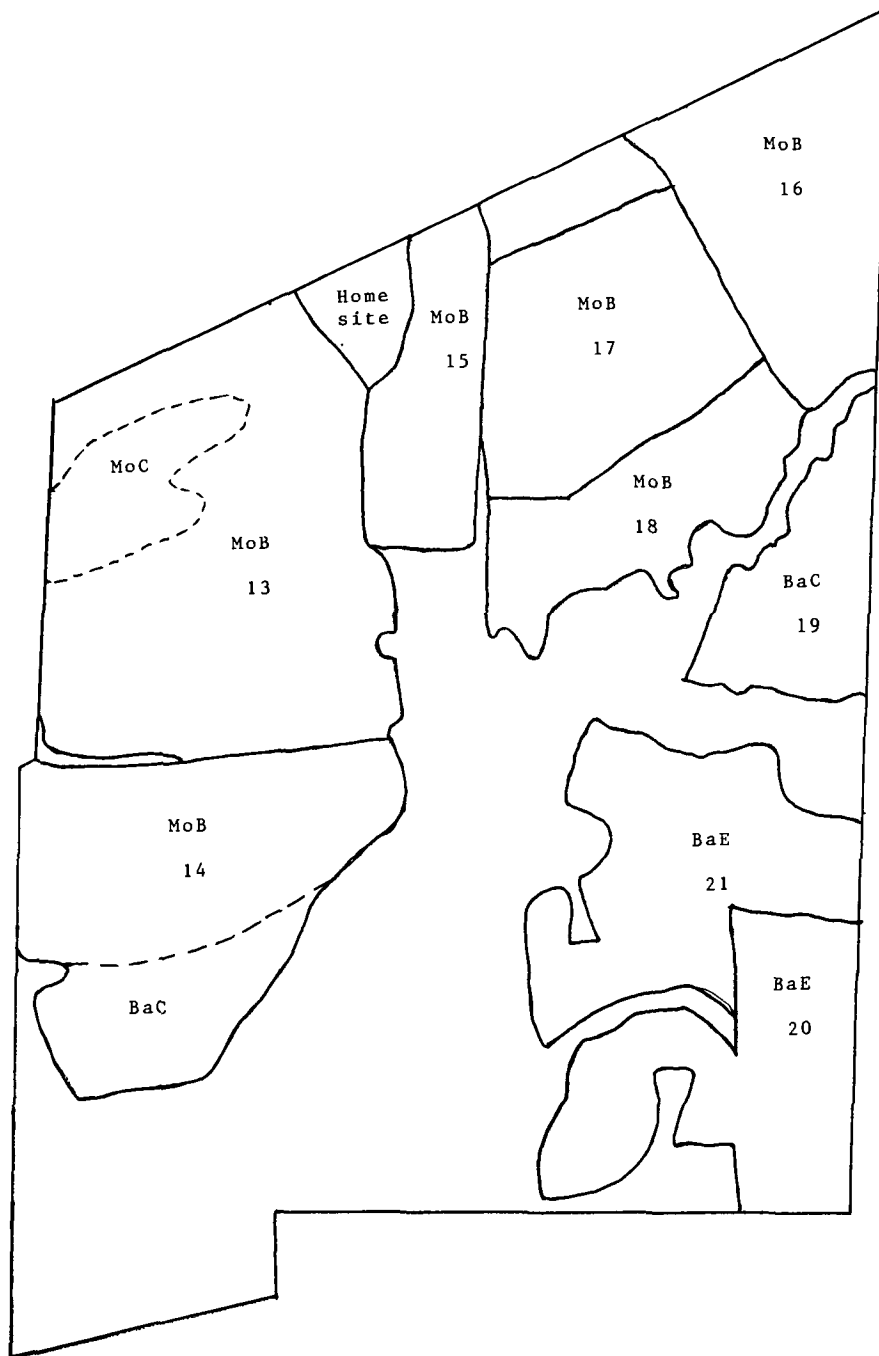


Exhibit 1. Field (solid lines) and soil series (dashed lines) identification for Farm A. BaB, Baxter cherty silt loam (Typic Paleudalfs), 2 to 6% slopes; BaC, Baxter cherty silt loam, 6 to 12% slopes; BaD, Baxter cherty silt loam, 12 to 20% slopes; E1B, Elk silt loam (Ultic Hapludalfs), 2 to 6% slopes; MoB, Mountview silt loam (Typic Paleudults), 2 to 6% slopes; MoC, Mountview silt loam, 6 to 12% slopes; and NhB, Nicholson silt loam (Typic Fragiuudalfs), 2 to 6% slopes.



**Exhibit 2. Field (solid lines) and soil series (dashed lines) identification for Farm B. BaC, Baxter cherty silt loam (Typic Paleudalfs), 6 to 12% slopes; BaE, Baxter cherty silt loam, 20 to 30% slopes; MoB, Mountview silt loam (Typic Paleudults), 2 to 6% slopes; and MoC, Mountview silt loam, 6 to 12% slopes.**

ample, a severe winter in 1985–1986 sharply reduced barley and wheat stands, resulting in the replacement of small grain/soybean double crop with full-season soybean. In 1988, mid-summer conditions were so dry that no double crop soybean could be planted behind either barley or wheat. For Farm B, Fields 20 and 21 had been mostly used as “set-aside” fields for government programs since 1987. Stratton planned to continue to keep these fields out of production, since they were his poorest fields, due to their slope and the resulting erosion hazard.

Exhibit 5 shows the Stratton farm yields, and Exhibit 6 shows the average market price received for each crop over the last 6 yr. Exhibit 7 shows production expenses for each crop for the past 6 yr. All variable and fixed costs were included, except for costs associated with owning or renting the land. In Stratton’s case, land charges amounted to turning over one-third of the gross income from his crops to Clendening. Since each crop in the two double crop systems that he used (barley/soybean and wheat/soybean) shared some production ex-

**Exhibit 3. Field sizes and cropping history for Farm A.**

Field no.	Area, ha	Year					
		1985	1986	1987	1988	1989	1990
1	16.7	wheat/soybean	corn	wheat/soybean	corn	barley/soybean	wheat/soybean
2	6.5	alfalfa	alfalfa	alfalfa	alfalfa	alfalfa	no-till corn (plus tobacco)
3	3.2	barley/soybean	soybean	barley/soybean	set aside	alfalfa	alfalfa
4a	13.6	corn	wheat	wheat	wheat	corn	barley/soybean
4b	13.6	barley/soybean	corn	set aside	soybean	soybean	corn
5	2.7	corn	wheat	soybean	set aside	corn	barley
6	7.4	corn	wheat	corn	wheat	corn	barley
7	3.2	wheat	corn	barley/soybean	set aside	corn	barley
8	10.1	corn	wheat/soybean	barley/soybean (plus tobacco)	corn	barley/soybean	wheat/soybean
9	4.9	soybean	corn	barley/soybean	set aside	wheat/soybean	corn
10a	4.0	wheat/soybean (plus tobacco)	wheat	soybean	set aside	alfalfa	alfalfa
10b	4.0	alfalfa	alfalfa	alfalfa	alfalfa	alfalfa	no-till corn (plus tobacco)
11	7.3	soybean	corn	soybean	set aside	alfalfa	alfalfa
Total	97.2						

**Exhibit 4. Field sizes and cropping history for Farm B.**

Field no.	Area, ha	Year					
		1985	1986	1987	1988	1989	1990
13	15.8	wheat/soybean (plus tobacco)	corn (plus tobacco)	wheat/soybean	corn (plus tobacco)	barley/soybean	wheat/soybean
14	10.2	barley/soybean	soybean	corn	barley	wheat/soybean	corn
15	3.2	barley/soybean	soybean	corn	barley	wheat/soybean	corn
16	6.8	barley/soybean	soybean (plus tobacco)	corn	barley	wheat/soybean	corn
17	6.9	wheat/soybean	corn	corn	barley	corn (plus tobacco)	barley/soybean
18	9.7	barley/soybean	soybean	set aside	set aside	wheat/soybean	corn
19	4.1	set aside	soybean	barley/soybean	set aside	wheat/soybean	corn
20	7.2	wheat/soybean	soybean	set aside	fescue	set aside	set aside
21	6.1	corn	soybean	set aside	set aside	set aside	set aside
Total	70.0						

**Exhibit 5. Mean crop yields for each of the last 6 yr.**

Crop	Year					
	1985	1986	1987	1988	1989	1990
	Mg ha <sup>-1</sup>					
Barley	3.50	4.04	4.04	5.39	4.58	3.77
Wheat	3.03	4.04	4.04	6.06	4.11	3.37
Corn	8.80	7.86	7.86	2.83	9.31	2.64
Soybean						
full season	2.90	3.03	3.03	2.49	3.64	2.02
double crop	2.63	1.68	1.62	0.00†	2.29	1.21
Alfalfa	11.23	11.23	10.10	8.98	7.41	8.98
Tobacco						
burley	3.87	3.59	3.37	3.59	2.86	3.09
dark air-cured	2.75	2.92	2.81	2.92	2.47	2.81

† Due to the severe drought in 1988, double crop soybean did not survive, and were not harvested.

penses, such costs were reported as one total for each double crop system for each year.

2. *Management Strategies.* Stratton had participated in government programs, and had bases of 40.5, 40.5, and 48.6 ha for barley, wheat, and corn, respectively. That meant that he had established a history of raising that many hectares of each crop, and therefore qualified to set aside a portion of each (depending on current regulations) in the U.S. government's surplus reduction programs.

The price support program for burley tobacco production involved a complex partnership between growers, government, and industry, but did *not* involve

**Exhibit 6. Average market prices received for each of the last 6 yr.**

Crop	Year					
	1985	1986	1987	1988	1989	1990
	\$ Mg <sup>-1</sup>					
Barley	78	62	55	105	87	89
Wheat	106	90	89	143	125	113
Corn	98	61	64	118	94	100
Soybean‡	196	179	206	266	259	220
Alfalfa	134	125	127	227	77	145
Tobacco						
burley	3520	3500	3560	3590	3670	3850
dark air-cured	3210	3370	3410	4180	4400	4400

† Figures in U.S. dollars for each reporting year.

‡ Prices for full season and double crop soybean were considered to be equivalent.

**Exhibit 7. Crop production expenses for the last 6 yr.**

Crop	Year				
	1985	1986	1987	1988	1989
	\$ ha <sup>-1</sup>				
Barley/soybean	593†	568	541	551	588
Wheat/soybean	598	573	543	546	583
Corn	553	501	472	494	524
Soybean	432	390	366	368	385
Alfalfa	654	576	561	583	635
Burley tobacco	7620	6640	6560	6270	6450
Dark air-cured tobacco	6740	6420	6080	6200	6490

† Figures in U.S. dollars for each reporting year. Taken from annual reports of the Univ. of Kentucky Agricultural Economics Department (13-18).

spending tax dollars. Since 1988, burley tobacco sold had been assessed a "no-net-cost" fee (\$9.00 Mg<sup>-1</sup> in 1988; \$4.50 Mg<sup>-1</sup> in 1989 and 1990). This arrangement forced the tobacco industry to absorb its own price support expenses. Further, burley could not be marketed without documentation of the appropriate quota owned (or leased) by the grower. This arrangement regulated the supply of burley tobacco. In contrast, dark air-cured tobacco production was less controlled, with only fixed hectareage limits for each producer, rather than limits on weight sold. In addition, dark air-cured prices were allowed to fluctuate based on supply and demand.

In 1988, Stratton indicated that tobacco "carried his farm" economically in that drought year of sharply reduced grain production. In 1990, a localized drought also hurt grain production, and tobacco again came through as his key profit-producing crop. Stratton had recently won an award as the state's top young farmer raising dark tobacco. This award was based on profitability, and showed his management skill in producing this particular crop, as well as his dependence on tobacco in general as his most stable source of income. His farms had been allotted "bases" of 2.73 Mg of burley tobacco and 0.81 ha of dark air-cured tobacco. In addition, he leased 1.82 Mg of burley base and 1.21 ha of dark air-cured base from other farmers in Simpson County who had decided not to grow their own tobacco.

He planted 'Winsor' barley, which matured later than the more traditional 'Barsoy' barley. However, he felt that his southern Kentucky location made season-ending frost a minor risk for the following double crop soybean. Most of the barley hectareage was followed by double crop soybean for seed production of 'SS-443' or 'SS-561' (popular Southern States Cooperative Maturity Group [MG] IV and V cultivars). Seed production required more careful attention to planting, weed control, and harvest techniques, but Stratton received a \$14.67 Mg<sup>-1</sup> premium for this crop, and he felt that the extra expense was more than covered by the extra income. After wheat, he planted 'Pennyrile' (late MG IV) or 'Essex' (MG V) soybean. When planting soybean as a full season crop, he used 'Asgrow 4595' (MG IV) or 'SS 443'. He used no-tillage for establishment of double crop soybean to speed planting and conserve soil moisture (5).

Tillage before corn was usually fall moldboard plowing. After corn, fields were usually disked in preparation for seeding of winter barley. In the fall of 1988, he moldboard plowed corn fields to try to reduce problems with atrazine (2-chloro-4-ethylamino-6-isopropyl-amino-s-triazine) carryover due to extremely dry summer conditions.

Alfalfa was raised as a cash crop, with most of this crop marketed directly to cattle producers in Tennessee and Georgia. Stratton routinely treated his alfalfa fields in early to mid-April with an insecticide to control alfalfa weevil (*Hypera postica* Gyll.). He used this scheduled spray each year to avoid potential conflicts with corn planting in late April and tobacco setting (transplanting) in early May, even though information was available that indicated that a scheduled spray has serious drawbacks (21). Half of the required K fertility was applied prior

to the first alfalfa cutting, and the second half was applied after the second cutting.

Fields 20 and 21 were in a 5-yr set-aside program, and covered the amount of grain cropland Stratton was allowed to set aside each year. In 1992, these fields would be released from the 5-yr program. At that time, he was considering no-till planting them to alfalfa. Prior to that time, the crop had to be mowed twice per year, and could not be harvested for forage unless the federal government declared a drought disaster (as it did in 1988).

### Equipment Available

Available equipment included a John Deere (JD) 7100 "Soybean Special" planter (with skip-rows for applications of postemergence herbicides), JD "Max-Emerg" planter (used for corn only), a 4420 JD combine with both grain and corn heads, and five tractors: 5088 International Harvester (IH), 885 Case-IH, 2440 JD, and a Super A and 140 (both Farmalls). In addition, Stratton had all the necessary tillage, spraying, and hauling equipment needed to handle his crops.

### Erosion Control

Several fields showed evidence that erosion problems were developing. These fields showed more reddish color in the topsoil near the tops of ridges, which was particularly indicative of a long-term erosion problem. Further, Stratton was required to have a soil conservation program in operation on his farm by 1994, or he would no longer be allowed to participate in government set-aside and tobacco programs. The cropping system he had been using on C slopes (6-12%) did not meet the Farm Bill's requirements. He desired a system that would reduce his erosion losses without drastically changing his cropping system.

### Tobacco Production

At the time of this case, Kentucky was the second leading U.S. state for total tobacco production, and was the leader for burley tobacco production (8). Tobacco had long been the leading Kentucky crop for gross value of production, reaching \$981 million in 1984 (7). By 1987, the crop's value had plummeted to \$476 million (8). In 1988 and 1989, some recovery in tobacco pricing had occurred, mainly due to increased tobacco export to the Far East. However, some Far Eastern countries were becoming more concerned about the health of their citizens. For example, the government of Taiwan no longer permitted cigarette advertising. Thus, many in Kentucky were concerned about the future of tobacco production. The decline in tobacco income was not merely an economic issue, but also a moral one. For more than 25 yr, the medical community had been publishing studies on the health consequences of smoking tobacco. Heart disease and lung cancer, directly attributed to smoking, resulted in more deaths than all other tobacco-related ailments (22). A more troubling problem was the evidence that health of

nonsmokers suffered following long-term exposure to someone else's tobacco smoke (11, 12, 19). Finally, smokeless tobacco was also found to be harmful, having been identified as the cause of nasal, esophageal, laryngeal, stomach, and urinary tract cancers (20).

### **Canola Adoption**

Canola, originally developed in Canada, had recently been promoted in Kentucky as an alternative to winter wheat. 'New "double-low" canola cultivars, which were low both in erucic acid and glucosinolates, were being tested for use in Kentucky. A key consumer advantage of this crop was the low saturated fat content of its oil product.

## **TEACHING NOTE**

### **Case Objectives**

This decision case study was designed to promote the application of crop production principles to the problems of erosion control, the difficult issue of whether or not to continue to raise tobacco, and the question of adopting a new crop, canola. In addition, the case was intended to improve skills in group problem solving, as well as written and oral communication. Erosion control is an increasing concern due to recent changes in federal regulations. Tobacco has served as the economic mainstay of Kentucky agriculture for many years, yet some people in our society are questioning the morality of producing a crop that can destroy the health of its consumers. Canola has received nationwide attention due to the quality of its oil, and has been given some statewide attention as a potential replacement for wheat or barley in our double crop systems.

### **Use of the Case**

This case study was used to provide a "capstone" experience for the course, and follows previous group exercises, including a non-Kentucky case study chosen from among a set available from Steve Simmons at the University of Minnesota. Because we have chosen to keep groups intact over the course of the semester, we have been able to observe that many of these groups "gel" as they improve their collective problem solving and time management skills.

The report format we used included both written and oral portions. The written paper was to include general recommendations on how Stratton should change his cropping system with respect to erosion control, tobacco production, and canola adoption; as well as a description of how adoption of all of the group's recommendations would influence erosion control, financial stability, and both short- and long-term profitability of his farm. A 1-page executive summary was required, and was expected to give an overview of each group's recommendations and rationale. The oral presentation followed completion of the written report. Students were instructed to assume that Stratton had already read their

written recommendations, and that he would be the primary audience for their oral report. Groups were allowed 25 to 30 min for their oral presentations, and were given the freedom to use any format they desired, with the following constraints: they had to begin with a brief statement of each of the three problem areas, visual displays of their general recommendations had to be included, and time for questions had to be reserved.

### **Student Evaluations**

This case has been quite popular with our students, the majority of whom are Kentucky natives. They have been particularly happy with the practical application of the principles they have been learning in the lecture portion of the course (2).

### **Author's Analysis and Interpretations**

Stratton's elimination of strip cropping on Fields 4a and 4b on Farm A, as well as his use of fall moldboard plowing prior to corn planting, revealed his lack of concern about erosion. The slides (see below) taken of several of his fields indicated that some serious problems were developing. It is possible that Stratton's improving production practices served to mask reduced yield potential of some of his fields. In other words, yields may have been higher if the erosion had been prevented (10). Stratton was a strong proponent of diversification. Therefore, while planting the entire farm to alfalfa would have reduced erosion by keeping all soil surfaces continuously covered with vegetative material, Stratton was unwilling to become that dependent on a single crop. We expected students to evaluate the potential use of canola on Stratton's farm. This could have fit quite well into his diversified cropping system. Their analysis was expected to include factors he would have to be ready to handle (e.g., disease, insects, weeds, markets), and include a plan for how he could incorporate this crop into his management scheme. The University of Kentucky publication on canola by Herbek and Murdock (6) would be helpful on this issue.

Familiarity with Kentucky agriculture has not produced uniformly critical analysis, particularly on the question of raising tobacco. In the four semesters we have used this case study (three to six groups per semester), not one group has recommended that tobacco production be discontinued. In fact, many groups of students have submitted reports encouraging Stratton to *expand* his tobacco production (allotments were increased in 1991). The only group that had some doubts about the morality of producing tobacco pitted three Kentucky students favoring production against two out-of-state students who questioned Stratton's growing the crop. The teams that were most successful considered each of the questions on a cropping system level, whereas less successful groups delivered their recommendations on a field-by-field basis. That approach was repetitious, and resulted in a superficial assessment of Stratton's cropping system.

A set of 184 slides, complete with narrative text, is available at cost (approx. \$100). Additional references

may be made available to students in the library or reference section. Possible references of interest to this case include 1, 3, 4, 5, 6, 9, 10, 13, 14, 15, 16, 17, 18, and 21.

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# The Worth of a Sparrow: A Decision Case in University Research and Public Relations

R. Kent Crookston,\* Melvin J. Stanford, and Steve R. Simmons

## ABSTRACT

For many years, birds had damaged the cereal research plots of the College of Agriculture at the University of Minnesota. In 1990, the College's practice of trapping and killing birds near the plots was challenged publicly by the Animal Rights Coalition (ARC), who demanded that trapping of birds be stopped. As the 1991 growing season approached, Phil Larsen, chair of the Bird Control Committee for the College of Agriculture, had to decide whether to again utilize trapping for bird control or to stop trapping and try other methods. The case focuses on a controversy generated when expensive university research, considered by scientists to be valuable to humans, is threatened by birds that others in society wish to protect. A primary objective of the case is to provide students with an opportunity to wrestle with a troublesome issue facing university researchers: the rights of interest groups who contest methodologies or agenda of public sector researchers. Another objective is to enable students to recognize a potential for synergy in resolving conflicts between groups with different viewpoints. The cereal research plots on the St. Paul campus of the University of Minnesota were located in an urban setting adjacent to the greenhouses and offices of cereal research faculty who had developed many new varieties with improved yield and other qualities. To reduce bird damage in small grain plots, the university had trapped and killed birds for many years. When the ARC demanded that the university stop bird trapping and killing, the situation became a public controversy. This case provides a focus for consideration of research methods, interest group agenda, and the role of the university in representing the public and performing its responsibilities.

## THE CASE (ABRIDGED)<sup>1</sup>

As Phil Larsen drove past the University of Minnesota-St. Paul campus research fields on 6 June 1991, his eyes looked over the expanse of green winter wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.), and oat (*Avena sativa* L.) research plots. "A regular smorgasbord," he thought, "just like Dean Wharton says, 'one big bird feeder.'"

"How'd I get into this mess anyway?" he asked aloud. Larsen was department head of plant pathology at the University of Minnesota's agriculture campus in St. Paul. He had just left a meeting of the Bird Control Committee; he was the committee chair.

Larsen's "mess" had started about a year earlier, on 1 Aug. 1990. On that day he had been heading home for supper via that same route when he noticed a remote telecasting van for a local television station parked near the plots by one of the bird-cage traps. A small crowd

of onlookers had gathered. "I was aware of the ARC's concerns about the trapping of birds on campus and realized immediately what was going on," he said. With mixed feelings of responsibility and curiosity, he drove over to the site. His anxiety increased when he discovered that the crew was telecasting *live* the lead story for KSTP's Six O'Clock Evening News, one of the Twin Cities' major news programs.

Larsen knew that live-trapping of birds represented a potential public relations problem for the university, but he never guessed it would come to this. During the late 1980s, the university had been the focus of a barrage of negative publicity. The media coverage of one 1987 story about alleged misuse of state funds had resulted in the resignation of the university president.

The University of Minnesota's research fields were annually plagued by birds that flew in from surrounding urban neighborhoods to feed on the ripening grain. A variety of control measures (including scarecrows, noise guns, ribbons, a falconer, and scare balloons) had been tried, but traps placed near the most vulnerable plots had been the longest-standing method. Larsen found records indicating that the traps had been used continuously since 1955 (Exhibit 1). In two of the years during that period, more than 10 000 birds were trapped, but the average was closer to half that number. Desirable birds, such as doves (*Zenaidura macroura*) and song birds, were set free; those deemed undesirable, such as house sparrows (*Passer domesticus*), starlings (*Sturnus vulgaris*), and grackles (*Quiscalus quiscula*), were stuffed into a bag and suffocated. Over the past decade, the suffocated birds had been utilized as food for injured birds of prey recovering at the university's Raptor Center.

Over the years, a few members of the university community had questioned the use of bird traps, but the television feature story was the most serious challenge to date. There were faculty within Larsen's own department who questioned the adequacy of bird control measures and suggested that greater protection of the grain was needed. Cereal plant breeders plus the faculty and staff who worked in the fields recommended that the traps and other control methods be maintained. "The traps are highly effective," said Dann Adair, the field plot supervisor responsible for managing them. Some researchers had suggested that the research might be moved off campus "to avoid the social and pest problems currently being experienced." However, moving the research was felt to be the "last resort" by most of the university cereal researchers, who considered the availability of extensive

Department of Agronomy and Plant Genetics, 1991 Buford Circle, 411 Borlaug Hall, Univ. of Minnesota, St. Paul, MN 55108-6026. Received 15 July 1992. \*Corresponding author.

<sup>1</sup>This is an abridgement of the complete case. The complete case consists of 9 pages of text, 20 pages of exhibits, including a video segment, and a 9-page interpretive note. For a copy of the complete case, contact the corresponding author.

**Exhibit 1. Bird trapping at the University of Minnesota Agricultural Experiment Station.**

Year	Sparrows	Blackbirds†	Starlings	Total
1955	7 551	296	1 348	9 195
1956	7 128	255	1 459	8 842
1957	6 129	1 701	1 796	9 626
1958	8 662	558	1 180	10 400
1959	4 128	500	619	5 247
1960	6 305	744	1 086	8 135
1961	6 135	508	739	7 382
1962	6 172	1 580	1 601	9 353
1963	6 811	357	314	7 482
1964	7 521	239	840	8 500
1965	3 698	2 060	1 100	6 868
1966	3 960	494	9	4 463
1967	6 959	2 104	575	9 638
1968	4 553	1 639	407	6 599
1969	2 086	1 358	341	3 785
1970	--‡	--	--	--
1971	2 317	1 590	400	4 307
1972	3 647	1 343	124	5 114
1973	2 105	1 190	112	3 407
1974	--	--	--	--
1975	--	--	--	--
1976	2 829	1 018	905	4 752
1977	4 907	2 067	887	9 846
1978	--	--	--	--
1979	3 752	561	576	4 989
1980	3 843	1 541	1 104	6 488
1981	4 701	1 041	272	6 014
1982	522	208	43	773
1983	346	171	218	735
1984	--	--	--	--
1985	1 824	912	912	3 648
1986	3 121	1 966	1 235	6 322
1987	1 038	363	804	2 205
1988	2 731	1 758	1 698	6 187
1989	3 977	2 943	3 460	10 380
1990	3 396	395	2 160	5 951

† Blackbird totals include grackles and cowbirds.

‡ Missing data.

plot areas adjacent to their offices and laboratories to be of "inestimable value." Yet, because of their convenient in-city location, the on-campus plots were annually raided by thousands of birds that nested in the trees of surrounding suburban yards.

Both the evening telecast and the next morning's newspaper featured bird killing at the university. On August 2, the morning after the telecast, Dan Oldre, vice president of the ARC in Minnesota hand delivered a letter to the dean of the College of Agriculture (Exhibit 2). Oldre insisted that the university "immediately stop the killing of these birds."

Both the *Minneapolis Star Tribune* and the *Saint Paul Pioneer Press* newspapers ran articles about the confrontation between the university and ARC. Larsen was quoted in the 4 August *Minneapolis Star Tribune* as saying, "We certainly do not enjoy killing birds, but I think it needs to be said that these plants are extremely valuable and will be useful in the development of high-yielding plants that will feed people worldwide." The ARC response was, "We're not saying their experiments are not valuable, and we're not saying the birds are not a threat, but the method they are using to control the birds is cruel and extreme. . . . We want them to dismantle the cages and get them out of there and never try that again."

Dean Wharton consulted with Larsen and Adair and, on 6 August, responded to the Oldre letter. He promised

to pursue alternative methods of controlling the birds, and offered to meet with ARC members for a discussion.

A meeting between university and ARC representatives was held on Friday, 10 August. On Monday, 13 August, *The Minnesota Daily*, the university's student newspaper, ran an article that reported the university and ARC had agreed on the use of bird traps for the rest of the season, but that ARC would insist on more humane methods next year. Dean Wharton was careful to point out that although the university would explore additional and alternative methods for controlling the birds, it had not agreed to stop trapping.

As publicity about the trapping of birds increased, Larsen began receiving some supportive responses from local citizens. One St. Paul woman sent a small cash donation to help support the bird control program. A campus employee sent Larsen an article about an organization called *Putting People First*, a group of citizens who objected to being intimidated by animal rights activists.

It was in this climate of diverse viewpoints that Larsen pondered his course of action between the 1990 and 1991 growing seasons. "It seems to me that this grain is important enough to justify the sacrifice of these birds," he said to colleagues. "There are world hunger and economic implications. We have to consider our right to prioritize research of value to humans over creature life." On 7 Sept. 1990, Larsen met with several interested university faculty and field staff to consider the issues. Minutes from the meeting included the following statements: "The effectiveness of our current bird control program was discussed and it was agreed that the current program was effective and needs to be continued. . . . Larsen appointed a committee, for which he will serve as chair, to develop and establish an integrated plan for bird control on the St. Paul plots. . . ." The first Bird Control Committee meeting was held on 6 Nov. 1990. Following a discussion of the merits and shortcomings of current approaches, committee members were assigned to check out other control options. In subsequent meetings it was agreed that Larsen and Adair would prepare a 1-page document providing an overview of the college's bird control program to be posted on the bird traps and anywhere else that might be appropriate for the purposes of communicating the issues. Larsen observed that "[we] know that this is a potentially very delicate issue, and that [our methods] will be under intense scrutiny." This led to a suggestion of abandoning trapping, but "capitulation" was felt to be out of the question by most of the committee.

On 29 May 1991, the committee met again to make specific decisions for implementing a bird control program for the coming year. It was decided to employ traps as early as 15 June to protect the winter wheat that would be forming grain. Various assignments were made, including an evaluation of alternative methods to repel birds, including sprayed grape juice concentrates, sprayed hot pepper sauce, balloons, ribbons, loud speakers with distress calls, etc. The plan was to vary the approach through the season to prevent birds from becoming accustomed to any one control tactic. A 6 June meeting was planned for all faculty and technicians from participat-



August 2, 1990

Dr. Keith Wharton  
Dean, College of Agriculture  
University of Minnesota  
277 Coffey Hall  
1420 Eckles Avenue  
St. Paul, MN 55108

Dear Dr. Wharton:

The Animal Rights Coalition was alerted by a concerned person two weeks ago that the University is trapping and killing large numbers of birds in the experimental crop fields on the Saint Paul campus. In our own surveillance and investigation we have learned that:

- Birds are lured to the traps by bait placed in them, and the number of birds in these large traps has been observed to be at least 50 at times.
- The reported method of killing the birds was suffocation, by placing them, 400-500 at a time, in a bag.
- Approximately 500 birds are killed every day at the St. Paul campus; 10,000 were killed in a three month period.

We object to this for the following reasons:

- It is a waste of animal life.
- It is ineffective. Trapping and killing birds will not permanently reduce the bird population in the area. Even temporarily it will have no more than a minimal effect.
- The trapping and suffocation of these birds is cruel in the extreme.

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page 2  
Dr. Keith Wharton

For these reasons, we insist that the University immediately stop the killing of these birds.

If you wish to discuss this matter, please contact me at 222-5537 or 870-5868.

Dan Oldre  
Vice President  
Animal Rights Coalition

cc:  
Dr. Phil Larson, Head  
Plant Pathology Dept.  
University of Minnesota  
495 Borlaug Hall  
1991 Upper Buford Circle  
St. Paul, MN 55108

President Nils Hasselmo  
University of Minnesota  
202 Morrill Hall  
100 Church Street SE  
Minneapolis, MN 55455

Kent Crookston, Head  
Agronomy and Plant Genetics  
University of Minnesota  
411 Borlaug Hall  
1991 Upper Buford Circle  
St. Paul, MN 55108

C. Eugene Allen, Director  
Agriculture Experiment Station  
University of Minnesota  
220 Coffey Hall  
1420 Eckles Avenue  
St. Paul, MN 55108

KSTP-TV  
WCCO-TV  
KMSP-TV  
KARE-TV  
WCCO-Radio  
Minnesota Public Radio  
KFAI-Radio  
Associated Press  
*Minnesota Daily*  
*Saint Paul Pioneer Press*  
*Star Tribune*  
*Twin Cities Register*

Exhibit 2. Text of letter received by Dr. Keith Wharton from the Animal Rights Coalition on 12 Aug. 1990.

ing projects to inform them about, and to solicit their participation in, the control program. There was a small crowd at the 6 June meeting. Larry Hood, assistant director of the Law Enforcement Division of the U.S. Fish and Wildlife Service, also attended. Larsen distributed a handout containing information about the bird damage management program for the 1991 season. It noted that birds would be trapped if necessary. After a few questions and some discussion, Hood pointed out the dangers of trapping protected species of birds. "The 'humaneiacs' will nail you if they find one dead robin (*Turdus migratorius*), bluebird (*Sialia sialis*), or dove in your traps. And you will be extremely vulnerable. You will have violated the migratory bird laws. Those laws have been here since 1918." He spoke of penalties of \$20 000 or maybe \$100 000 and mentioned complaints that the U.S. Fish and Wildlife Service was not enforcing the law.

"So why don't we stop trapping?" asked the college's public relations officer.

Adair's response came quickly, "It's clearly valuable to trap."

"How do we know that?" asked another professor. "Does trapping really help, or is it a matter of revenge? Isn't it possible the baited traps actually attract birds? Do we have any data on the effect of traps and actual damage to the grain?"

"Tell us how to conduct the study and we'll do it," responded Adair.

Larsen was as perplexed as any in the group by what he was hearing. He looked at his watch; it was time to leave for an off-campus meeting. He asked Adair to field remaining questions and excused himself.

And so it was that on the morning of 6 June 1991, Larsen was again driving past the cereal plots asking, "How'd I get into this mess anyway?" A colleague riding in the car and who had also been in attendance at the 6 June meeting listened as Larsen talked.

"We wouldn't be into this if it wasn't for the ARC,"

he said. "But I've got to give them credit. We're all a lot more conscious and sensitive about the way we view the life of a creature. We've done a lot of things to get our act together, things we would never have tried on our own. But, I'd like to get us to a place where we say enough is enough. We need to be ethically responsible, but we can't go overboard. They have taken the issue and exploited the media to influence public opinion in their favor. Will we really serve the public if we give in to them?"

"And there's another thing about all this," Larsen continued. "I'm concerned about vandalism. I've never feared for my life, but I've definitely been concerned about vandalism of the plots."

Larsen looked at his colleague. "What's the *right* thing to do?" he asked.

### CASE EXHIBITS<sup>2</sup>

1. A video recording of the lead story for KSTP's Six O'Clock News, 1 Aug. 1990. *Available separately.*
2. Bird trapping data, 1955-1990, University of Minnesota. *Included with this abridged case as Exhibit 1.*
3. 21 July 1981 letter to James Tammen, dean of the College of Agriculture, from Richard McGehee, professor of mathematics, University of Minnesota, urging abandonment of bird trapping.
4. 24 July 1981 reply to Richard McGehee from James Tammen.
5. 29 July 1987 letter to Phil Larsen from Roy Wilcoxson, both in the Department of Plant Pathology, University of Minnesota, complaining of bird damage.
6. 2 Aug. 1990 letter to Keith Wharton, dean of the College of Agriculture, from Dan Oldre, vice president of the Animal Rights Coalition of Minnesota, demanding an end to bird trapping. *Included in this abridged case as Exhibit 2.*
7. 6 Aug. 1990 reply to Dan Oldre from Keith Wharton.
8. 13 Aug. 1990 article from *The Minnesota Daily*, student newspaper of the University of Minnesota.
9. 13 Aug. 1990 letter to Keith Wharton from Mary Britton Clouse, member of the ARC, summarizing a meeting and implying that the University of Minnesota had agreed to stop trapping in 1991.
10. 20 Aug. 1990 letter to Keith Wharton from Phil Larsen, indicating that no agreement was made to stop trapping.
11. 22 Aug. 1990 letter to Mary Britton Clouse from Keith Wharton, clarifying the university's position.
12. A petition to the Congress of the United States, distributed by *Putting People First*, Washington, DC.
13. Description of the university's bird damage management program. Handed out at the 6 June 1991 meeting of the University of Minnesota Bird Control Committee.

<sup>2</sup>This list shows all exhibits included in the complete case. In this abridged case, only Exhibits 2 and 6 are provided in their entirety.

## INTERPRETIVE NOTE

### Case Objectives

A primary objective of this case is to engage students in one of the most troublesome issues facing university researchers, i.e., the rights of interest groups who disagree with methodologies and agenda of public sector researchers. Another objective is to enable students to recognize potential for synergy in resolving conflicts between groups with different viewpoints.

Other issues to discuss are the effectiveness of the university's bird trapping program and whether it should be continued, terminated, or modified; to consider whether and how to research the complex phenomenon of bird damage; and to consider whether the university continue on-campus cereal research or transfer the program to a rural location.

### Use of the Case

This case can be used by agricultural students, professionals in agriculture, and public interest groups. The case has been used with good results in senior-level crop management classes and in agricultural case development seminars. Users can have varied backgrounds, but some interest in university research policy is valuable.

Particular effort should be made to focus divergent opinions that are likely to arise over sensitive issues within the case. Divergence represents potential synergy. The focus should be on a good decision for Larsen, not on a debate over the merits of divergent opinions. The instructor should help students to determine how Larsen might exploit the diversity of values and perspectives to create a synergistic resolution, which is better than a compromise.

### Issues in the Case: Questions for Discussion

The authors believe the following questions will direct case users to key issues in the case.

1. Consider Larsen's question about the "right" thing to do. What did Larsen mean by "right?"
2. Was killing birds justified by the value of the grain research?
3. What were Larsen's objectives?
4. What were Larsen's options?
5. What should Larsen do?

The authors' insights into these issues, and possible responses to each question, are provided in the full interpretive note.

By way of summary, it should be recognized that the only evidence that trapping was effective in protecting the cereal grain plots from the birds was:

1. Records of the number of birds trapped.
2. The belief by Adair, the field plot supervisor, that the traps were "highly effective."

There is no indication of research on how effective the traps were or of other methods of protecting the grain. Thus, Larsen will need to decide to what extent to research these questions in relation to ARC demands, the desire of the researchers to protect the grain, and the

timeframe. A “right” decision for Larsen would seem to be a wise or prudent decision. It is not suggested that there is a right or wrong answer. Instead, a discussion

should cover a range of options that could preferably resolve the confrontation with a synergistic win-win outcome, if possible. ■

# Assessing Extension Program Impact: Case Study of a Water Quality Program

J. W. Bauder\*

## ABSTRACT

Water quality is a focus of research, public education, and curriculum development throughout the USA. Within the U.S. Department of Agriculture Extension Service (USDA-ES), this focus has been driven by a national initiative emphasizing water quality education, motivation to change, and impact assessment. In 1989 and 1990, Montana State University conducted a voluntary, private well water test program to direct public attention to water quality education. Nearly 3400 well owners participated during four testing periods. The multifaceted educational outreach program included instructional videos, written instructions, sample collection and submission, and a year-after impact assessment questionnaire. The impact assessment return rate was 44%. Nearly 65% of the respondents indicated they understood the test results. Twelve percent of the respondents purchased point-of-use treatment equipment, and 8% made changes in land use practices to improve well water quality. The average value placed on the information about water quality, well improvement, and water quality protection by well owners was \$108, which was nearly nine times more than the cost of participation. Eighty-four percent of the respondents rated the activity as moderately to very effective at increasing public awareness of water quality issues; 74% rated the activity as moderately to very effective at increasing individual well user awareness of responsibilities and knowledge about water quality. Seventy percent reported improved ability to make decisions about water quality. More than 80% of well owners preferred obtaining information from printed text, county agent contact, or video materials. Contact with county agents or use of printed text depended on education level of the well owner, geographic location within the state, and whether well owners considered themselves nonfarm or farm residents. Knowledge gained was a function of a perceived need for, or benefit gained from, the information, immediate applicability of the information to the recipient, and method used to transfer information to the well owner. Thus, impact of future extension programs of this nature may be improved by targeting specific educational resources to selected audiences and providing education from which participants can derive immediate benefit. From the program impact assessment it was also concluded that extension educational programs should be structured to the educational level of participants and should provide information that has immediate utility to program participants.

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EDUCATORS are constantly looking for educational resources, teaching tools, and new methods of information delivery. However, active student interaction and participation is usually necessary for learning by audiences of diverse background. Extension audiences seldom consist of well-defined groups that are focused on in-depth education. They have been described as casual learners. Consequently, traditional extension programming involves educational meetings and mass media to inform the public.

Extension faculty have been encouraged to develop and assess the impact of programs dealing with emerging social, environmental, and economic perspectives. One such issue is water quality. Simultaneously, extension faculty and others involved in education at a distance or technology transfer are faced with several challenges as an increasing number of vendors compete for the traditional extension audience. These challenges include: identifying appropriate issues and specific target audiences; developing appropriate instructional and educational delivery methods; incorporating effective technology transfer mechanisms into teaching opportunities; and assessing educational program impact through modification of learner behavior.

Shih and Evans (1992) reported how and where extension field staff get their information. Since extension field staff must cover diverse subjects, relevant information is often widely scattered and ephemeral in nature. These same conditions likely apply to individuals in the agricultural audiences. Information sought by the general public is seldom in a form readily available or specific to the audience needs or focus.

Shih and Evans (1992) also report that individuals seeking information use a mix of written and oral information from familiar sources. Written information is often supplemented by personal contacts that allow discussion, clarification, and interaction. Educators and the general public prefer brief, summarized, easy-to-read, easy-to-file single-issue fact sheets, research summaries, and pamphlets. Scholarly journals, research reports, and libraries are of less value. Zipf (1949) and Kremer (1980) report that people use the source of information that requires the least effort to obtain and interpret. The most

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**Abbreviations:** USDA-ES, U.S. Department of Agriculture Extension Service; MSU, Montana State University; DHES, Department of Health and Environmental Sciences; FFA, Future Farmers of America; TDS, total dissolved solids.

significant constraint to information gathering is the inability of learners to organize information by themselves.

Extension county agents use an average of two sources of information to answer questions from clientele (Zipf, 1949; and Kremer, 1980). When a single source is used, 46% of the time the source is a publication, while 43% of the time the second source of information is an oral contact. Extension publications account for more than 40% of all written material used, while 70% of the oral contacts are with extension specialists.

Twidwell and Thiex (1991) used a contest to educate a targeted audience of forage (alfalfa, *Medicago sativa* L.) producers in South Dakota. Prizes were awarded for quality forage. Recognition and prizes provided incentive for contest participation. They reported that for an outreach program to be effective, the audience must have a need, objective, or perceived benefit of participation. The format used in the South Dakota contest was to create a forage quality contest, announce the rules, conduct educational programs on production methods, display contest entries, and select winners. All information delivery was informal.

Twidwell and Thiex (1991) used a follow-up questionnaire to assess the program value and impact on participants. Sixty percent of the respondents said the program value was primarily educational, 30% said the biggest value was recognition of winners, and 10% said the greatest benefit was winning the prize.

Use of private well water quality test program has been reported previously, but not for general education. Baker (1990) used a well testing program to assess groundwater quality on a large geographic scale in Ohio. He reported that one benefit of private well test programs was that they helped identify groundwater quality issues; they also provided direct involvement of organizations and individuals with a factual basis to understand their own situation while supporting local educational programs.

The objectives of the study reported herein were to assess the impact of an extension-sponsored private well water test program on participant behavior and learning characteristics, and to gather information about preferred learning methods of a diverse, targeted extension audience.

## METHODS AND MATERIALS

An extension-sponsored private well water test program was initiated in January 1989 in cooperation with Montana State University (MSU), the Montana Department of Health and Environmental Sciences (DHES), and several agricultural organizations. The program was prompted by the 1988 "Well Aware" program conducted by the Future Farmers of America (FFA) with *Successful Farming* magazine (Freese, 1988), and structured similar to that of Baker (1990).

The purpose of the program was to use an inexpensive, nonthreatening well testing service to provide educational resources to rural and urban private well water users in Montana. Another goal was to educate private well water users about groundwater quality issues

specific to agricultural areas of Montana. The emphasis of this article is on the educational program and program impact assessment.

## Program Format

Specific details of well water sampling, geographic distribution of 3342 private wells sampled and tested, testing procedures, and summaries of well test results have been reported previously (Bauder et al., 1991). Samples, submitted on a voluntary basis from 53 of the 56 counties in Montana, were tested for coliform bacteria, pH, and total dissolved solids (TDS) concentration,  $\text{Na}^+$  concentration, and  $\text{NO}_3^-$ -N concentration. The program was not designed or intended to obtain a random sample of private wells throughout Montana. The testing service was offered to private well water users through county extension offices, conservation districts, and Farm Bureau offices. The service was part of a multiphase, multimedia distant delivery program consisting of the following eight steps.

**Step 1.** Two educational video tapes were developed, one dealing with general water quality issues (Johnson, 1989) and the other providing specific details of sampling and sample submission procedures (Bauder, 1990). The video tape containing general water quality information was broadcast statewide on public television in advance of the first testing period. In addition, a copy of each video tape was provided to each county extension office.

**Step 2.** Sampling and testing periods were selected for the spring and fall of 1989 and 1990. Participating county offices were informed of the sample submission periods. A news release containing details of sampling periods, sample handling, and participation was provided to each county office to modify for publicity. Sampling and testing periods were selected to coordinate work loads between testing labs and provide a large number of samples from two periods of the year.

**Step 3.** A 12-part fact sheet series dealing with specific issues of water quality was developed and distributed to each county extension office. In addition, one fact sheet in the series was printed in a statewide agricultural magazine each month for a 12-mo period during the first year of the program. Previous surveys of farm and ranch audiences revealed that farm journals represent a significant source of information for rural farm families in Montana (Saltiel, 1990).

**Step 4.** Sample testing and reporting of results were completed by two different agencies: the DHES conducted all coliform tests and reported results directly to participants; all other analyses were completed by an analytical laboratory at MSU. Results of the latter tests were reported directly to participants by the extension service. Tests were completed and reported to participants within 3 wk of sample submission.

A statement of significance of test results, interpretation, and recommendations for action was mailed with test results to each participant along with three of the fact sheets from the series. These fact sheets addressed  $\text{NO}_3^-$ -N and bacterial contamination, health guidelines, and

**Table 1. Number of program participants and number of respondents to impact assessment questionnaire, by testing period.**

Variable	Program period			
	June 1989	Nov. 1989	May 1990	Dec. 1990
Number of wells tested	556	693	1426	667
Number of surveys returned	267	359	587	251
Percent return of survey	48%	52%	41%	38%

point-of-use water treatment. Recommendations were specific to treatment for  $\text{NO}_3^-$ -N levels in excess of the USEPA standard of  $10 \text{ mg L}^{-1}$ , well and water disinfection for bacterial contamination, water conditioning, and water softening. Participants were encouraged to contact the county extension agent or specialist, or county sanitarian, if they had questions about the test results.

**Step 5.** Summaries of test participation and results were prepared for each county for each sampling period and for total participation in all four testing periods. Summaries were provided to each county, along with a generalized news release, which county extension agents could modify to suit the conditions of their counties. In addition, a statewide summary of results for each testing period and for the entire program period was prepared and published in a statewide agricultural magazine.

**Step 6.** Two areas of regionalized contamination of groundwater by  $\text{NO}_3^-$ -N were detected by the well test program (Bauder et al., 1991). Nearly 40% of all well water samples were contaminated with coliform bacteria. To provide additional education and information to well water users in the regions of high  $\text{NO}_3^-$ -N concentration, a seminar series was developed and presented in counties where high  $\text{NO}_3^-$ -N concentrations were detected. The seminar series, addressing health issues, water quality policy,  $\text{NO}_3^-$ -N contamination, well disinfection, and point-of-use treatment, was advertised in local media and presented approximately 3 mo after the final testing period.

**Step 7.** Approximately 1 yr after the test results and recommendations had been mailed, an 8-page questionnaire was mailed to each participant to assess program impact. Return postage was prepaid, and participants were informed that they would receive a complete summary of the program test results when they returned the questionnaire. The questionnaire consisted of six sections: (i) participant background, (ii) test results, (iii) participant opinions, (iv) recharge area land use characteristics, (v) program value and impact, and (vi) participant demographics. Copies of the questionnaire are available on request.

**Step 8.** Questionnaire responses of each test period were summarized and mailed to each participant. Results from each test period questionnaire were compared by one-way analysis of variance of sample means. On the basis of lack of significant differences in responses among the four response periods, the data were composited into a single dataset. All questionnaire responses were included in a final report, which was provided to all county extension agents. Participant responses to selected questions were analyzed using a standard *t*-test to determine significance of differences.

**Table 2. Reasons for well owner participation in the Montana private well water test program ( $N = 1408$ ).<sup>†</sup>**

Reason for participation	Respondents who said the reason affected their participation	Respondents who said this was the most important reason for participating	Rank
	%		
Curiosity about quality of water	79.6a*	28.0b	2
Concern for personal or family health	72.6b	49.8a	1
Cost and availability of program	55.6c	8.7c	3
Encouragement from concerned party	22.1d	3.8d	4
Questions about agrichemicals in water	20.7d	2.1d	6
Questions about nonagricultural chemicals in water	18.6d	2.5d	5
Advice or alarm of someone else	3.8e	1.6d	7

\* Numbers in the same column followed by different letters are significantly different at the 0.05 probability level, according to Duncan's multiple range test.

<sup>†</sup>  $N$  = number of well owners responding to question.

The well test program was an opportunity to gather an extensive database about private well water quality during a short time period. The resultant data consisted of  $\text{NO}_3^-$ -N distribution, number of wells contaminated, coliform contamination, correlations between parameters tested, participant demographics, behavioral attitudes, and action taken.

## RESULTS AND DISCUSSION

The following summarizes well owner interest in testing, perceived value of the well test program, views on sources of contamination, and water quality action taken. Results are reported for the entire sample and also separated for farm vs. nonfarm, geographic location, and level of education, where appropriate. Return rate for the follow-up impact assessment questionnaire averaged 44% (Table 1). However, when considering the response rate, it is necessary to recognize that respondents are more likely to report positive results than negative impacts. In addition, the higher percentage of responses from initial test periods suggests that the best, most interested, most responsive well owners were first to participate. Consequently, the responses to the impact assessment are likely to be somewhat biased.

### Program Participation

Fewer than 20% of the respondents indicated that they occasionally (once every 5 yr or less) tested their water supply. Twenty-five percent of the respondents indicated that they tested only when there was an apparent need, whereas nearly 60% of the respondents said they had no record of previous testing. Well owners who previously had tested their water most commonly cited three reasons: advice of others, extension publication and newspaper articles, and water treatment salespersons. Nearly 10% of the previous testing was prompted by a water treatment salesperson.



**Table 3. Conclusions about quality of well water samples and the need for action to ensure the quality of future well water supplies (N = 1395).**

Conclusions from program participants	% of respondents
Water was okay to drink	69.1
Water quality was questionable	20.9
Water may be harmful to personal health	11.1
Need to resample and retest	6.7
Water was unfit to drink	6.7
Need to secure new source of water	2.9
Initiate regular/periodic sampling and testing	24.5

Participation in voluntary programs of this type may be caused by a variety of factors, mostly specific to the participant. Table 2 ranks the reasons for participation in the program and gives the percent of participants who indicated each reason contributed to their decision to participate in this program. The high level of participation in the program may have been associated with the limited effort required by well owners to participate.

Nearly 50% of respondents indicated the most important reason for participation in the program was concern for personal or family health; 28% said curiosity about the quality of their water was the main factor causing them to submit a sample for testing.

#### Program Value and Participant Learning

Several different approaches can be taken to assess the degree to which participants of outreach programs learn. One approach is to ask participants specific questions about a subject, i.e., content questions. Another way is to ask participants questions regarding their perceptions of specific subjects. Participants were asked what conclusions they reached about the quality of their water, based on well test program results. Table 3 summarizes participant responses.

Nearly 70% of the participants concluded the water they had tested was safe to drink. About 30% of the participants questioned the quality of the water. One of every four well owners concluded they should initiate a regular sampling and testing program. This contrasts with the fact that only 15% of the participants indicated they occasionally tested their water prior to participation in the well test program. As many as 25% of the participants expected to increase the frequency of testing as a result of the well test program. An additional 2.9% concluded that they should secure a different source of water.

Seventy-five percent of the respondents said the results were what they expected. Only 12.6% of the respondents said they were alarmed or surprised by the well test results. Approximately 3.5% of the respondents said they

**Table 4. Comparison of test results reported by well owners in impact assessment with well water test data obtained from testing program.**

Test results	Survey respondents indicating "yes"	Test results indicating "yes"
	%	%
Well water tested high in Na <sup>+</sup>	28.2	22.2
Well water tested high in TDS	21.0	42.7
Well water tested high in NO <sub>3</sub> <sup>-</sup> -N	7.8	5.2

**Table 5. Potential sources of NO<sub>3</sub><sup>-</sup>-N contamination and coliform bacteria identified by private well owners (N = 406; 743).**

Source of contamination	Participants who said this was the most likely source of contamination	
	%	Rank
<b>Most likely source of NO<sub>3</sub><sup>-</sup>-N</b>		
Naturally occurring	18.2	1
Septic tanks and sewer systems	14.3	2
Livestock feeding and confinement operations	12.1	3
Fertilizer application	11.8	4
Faulty well construction	7.1	5
<b>Most likely source of coliform bacteria</b>		
Septic tanks and sewer systems	13.9	1
Naturally occurring	13.3	2
Faulty well construction and maintenance	10.6	3
Incorrect sampling procedure	10.2	4
Lack of well decontamination after drilling	8.6	5

did not understand the results or significance of the results.

To assess the representativeness of the respondents and how much impact the program had on their understanding of water quality issues, the questionnaire responses were compared with actual water test statistics. For example, using a Na<sup>+</sup> concentration of 250 mg L<sup>-1</sup> or more as an indication of high Na<sup>+</sup> concentration, well owners were asked if the sample they submitted tested high in Na<sup>+</sup>. Survey responses were then compared with actual test results (Table 4). A similar question was asked about TDS and NO<sub>3</sub><sup>-</sup>-N, using threshold levels of 500 mg L<sup>-1</sup> TDS and 10 mg L<sup>-1</sup> NO<sub>3</sub><sup>-</sup>-N.

#### Well Owner Opinions

Participants were asked what might be potential sources of either NO<sub>3</sub><sup>-</sup>-N or bacterial contamination of well water. They selected from a list of 18 possible sources, ranging from naturally occurring contamination to fertilizer, mining, septic tanks, and soil erosion. No single source of contamination was consistently assigned blame; the most frequently cited sources were: (i) septic tanks and sewer systems; (ii) naturally occurring in groundwater; (iii) livestock confinement and feeding or manure stockpiling; and (iv) faulty well construction and maintenance. Participant responses to this question were ranked, based on which source was blamed (Table 5).

**Table 6. Participant understanding of water treatment options available to private well owners (N = 1289).**

Water quality contaminant	Respondents who know how to treat for this problem		
	Yes	No	Don't recall
	%		
Coliform bacteria	62.7	32.8	4.4
NO <sub>3</sub> <sup>-</sup> -N	26.7	61.9	11.4
Total salts	29.1	60.8	10.1
Sodium salts	32.0	58.2	9.8
Hard water	63.8	29.8	6.3
Lead	22.2	66.9	10.9

**Table 7. Costs well owners indicated willingness to pay to obtain well water testing services and information about well water quality (N = 1346).**

Percentage of respondents willing to pay	Amount
13.7	\$10
39.7	\$10-20
32.2	\$20-40
11.2	\$40-80
3.1	\$80-200

### Action Taken

As part of the educational program, each participant was sent a fact sheet describing water treatment options. Well owners were asked if they knew how to treat water for various contaminants and other undesirable conditions. Well owners claimed they best understood treatment for coliform bacteria and hard water (Table 6). The least understood treatments were for lead (which was not tested for in the program) and  $\text{NO}_3^-$ -N.

Well owners can take a variety of actions to deal with undesirable water quality. These include, but are not limited to, purchasing bottled water, modifying an existing well or drilling a new well, hauling water, or joining a water district. We asked each well owner *how much money* they spent on any of these actions, other than purchasing water treatment equipment, as a result of the information they obtained from the program. Average amount of money spent was \$992.00 per well where some action was taken, and the annual cost was about \$238.00 per well. Average cost of point-of-use water treatment equipment was \$425.00 per household.

Participation in the well test program and perceived benefit gained from the program appeared to be a function of the immediate usefulness of information to the participant, amount of effort needed to get the information and participate, and cost of participation. For example, we asked each participant how much they would be willing to pay for the water testing service they received if they were required to get the information from a private testing laboratory. Nearly 85% of the respondents indicated willingness to spend between \$10 and \$40 for the water testing service (Table 7).

### Program Value and Information Transfer

We asked well owners if they told anyone else about the program. Nearly 55% of the respondents indicated they told an average of four people (friends, relatives) about the program.

Well owners were asked what benefit they gained from the program. According to those surveyed, the most valu-

**Table 8. Participant perceptions of value and usefulness of the Montana private well water test program (N = 1374).**

Segment of the program of value	Rank	Percentage of participants
Test results for own well	1	89.4
Low cost to well owner	2	76.2
Private well/water protection information	3	64.2
Specific information about treatment	4	50.2
Information about Montana groundwater quality issues	5	43.7

**Table 9. Participant perceptions of effect of the well test program on their ability to understand water quality issues and make knowledgeable decisions about water quality action (N = 1365).**

Effect of program	Responses			
	Not at all	A little	A moderate amount	A great deal
	%			
Increased my awareness of individual responsibilities for well water testing and protection	6.0	19.6	39.3	35.0
Increased my knowledge of water quality, common contaminants, and testing	3.7	21.0	38.7	36.6
Improved my own qualifications to make decisions about water quality issues	6.3	24.0	40.5	29.0

able parts of the program were: (i) water test results, (ii) cost of the program and participation, (iii) information on water quality protection, and (iv) specific information about treatment options (Table 8).

We asked participants to specify the extent to which their participation in the program: increased their awareness of individual responsibilities for well water testing and protection; increased their knowledge about water quality, common contaminants, and ways to test water supplies; and improved their qualifications to make decisions about action needed to preserve, protect, or improve the quality of their drinking water. Table 9 includes a summary of the responses.

Eighty-three percent of the participants indicated that the Montana well test program increased public awareness of private water quality issues and well water protection a moderate amount or a great deal.

Each well owner identified the educational resources and materials that they would consider using in future programs of this type and which they would prefer to use to gather information of this type. A summary of responses is presented in Table 10.

### Farm Versus Nonfarm Well Owners

Montana is considered a rural state, although nearly 50% of the population resides in communities of 10 000 people or more. All well owners responding to the questionnaire were asked to specify if the well tested was located on a farm. Responses from farm residences were

**Table 10. Participant preferences for types of educational information offered through distant delivery (N = 1377).**

Educational resources	Participants who said they would use the resource	Participants who said this was the most preferred resource	
		%	Rank
Printed text	71.6	40.0	1
Talking to county agent	59.3	21.9	2
Video	32.2	9.9	3
Workshop	28.8	9.7	4
Television	26.6	5.4	5
Talking to specialist on phone	24.5	8.3	6
Lecture	23.5	4.6	7
Audio tape	3.4	<1.0	8

compared with responses from nonfarm residences. Fifty-six percent of the respondents said the tested well was located on a farm or ranch; 42.3% said the sample came from a well located in a nonfarm environment.

Concern for personal health was the most important reason for program participation by farm and nonfarm well owners alike—47% of the farm well owners and 43% of the nonfarm well owners. Curiosity was cited as the primary reason by approximately 26% of each group. Cost of the program was the third most-important reason for participation by either group.

Farm well owners consistently reported higher  $\text{Na}^+$  concentration, TDS,  $\text{NO}_3^-$ -N, and coliform bacteria. A significantly greater percentage ( $P = 0.05$ , based on standardized  $t$ -test) of farm well owners than nonfarm well owners acted to treat water and protect wellheads. Farm well owners with wells that tested positive for coliform contamination were more likely to act (36.2%) than were nonfarm well owners faced with the same situation (27.7%).

Individual expenditures on well treatment, modification, and annual maintenance did not differ significantly between the two groups. About 20% of each group spent the same amount of money on point-of-use treatment. Both groups indicated equal willingness to purchase water quality testing services, although farm well owners placed a significantly greater value on the total program (\$127) than did nonfarm well owners (\$83). Both groups indicated that test results were the most valuable part of the program. The relatively low cost of the program was rated as the second most important aspect of the program by both groups.

Responses to the questions indicated that the nonfarm audience was slightly (although not significantly) better informed about individual responsibilities, knowledge of water quality issues, and action needed than the farm audience. On average, 6.5% of the nonfarm audience said they did not benefit from the program, whereas 3.5% of the farm well participants. Conversely, farm well owners placed significantly greater value on the education than did the nonfarm well owners. Only 11% of the farm well owners said the program was of limited or no educational value. Nearly 17% of the nonfarm audience said the program was of little or no value, although the difference was not significant.

Regarding preferred sources of information, the two groups responded similarly, with the exception of significant differences in their preference for use of text materials and assistance from county agents. Forty-four percent of the nonfarm audience identified text as their preferred source of information; only 36.2% of the farm well owners preferred text. In contrast, 27.3% of the farm well owners listed county extension agent contact as their preferred choice of information, compared with only 17.3% of the nonfarm well owners. These two differences were significant at the 5% probability level, based on the standardized  $t$ -test.

The difference in responses between the two groups can be explained in part by significant difference in level of education between nonfarm and farm well owners. Nonfarm well owners had a slightly higher average level of

education than farm well owners. Nearly 20% of the nonfarm well owners indicated that they had earned a post-college graduate degree, whereas only 5.8% of the farm well owners indicated an equal level of education.

### Geographic Location within Montana

The database was sorted into subsets consisting of well owners residing in the forested, intermountain areas of central and western Montana, the northern Great Plains where dryland small grain farming predominates, and the south and south central region, where livestock production is the primary land use.

Well owners residing in the western, intermountain area of the state indicated significantly less frequent well testing prior to the current program than well owners in the northern and southern agricultural regions. Forty-seven percent of the well owners in the intermountain region said they had never tested their wells before, while 36.3 and 37.8% of the well owners in the northern and southern regions, respectively, indicated that they had not had their wells tested before.

Well owners from all three geographic regions indicated that concern for personal and family health was the primary reason for participating in the current program. A greater, although not significantly different, percentage of people from the intermountain area than from the northern and southern agricultural regions indicated that curiosity was the primary reason for their participation in the program.

Well owners in the two agricultural regions took an aggressive approach to dealing with bacterial contamination. Forty percent and 32.8% of the well owners in the northern and southern agricultural regions, respectively, with bacterial contamination indicated they had switched to a different water source; a significantly smaller percentage (11.0%) of the well owners from the intermountain area with bacterial contamination indicated that they had switched to a different water source. Similarly, 16.2 and 10.6% of the well owners from the northern and southern agricultural regions and with bacterial contamination indicated that they had taken some corrective action, compared with only 5.6% of the well owners in the intermountain area facing the same situation. These significant differences in response were somewhat surprising, because the actual level of bacterial contamination was similar for all three of the areas. Conversely, well owners in the intermountain area spent more money on well improvements (\$1175) than did well owners in the northern agricultural region (\$1095) or the southern agricultural region (\$841).

The intermountain region of Montana represents a geographic area comprising primarily small land owners, much forest land, and relatively high population density, compared with the northern and southern agricultural regions. Well owners from the intermountain area indicated a significantly greater preference for written material (42.9%) than did well owners from the northern (33.6%) or southern (40.1%) agricultural regions. However, well owners from the northern agricultural region (28.9%) indicated significantly greater preference

for contacting county agents for information than did well owners from the southern agricultural region (24.1%) or intermountain western region (18.4%).

### Education

The entire database was sorted by educational level of participants. One subset was for individuals with some college education and the other subset comprised responses from individuals with no college course work. Responses of the two groups were similar regarding reasons for participation, conclusions arrived at from the results, and recollection of test results.

Although the summary of actual test results varied between the two groups, this variation was attributed to a higher educational level for nonfarm settings. The results indicated that individuals with less education were more inclined to seek alternative water sources if problems existed, whereas individuals with some college education were more inclined to implement some wellhead protection action.

Participants with some college education reported spending significantly more (\$1121 per well) than individuals with no college education (\$927 per well). Individuals with some college education indicated a greater understanding of water quality issues before participating in the current program. Only 19.4% of the well owners with no college education reported the program made little or no contribution to their awareness of water quality issues; 27.0% of those with some college education indicated little or no increase in their awareness of water quality issues. The value of the program for increasing knowledge and improving decision-making was similar.

The groups differed significantly in their preference for information sources. Forty-one percent of those respondents with some college education indicated that their preferred source of information was printed text, compared with only 36.8% for those individuals with no college education. Individuals with no college education indicated a greater preference to rely on the county agent (28.0%) for information than individuals with some college education (19.8%).

The private well test program was intended to improve the decision-making skills of private well owners in Montana, with specific interest in farm residents. The impact assessment verified that by using a variety of information delivery sources and methods, including text, video, participatory activity, and written results specific to the needs of well owners, the program was able to improve decision-making skills and also promote participants to take follow-up action. In addition, the program provided a cost-effective approach to distance delivery education of more than 3300 Montana residents. Consistent with the findings of Baker (1990), direct involvement of participants (well owners) in the program resulted in individual well owner problem assessment and initiation of corrective action in many cases. Based on these findings, extension faculty may be able to improve the effectiveness of future distant delivery education. Extension faculty could integrate a variety of educational delivery mechanisms into programs that provide opportunity for direct participant involvement and that offer information of immediate utility to program participants.

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# Minto-Brown Island Park: A Case Study of Farming the Urban-Agricultural Interface<sup>1</sup>

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## ABSTRACT

As urbanization increases, the potential for conflict between urban and agricultural interests grows. In Salem, OR, a 1989 Audubon Society report expressed concerns about pesticide use on agricultural lands that were part of Minto-Brown Island Park. The report recommended that the city of Salem ban the use of pesticides known to cause health or environmental damage. R.G. Andersen-Wyckoff, president of the Salem Parks Advisory Board, felt the issue could turn into a divisive conflict between farming and nonfarming interests in the Salem community. This case presents Andersen-Wyckoff's dilemma as he decided what action to take to alleviate tensions between environmental and agricultural concerns. By working through this case, students consider and discuss varying perceptions about pesticide use by farmers while evaluating data concerning pesticides. In addition to enhanced awareness of pesticides and controversy surrounding their use, students also gain appreciation of the need for improved communication between agricultural and nonagricultural interests.

**P**ESTICIDE USE by agricultural producers is under increasing scrutiny. The amount of U.S. farmland has shrunk by 86 million ha (215 million acres) since 1954, in part due to increased urbanization (USDA, 1991). As urban boundaries expand into agricultural areas, concerns regarding agricultural pesticide use are heightened. This case was developed to increase students' awareness of urban agricultural issues and interactions between farmers and society at large. Reconciling conflicting interests of the community, wildlife, and agriculture will continue to be a major dilemma for individuals in all segments of society.

## THE CASE

One observer compared the situation at Minto-Brown Island Park to a "powder keg near a lit match." Another stated, "It was like the spotted owl, only on a smaller scale" (Savonen, 1993). Minto-Brown Island Park was unusual as agricultural fields were incorporated within the park grounds. Visitors to the park in Salem, OR had observed a substance being sprayed on a waterway near agricultural land located in the park. Assuming the park's tenant farmer was irresponsibly handling agricultural pesticides, the visitors reported that information to their local Audubon Society chapter. In 1989 the Salem, OR, chapter of the Audubon Society published a report (Doherty, 1989) criticizing the use of pesticides on farm hec-

tarage within the Minto-Brown Island Park of Salem. The report recommended that the Salem Parks Department and the city of Salem ban the use of pesticides suspected of causing long-term health or environmental damage. R.G. Andersen-Wyckoff, then president of the Salem Parks Advisory Board, felt the situation would develop into a major confrontation between agricultural and environmental interests unless it was quickly resolved. Another member of the parks board, who was also a member of the local Audubon chapter, had pressed Andersen-Wyckoff, insisting that he implement the report's recommendation to ban pesticide use on the park farm.

Salem is the capital of Oregon, the county seat of Marion County, and part of one of the most productive and diverse agricultural regions in the state, the Willamette Valley. Marion ranks as Oregon's number one agricultural county based on farmgate sales. Andersen-Wyckoff knew that decisions regarding pesticide use in the park could have wide-ranging implications for agriculture and pesticide use policies throughout the state.

In 1989, Andersen-Wyckoff discussed the situation with Rob Miller, a local farmer who had been active in agricultural issues in the area for some time. Miller provided Andersen-Wyckoff with a list of people who he knew had an interest in the outcome of the pesticide decision. This list included farmers, park-users, environmental groups including the Audubon Society, local businesses, and land owners in the area. These groups represented a variety of interests. For example, the Oregon Tilth organization worked toward organic certification for farmers, while Oregonians for Food and Shelter favored conventional agriculture and opposed further regulation of agricultural chemicals. The Oregon Agricultural Chemical Association was also interested in cases involving public concern and perceptions related to pesticide use. The park's tenant farmer was a member of the Northwest Food Processors Association, a research, marketing, and advocacy organization. Food processors were still reeling from the Alar controversy earlier that year and concern about public perception regarding pesticides was high. Oregon State University Agricultural Experiment Station and Cooperative Extension Service personnel also had an interest in the outcome of the park board's decision as an agricultural issue. This was clearly an issue that touched many elements and interests within the Salem community and beyond. Andersen-Wyckoff knew that great care would be required to resolve this dilemma while maintaining support of the many diverse parties interested in the outcome of the Park Advisory Board's actions.

Department of Agronomy and Plant Genetics, 1991 Buford Circle, 411 Borlaug Hall, Univ. of Minnesota, St. Paul, MN 55108-6026. Minnesota Agric. Exp. Stn. Journal Series no. 21,022. Received 22 Feb. 1994. \*Corresponding author (ssimmons@maroon.tc.umn.edu).

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<sup>1</sup> Teachers who intend to use this case for classroom or extension education purposes may request a copy of the full *Case Teaching Note* from the corresponding author.

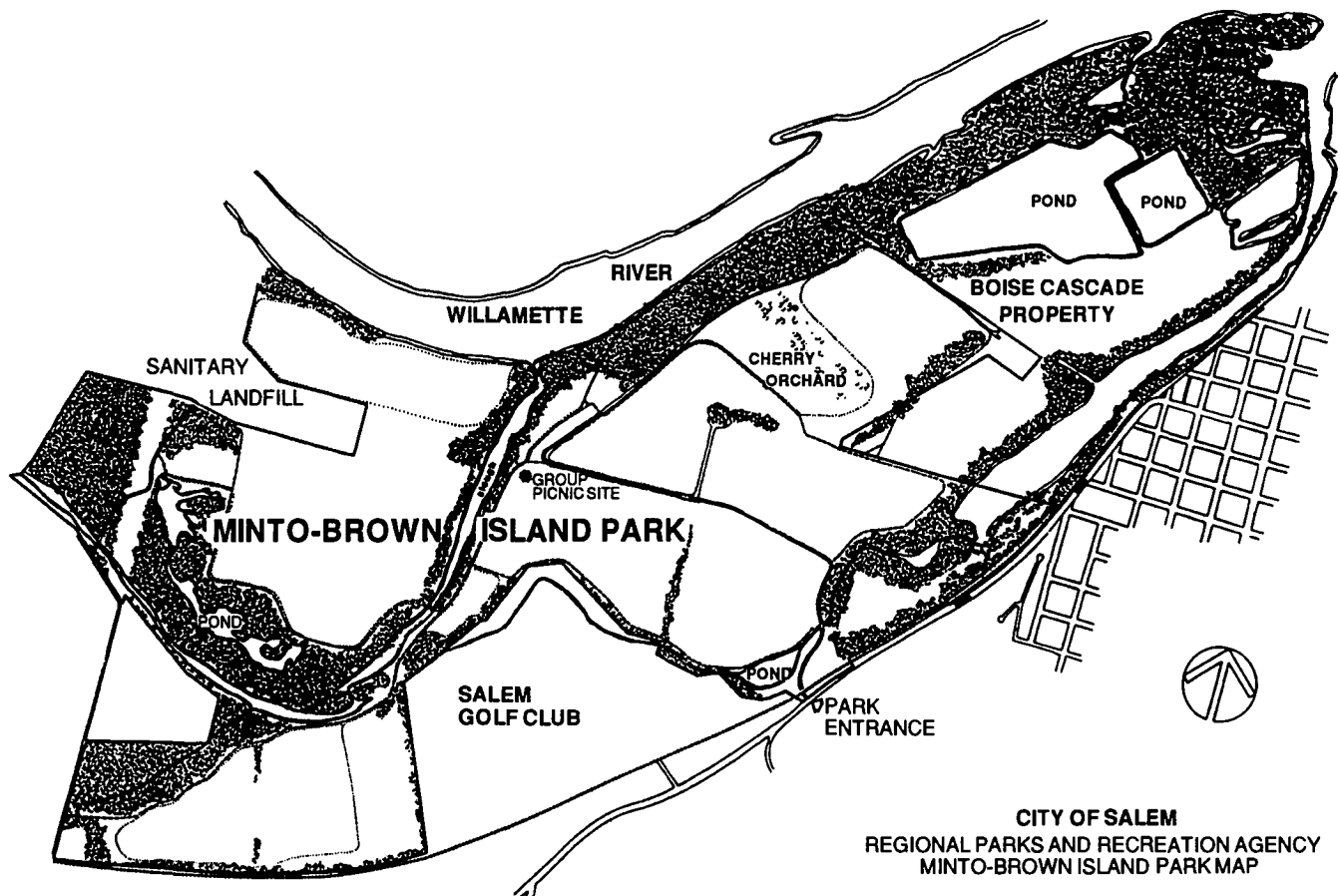


Exhibit 1. Map of Minto-Brown Island Park.

### Background on the Decision Maker

Andersen-Wyckoff had been a member of the Park Advisory Board for 6 yr and had been president of the board for 2 yr before the Audubon Society issued its report. In 1989 he was nearing the end of his term as president and was entertaining thoughts of becoming a candidate for mayor in 1990. A local business owner, he had no background in agriculture and felt his views were more those of a “conservationist” rather than a “preservationist”. Andersen-Wyckoff felt that the principle components of Minto-Brown Island Park, wildlife conservation, recreation, and agriculture were “like three legs of a three-legged stool.” Each leg contributed to and was necessary for the others. He believed that the agricultural component of the park contributed to its uniqueness and helped Salem citizens relate to and identify with the agricultural heritage and economy of the Willamette Valley.

### Background on the Park and Farm<sup>2</sup>

In 1857 Isaac “Whiskey” Brown homesteaded an island in the Willamette River near the present community of Salem. In 1861 the worst flood in Salem history changed the course of the Willamette River and caused Brown’s property to be joined with another island, and

<sup>2</sup>Unless noted, factual information included in this section was obtained from Gredler (1990).

the southwest edge of Salem (Savonen, 1993). Another settler, John Minto, purchased a parcel on the other island, which was now also connected to Brown’s. Both the men cleared their lands, converting them into farmland, which has remained in agricultural production since that time (Exhibit 1).

In 1970 the City of Salem and Marion County acquired 344 ha (860 acres) of these lands to create a park and wildlife refuge. The park was subsequently expanded to 357 ha (892 acres). The city named the park after the original settlers, Minto and Brown. Beginning in 1970, 96 ha (240 acres) of the park area were leased to area farmers for agricultural use. Farmer Ken Iverson had been the sole tenant since 1986. Iverson grew commercial potato (*Solanum tuberosum* L.), bean (*Phaseolus* sp.), and sweet corn (*Zea mays* L.) (Exhibit 2). As part of his lease agreement he planted corn and cover crops for water fowl. The lease was due to expire 30 Sept. 1991.

The park was also under the jurisdiction of the National Parks Service as it was located in the National Wildlife Refuge of the Willamette Valley. Over 175 bird and 35 mammal species had been identified within Minto-Brown Island Park. Dusky Canada Geese (*Branta canadensis occidentalis* Baird), a rare species, regularly overwintered in the park. The geese and waterfowl were a prime attraction of the area, as well as the scenery, bike trails, and other recreational facilities. Primary recreational users of the park were runners, walkers, bicyclists, and

**Exhibit 2. Crops and crop rotations on the Minto-Brown Farmland, 1986-1989 (Gredler, 1990).**

Field 1	Field 4
1986 potato	1986 potato
1987 bean	1987 potato
1988 corn	1988 corn
1989 corn	1989 corn
Field 2	Field 5
1986 potato	1986 potato
1987 1/2 fallow, 1/2 bean	1987 fallow
1988 potato	1988 corn
1989 bean	1989 corn
Field 3	Field 6
1986 bean	1986 bird feed
1987 potato	1987 potato
1988 bean	1988 corn
1989 potato	1989 corn

bird watchers. On any given day, more than 100 runners and walkers were known to use the park facilities.

Agriculture also played a significant role at Minto-Brown, allowing urbanites to better view the cycles of agriculture such as plowing, planting, and harvesting. In addition, the farming practices provided excellent food and shelter for some of the wildlife. The parks board did not have the resources to provide the necessary cover crops. Therefore, without the farmer's inputs, much of the land would revert to bramble and blackberry (*Rubus* sp.), of little use to the waterfowl.

### The Pesticide Review

The 1989 Audubon Society report, which proposed banning pesticide use on the Minto-Brown Island Park farm was prepared by Maura Doherty, an industrial hygienist. The report had been jointly funded by the city of Salem and the local chapter of the Audubon Society. The Audubon Society was particularly concerned by the park's use of dinoseb (2-(1-methylpropyl)-4,6-dinitrophenol), a herbicide that had been under emergency suspension by the USEPA since October 1986 (Exhibit 3). Dinoseb could be used as a preemergence herbicide and for vine killdown in potato. The USEPA stated that exposure to dinoseb presented "imminent" and "unacceptable" risks of detrimental health effects to exposed persons. These risks included sterility, birth defects, and other health hazards.

The Audubon Society report (Doherty, 1989) also indicated that a total of 24 pesticides or growth regulators could have been used in the park and evaluated each of them for their possible effects on health and the environment (Exhibit 4). The report concluded that the majority of these chemicals could cause long-term health problems in experimental animals. The USEPA testing had not been completed on eight of the pesticides at the time the report was prepared. Fifteen of the chemicals had been shown in contaminated water supplies in other parts of the USA. The Audubon researchers had not spoken to the farmer regarding specific pest management strategies used on the property. The report did not indicate how frequently or widely each chemical had been used by the current or previous farmer(s). Neither did it consider pesticide use on the Salem Golf Club or on the

**Exhibit 3. Fact Sheet for dinoseb from the Pesticide Review for Minto-Brown Island Park (Doherty, 1989).**

<b>Legal status</b>	In October 1986 USEPA announced an emergency suspension of dinoseb use. Prior to this, approximately 180 products contained dinoseb and more than 5 million kg (11 million pounds) were sprayed annually in the USA.
<b>Toxicity</b>	<p><b>Acute</b> The oral LD<sub>50</sub>† of dinoseb was between 20 and 60 mg/kg or highly toxic. 100% of the dose applied to skin could be absorbed.</p> <p><b>Chronic</b> Dinoseb lowered the sperm count in exposed animals and caused teratogenic and reproductive effects. Dinoseb was listed as a potential human carcinogen and caused the development of cataracts at low exposure levels. Dinoseb also damaged the immune system, liver, kidney, and spleen.</p>
<b>Population at risk</b>	Dinoseb was highly toxic to fish and wildlife, causing fishkills and field kills of pheasants ( <i>Phasianus colchicus</i> ) and songbirds. Dinoseb was banned from use because of the potential harm to the reproductive system of workers and exposed members of the public.
<b>Environmental fate</b>	USEPA noted that this chemical was a Priority 1 chemical able to leach from soil into water. Dinoseb can persist on crop treated soil from 2 to 4 wk. Ontario, OR, wells show persistent contamination with dinoseb. A British Columbia report noted that dinoseb showed residual action in soil for approximately 1 mo or less.
<b>Sources</b>	USEPA Factsheet no. 130, October 1986. Exotoxnet, Extension Toxicology Network, Pesticide Information Project, Michigan State University, January 1989.

† Dose needed to kill 50% of tested animals.

privately owned Boise Cascade properties adjacent to the park.

All of the pesticides were labeled by the USEPA at the time they were used by the farmer. Although dinoseb could no longer be purchased, existing supplies could still be used in accordance with the label. It was under this provision that dinoseb had been used on the Minto-Brown farm since 1986.

The Audubon Society report recommended that the city of Salem take action to ban the use of all pesticides in the park, citing increasing concern among "many park users" (Exhibit 5). The pesticide review was the first phase of a three-phase process planned by the Audubon Society. Phase 2 was to evaluate alternatives to chemical pesticide use in the park and Phase 3 would evaluate the feasibility of developing a compost program using vegetation from the park grounds.

### The Decision

Andersen-Wyckoff had to decide what action to take to alleviate tensions among environmental and agricultural interests in the community and resolve differences regarding use of pesticides on the Minto-Brown Park farmland. He knew that members of the nonfarming public expected farmers to protect the environment and conserve natural resources without raising the cost of food. Some clearly regarded pesticide use on the farm as hazardous to park users and detrimental to wildlife and the environment. They expected Andersen-Wyckoff to act favorably on the Audubon Society report's recommendations. On the other hand, some representing farm-

**Exhibit 4. Toxicity and water contamination information for pesticides used in Minto-Brown Island Park (Doherty, 1989).**

Chemical	Acute				Chronic†				Inadequate chronic data	Inadequate environmental data	Water contamination‡
	Oral LD <sub>50</sub> ‡	Acute toxicity	Eye/skin effects	Other organ damage	Ter	Mu	Repro	CA			
<u>Herbicides</u>											
Amitrole	> 400	Slight	+¶	+			+	+	+		
Atrazine	1 750	Slight	+			+	+	+			+
Bentazon	2 063	Slight	+		-		-	-	+	+	+
2,4-D	300-1 000	Slight to moderate	+	+	+		-	+			+
Triclopyr	515-1 127	Moderate		+	+		+		+		+
Dichlobenil	4 250	Slight								+	
Dinoseb	20-60	Highly		+	+		+	+			+
Diquat	215-235	Moderate	+	+	+	+	+	+			
EPTC	1 650	Slight	+						+		+
Metolachlor	2 780	Slight	+		-		-	+		+	+
Metribuzin	1 100-2 300	Slight	-	+	-	-		+	+		+
Simazine	> 5 000	Not so toxic	+	+			+		+		+
Trifluralin	> 10 000	Not so toxic	+	+	+	+	+				+
<u>Insecticides</u>											
Carbaryl	255-800	Slight to moderate		+	+	+	+			+	
Carbofuran	3.8-35	Highly							+		+
Disulfoton	2-6.2	Highly							+	+	+
Fonfos	3-18.5	Highly							+		
Permethrin	1 500	Slight	+	+	-	-	+	+			
<u>Fungicides</u>											
Benomyl	> 10 000	Not so toxic	+	+		+	+	+			
Copper hydroxide	1 000	Slight	+							+	
Mancozeb	> 5 000	Not so toxic		+	+			+	+	+	+
Metalaxyl	669	Slight			-	-		+			+
Vinclozolin	> 10 000	Not so toxic	+		-	-	+	+		+	
<u>Growth inhibitor</u>											
Maleic hydrazide	6 950	Not so toxic			+		-	-	+		+

† Mu = mutagenic effects; Ter = teratogenic effects; Reprod = reproductive effects; CA = oncogenic/carcinogenic effects.

‡ Oral LD<sub>50</sub> = oral dose needed to kill 50% of tested animals.

§ Water contamination = detected in water or expected to be mobile in soil.

¶ + = yes or positive results in at least one study; - = negative results in most studies.

ing interests regarded the report as alarmist and poorly researched and expected Andersen-Wyckoff to protect their right to utilize legal pesticides when the situation merited.

There were many questions in Andersen-Wyckoff's mind as he weighed how he should respond to the Audubon report.

- Were the concerns of the Audubon Society regarding adverse pesticide effects on wildlife valid?
- Would restricting pesticide use on the Minto-Brown farm have symbolic and negative repercussions for other farmers in the region or in other parts of the state?
- Had pesticide use by the tenant farmer been a hazard to park visitors?
- Was there a way to manage the agricultural part of the park in such a way that all of the diverse interests and stakeholders, farmers, consumers, park patrons, and environmentalists would be satisfied?
- Could he turn this situation into a positive one by uniting these diverse interests rather than heightening confrontation?

### CASE EXHIBITS

1. Map of Minto-Brown Island Park.
2. Crops and crop rotations on the Minto-Brown farmland, 1986-1989 (Gredler, 1990).
3. Fact sheet for dinoseb from the Pesticide Review

### Exhibit 5. Excerpts from the Executive Summary of the Pesticide Review for Minto-Brown Island Park (Doherty, 1989).

Managing pesticide programs had changed dramatically in the 1980s. Neighboring residents and park users may now want to know more about the toxicity and location of pesticides used. In addition, emergency suspensions by the USEPA and voluntary withdrawals by manufacturers has made many pesticide users wonder how reliable past research data really is. Professional applicators now know that "EPA approved" pesticides can't always be assumed to be "safe" for people or the environment.

... The Audubon Society became increasingly concerned over pesticide use in Minto-Brown Park after USEPA focused attention on the toxicity of dinoseb, an herbicide used in the park. In 1986, USEPA issued an emergency suspension order stopping use of dinoseb due to its ability to cause male sterility, birth defects, and numerous other health and environmental effects.

... Several cities and the state of California have stopped or are proposing bans on the use of pesticides that can cause cancer, birth defects, or environmental damage. The city of Salem should take similar action. The Alternatives phase of this project will help to identify effective, less toxic, and more environmentally acceptable pest control methods. In light of the data presented in this Pesticide Review and the increasing concern on the part of many park users, the Salem Parks Department would be well advised to adopt a policy of stopping the use of pesticides known to cause long-term health or environmental damage.

for Minto-Brown Island Park (Doherty, 1989).

4. Toxicity and water contamination information for pesticides used in Minto-Brown Island Park (Doherty, 1989).
5. Excerpts from the Executive Summary of the Pesticide Review for Minto-Brown Island Park (Doherty, 1989).



## TEACHING NOTE

### Case Objectives

Upon completion of this case students will have:

1. Enhanced understanding of issues involving the urban-agricultural interface, and particularly controversies that exist regarding the use of agricultural chemicals.
2. Experience in resolving a conflict between agricultural and societal interests.
3. Enhanced awareness of pesticides and their characteristics.
4. An appreciation of the need for improved communication between interests representing agriculture, environmental advocates, and the society at large.

### Uses of the Case

This case has been used in a general education ecology course at the University of Minnesota. It may also have utility for courses in natural resources, sustainable agriculture, parks-public grounds management, environmental studies, landscape ecology, pest management, or water quality.

The case can be assigned to small groups for deliberation prior to a general class discussion. These groups may respond to questions such as those listed below. As an alternative, each group may be required to prepare a written or oral response to the case, stating their decision as Andersen-Wyckoff and their rationale for that decision.

### Discussion Questions and Issues in the Case

Possible questions that can be used in preparing for and discussing the case and its issues:

**What is the dilemma?** Andersen-Wyckoff faced a decision concerning what action to take regarding pesticide use on farmland in the park. His main concern was the potential for confrontation and dissension among the diverse interests concerned with pesticide use policy in the park. The multiple stakeholders ranged from agricultural to environmental interests with great potential to clash over the issue.

Andersen-Wyckoff maintained that agriculture was an integral component of the park management plan, both for its educational value and its importance to the resident wildlife. He feared that a confrontation between stakeholders would jeopardize continuation of the park farm. Also, Andersen-Wyckoff knew that potential conflict between the rural and urban sectors within Salem could persist as the city continued to grow. A legitimate concern was that the debate might spread to other parts of Oregon.

**Is pesticide use in Minto-Brown Island Park a legitimate concern or problem?** Fifteen of the 24 pesticides used were known to be in contaminated water supplies elsewhere in the USA. Eight of the pesticides had not been fully tested for their environmental effects. One (dinoseb) was to be suspended from use once current supplies were exhausted.

However, the frequency and extent of each pesticide's use by the farmer had not been considered in the Au-

dubon report. Furthermore, each pesticide the farmer did use was being used legally in a manner consistent with its labeling. Use of pesticides and other chemicals in the neighboring golf club and on the privately owned Boise-Cascade properties had not been evaluated or considered in the report.

**Who will this decision affect and who are the stake holders in the outcome?** If pesticide use in the park was banned, the farmer on the island would feel the immediate effects. That farmer might feel that his operation was in jeopardy by losing this management option. A change in pesticide policy by the City of Salem might also have wider reaching effects for agriculture throughout Oregon and the region due to the high visibility of the city and its function as the capital of state government.

Varying interests, values, and perceptions were held by people concerned with management of Minto-Brown Island Park. Farmers, park users, environmental groups including the Audubon Society, local businesses such as Boise Cascade, the Northwest Food Processors Association, wildlife biologists, Oregon Tilth, the Oregon Agricultural Chemical Association, and Oregon State University Agricultural Experiment Station and extension satellite personnel all had a stake in the outcome of the park board's pesticide use decision.

**What are Andersen-Wyckoff's options?** Following are some of Andersen-Wyckoff's options for addressing the dilemma (not prioritized):

1. *Eliminate agriculture from the park.* Put in alternative vegetation and have the city manage for wildlife use and recreation only. This option runs counter to Andersen-Wyckoff's "three legged stool" philosophy of management for the park. Also, the city and parks board do not have the resources to plant and maintain corn and cover crops important to the Dusky Canada Geese and other waterfowl populations that overwintered in the Wilamette Valley.
2. *Reduce agriculture in hectareage and intensity to reduce the amount of pesticide used.* The option could have negative repercussions for the tenant farmer and might be unpopular with agricultural interests concerned with the issue.
3. *Require that the farmer grow different crops that would require few or no chemical inputs or require the farmer to begin farming without chemicals.* This option also could have negative aspects for the tenant farmer and would likely be opposed by agricultural interests as setting a bad precedent and symbol that could have effects in other agricultural areas. It might be an option highly favored by the more strident environmental interests in this issue.
4. *Purchase the farmer's stock of dinoseb.* This option removes the immediate concern about the primary concern of the Audubon report. It may serve to defuse the issue and give Andersen-Wyckoff time to explore a more permanent solution to the pesticide debate. It also gives Andersen-Wyckoff an insight into stakeholder's agendas, based on their response to this action.

5. *Use the park for studies to help determine the actual effects of and alternatives to chemical use.* This option has appeal for possibly creating a cooperative and common purpose among the disparate interests in the situation. Funds to finance this option would also be an issue.
6. *Increase use of the park for public education about agriculture and associated issues, including conflict and controversy over pesticide use.* This option, like Number 5, has potential for shifting the debate away from agriculture vs. environment and more to a common concern for educating and informing. How the diverse views of the stakeholders could be represented in such a public education venture could itself present a substantial challenge.
7. *Rebut the Audubon report for lack of evidence.* This option effectively ignores the concerns of environmentalists regarding pesticide use in the park. The potential then exists for Audubon to increase exposure of the issue to raise public awareness and concern.

Andersen-Wyckoff would need to counter with his own information campaign.

### ACKNOWLEDGMENTS

Sincere appreciation is expressed to R.G. Andersen-Wyckoff and John Burt, Oregon State University Extension Service, for their valuable information regarding the case. We also thank Janette Almlı, Todd Pester, and Terry Simon, who assisted with the original case outline.

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# Heavy Metal Veggies: A Decision Case for Environmental and Nutrition Education<sup>1</sup>

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## ABSTRACT

The issues of municipal solid waste (MSW) disposal are becoming more complex as landfills close and environmental concerns increase. One alternative to continued landfilling or incineration is the development of MSW composting facilities. These facilities process raw waste into MSW compost, which can then be used for agricultural, revegetation, and landscaping purposes. However, if the MSW compost does not have suitable qualities, such as an optimum carbon-to-nitrogen ratio (C/N), or if it contains high levels of heavy metal contaminants, its use for these purposes is questionable. This case considers a dilemma faced by a farmer in southern Minnesota in 1992 who used MSW compost as a soil amendment for his vegetable garden. Besides being associated with nutrient stress to his crop plants, the compost was suspected of containing heavy metals. The case permits students to examine issues associated with environmental contamination by MSW and to make decisions based on agricultural, environmental, economic, food safety, and ethical considerations. This case has been tested in junior and senior high school social studies and science classes, as well as in a university undergraduate environmental science course. A majority (65%) of the high school students rated the case positively, while 75% of the university students evaluated it as *good to excellent*.

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UNTIL RECENTLY, landfills were widely regarded as the least expensive and easiest means for disposing of municipal solid waste (MSW). However, existing landfills are closing, and pollution concerns have made new landfill sites difficult to establish. Disposal into landfills is now much more expensive than a decade ago (Halbach, 1992), which makes consideration of alternative disposal strategies feasible.

Production and use of MSW compost has received intermittent attention over the past 30 yr (Rosen et al., 1993). Municipal solid waste is defined as waste generated by domestic and industrial sectors in municipalities, excluding sewage sludge (McCalla et al., 1977). However, MSW compost is sometimes produced with the addition of sewage sludge to provide N and to accelerate the composting process.

There were 16 MSW composting facilities operating in the USA in 1992; almost all have been constructed since the mid-1980s (Kitwana, 1992). The state of Minnesota was particularly active in MSW composting, with eight facilities operating in 1992. The capacities of these facilities ranged from 9.1 to 226.7 Mg (10–250 tons) of raw waste composted per day.

The future of MSW composting depends on the abili-

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<sup>1</sup>Teachers who intend to use this case for classroom or extension education purposes may request a copy of the full *Case Teaching Note* from the corresponding author. Names of individuals and the composting facility in this case have been disguised.

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**Abbreviations:** MSW, municipal solid waste; PCA, Pollution Control Agency.

ty to produce compost that is safe and uniform in quality. In the USA, major uses of MSW compost are in horticulture, landscaping, and revegetation of disturbed soils. For agricultural purposes, MSW quality factors include C/N ratio, odor, pH, soluble salt content, physical properties, nutrient availability, and heavy metal contamination. Elements of concern in MSW are As, Cd, Cr, Cu, Pb, Hg, Ni, and Zn. Municipal solid waste compost can contain these contaminants through the inclusion of plastics, metal objects, pigments, solvents, petroleum products, and other discarded materials. Even with screening and sorting of waste, heavy metal contaminants can still be present in the final compost product. When this occurs, use of the compost might result in contamination of the environment and agricultural produce, and thus pose a threat to human health.

The following case was developed to engage students with issues associated with the use of MSW compost involving soil science, crop physiology, and human nutrition.

### THE CASE

29 June 1992

For the past 30 yr, George McKinley had been growing vegetables for his family on his 40-ha (100-acre) farm.

## Bradford Changes Garbage into Compost

By Mabel Hamilton  
Staff Writer

Byron--Like the alchemists who tried to make gold from cheap metals, the goal of the Bradford composting facility is to change something worthless into something valuable. However, at Bradford the transformation is from garbage to garden soil enhancers, and, unlike the medieval experimenters, the Bradford facility is successful.

The \$6.9 million facility has been in operation for a year and is one solution to the problem of what to do with garbage. Currently, nonrecyclable trash is sent to a landfill or incinerated.

At composting facilities such as Bradford's, recyclable materials are removed from the garbage before it is dumped into a tipping room. In the tipping room, workers remove large inorganic materials from the garbage discovering everything from tires to disassembled couches. Electric magnets and screens try to remove the smaller pieces of metal, glass, and ceramics. The

remaining garbage is then crushed, mixed with water, and poured into bunkers.

The bunkers are designed so that bacteria and fungi can break down the organic garbage and create, within about three months, a compost for fields and gardens. This compost will enrich the soil and improve plant growth.

Not all of the garbage is changed into compost. About one third of the trash that arrived at the plant is removed and sent to a land fill. Another third is released as carbon dioxide and other gases as the bacteria work to decompose the material. What remains is compost.

All this technology and expense would be useless without the basic biology of decomposition, a process which continually occurs naturally. At Bradford the process is simply accelerated.

He loved the feeling of being connected with the land and enjoyed the results of his hard work: fresh, wholesome produce that he could confidently give to his family. The growing season of 1992 had been unseasonably cool, which made it pleasant for McKinley to work outdoors, but caused his crops and vegetables to lag behind in their development.

McKinley has just begun to read the newspaper after a busy day on the farm. As he paged through the paper to find the weather forecast, an article about compost and the local composting facility caught his eye. As he read the article, McKinley became concerned. He realized that the compost he had used on his garden that spring might not be as "pure" as he had thought it was.

McKinley put down the newspaper and walked over to the window where he could still make out the rows of his garden in the dim evening light: he could see lettuce (*Lactuca sativa* L.), pea plants (*Pisum sativum* L.), cabbage (*Brassica oleraceae* L.), potato (*Solanum tuberosum* L.), tomato (*Lycopersicon esculentum* Mill.), and sweet corn (*Zea mays* L.); lettuce and pea plants were ready to be picked. McKinley's mind flashed back to spring when he had prepared for the planting season. He remembered reading about the new Bradford composting facility that was giving away compost made from municipal solid waste (Exhibit 1). The Bradford facility was designed to process 91 Mg (100 tons) of raw waste per day into compost suitable for use in agriculture and landscaping. Use of this compost had been recommended by Mary Hansen, a master gardener in the area.

June 1, 1992

Dr. Jim Duffy  
Fertility/Horticulture Specialist  
University of Minnesota  
233 Soils  
1529 Gortner Avenue  
St. Paul, Minnesota 55108

Dear Jim:

I would like you to analyze this compost sample and share with me your opinion of it.

The sample is from the Bradford Compost Facility, north of Byron, Minnesota. I am a little concerned about the foreign material content. This is why I would like your comments dealing with the inclusion of this compost in home gardens or landscape situations.

If you have any questions, feel free to contact me at the Canary County Extension Office.

Sincerely,

Mary Hansen  
Master Gardener  
Canary County Extension Service

Exhibit 1. Local newspaper article describing composting facility and process.

Exhibit 2. Letter from master gardener to university soil fertility specialist requesting compost analysis.

McKinley had welcomed the opportunity to try the free compost, having been dissatisfied with his garden's production using inorganic fertilizers the year before. He had gone to the facility, picked up the compost, and liberally incorporated it into his garden soil when he worked up his seedbed.

"I believed I was being real smart back then," McKinley remembered. After his garden plants emerged and began growing, he noticed that they were becoming yellowed, stunted, and spindly. "They looked half dead," he recalled. He called Mary Hansen and asked her about the problem. "You know, George," she told him, "others are having similar problems with their plants. The flowers that the 4-H kids planted in the boxes around the bank look terrible." Hansen realized that a common factor for these gardens was that they had all been fertilized with compost from the Bradford facility. "I'm wondering if these plants need more nitrogen," she said.

As a result of her observation McKinley decided to apply inorganic N fertilizer to his garden. Meanwhile, Hansen sent a sample of the Bradford compost that she had used to Jim Duffy, a soil fertility expert at the university, to be analyzed for "foreign material content" (Ex-

hibit 2). The response from Duffy (Exhibit 3) summarized the results of the compost analysis (Exhibit 4).

"And this is what came of it," McKinley thought. He looked at the Bradford article in his newspaper once again (Exhibit 5). The article confirmed that Hansen had been right about the N deficiency. Compost is created by microorganisms decomposing organic materials such as solid waste. Like all living things, microorganisms need water, oxygen, C, and N. If compost is used in a garden before the microorganisms have thoroughly decomposed the materials (i.e., the C/N ratio is high), the microbes take N from the soil to supply their needs. The plants, therefore, may not have enough N to support vigorous growth. The article explained that the Bradford composting facility's "accelerated process" did not allow the compost ample time to "mature". Bradford's immature compost apparently had a high C/N ratio. As a result, plants grown in soils amended with the compost showed evidence of N deficiency. McKinley was pleased that he had added N fertilizer to his garden when he did. At least now his garden crops appeared to be growing better.

However, in reading the article further, McKinley noted that university experts had also found that the compost contained levels of metals that were "much higher than in fertilizers or other soil enhancers." Duffy, the soil fertility expert quoted in the article, had noted the possibility that these elements might accumulate in vegetables grown using the compost. He stated that he would

June 16, 1992

Mary Hansen  
Master Gardener  
Canary County Extension Office  
Rural City, MN 59234

Dear Mary:

I am writing in response to your questions concerning the compost sample you sent in from the Bradford compost facility. As we discussed by phone, there is an active research program testing the suitability of this compost for agricultural use. Unfortunately, we just started this year so we do not have any results yet. Based on some of the preliminary analyses we have conducted, the C/N ratio is high (greater than 40) indicating that if added to the soil it will tie up nitrogen. The heavy metal contents are extremely variable, but are generally within the range for a Class 1 compost. The plastic material, small metal and glass pieces are more of a nuisance than anything else.

My general comments on this compost is that it is not yet mature. It needs more nitrogen and time before it would be optimum for a gardening situation. Provided that more nitrogen is supplied (maybe double the recommended level), I think it is safe to use in landscape and flower garden situations, but I would like to see more tests before it is used for home vegetable gardens. I am concerned about metal uptake and accumulation by some vegetables.

If you have any further questions regarding the compost or composting procedure, please let me know. I will keep you informed of our research as it becomes available.

Sincerely,

Jim J. Duffy  
Extension Soil Specialist

Exhibit 3. Letter from soil fertility specialist to master gardener summarizing results of compost analysis.

ML<sub>inc.</sub> Minnesota Laboratories, Inc.  
14 N. Frontier St.  
Minneapolis, MN 56429-4896  
Phone (612) 968-4420

Sample Type: Compost  
Date Sample Received: June 10, 1992  
Sample #42684

Analyte	Dry Basis	Comments
Solids, Total	46.4%	
Total PCB's	< 1.1 ppm	
Combustibles	44.3%	
Non-Combustibles	55.7%	
Nitrogen, Total	2.00%	
Mercury	5.22 mg/kg	
Sieve 10 mm	12.2%	
Sieve 16 mm	7.41%	
Sieve 25 mm	0.00%	
Cadmium	5.27 mg/kg	
Chromium/Total	67.8 mg/kg	
Copper	520 mg/kg	
Lead	300 mg/kg	
Nickel	67.8 mg/kg	
Zinc	1210 mg/kg	

The result for each analyte meets ML<sub>inc.</sub> quality control specifications.

Report approved by: Laura Swank

Exhibit 4. Laboratory compost analysis summary sheet.

like to see more tests before the compost was used on vegetable gardens.

Heavy metals can contaminate compost whenever trash items such as batteries, paints, fluorescent light bulbs, and industrial waste are not removed from the garbage prior to its being composted. Small amounts of these elements occur naturally in the soil or reach the food chain as a result of pollution. Even inorganic fertilizers may contain some heavy metal contamination. Composting facilities needed to have their compost regularly tested for metal contamination according to limits established by the Pollution Control Agency (PCA) (Exhibit 6). It was still a matter of controversy whether PCA regula-

## Use of Bradford's Compost on Gardens Has Soil Experts Worried

By Leanne Duffie  
Staff Writer

RURAL CITY - The compost from Bradford's \$7 million facility may not be the best thing to be putting on your garden.

That's the current recommendation from Mary Hansen, a master gardener with the Minnesota Extension Service, and soil scientists at the University of Minnesota.

Hansen, who recently advised area farmers and gardeners to use the compost, didn't realize that the Bradford facility uses an "accelerated process", or that the compost might still contain contaminants, despite passing quarterly tests monitored by the Pollution Control Agency.

How is this possible? The process of changing garbage into compost on a large scale basis is very new. Both the Bradford facility and the PCA need more time to develop proper procedures and standards. However, to keep the project going, Bradford must find users for its product, and therefore offers its compost to area residents at no cost.

Mary Hansen was one of the many who went to Bradford to get a truckload of the free compost. She noticed that Bradford's product was like "chopped up spit wads" whereas quality compost feels and smells like soil.

Exhibit 5. Local newspaper article describing problems with compost use.

Hansen sent a sample of the compost to Jim Duffy, a soil expert at the U of M, after hearing complaints and concerns from others who had used the compost.

Duffy found that Bradford's accelerated process did not allow the compost ample time to mature. Immature compost has a high carbon to nitrogen ratio and instead of adding nitrogen to the soil as fertilizers do, it will actually take nitrogen from the soil, resulting in poor plant growth.

Furthermore, Duffy expressed concern about the levels of metals in the compost, which were much higher than in fertilizers or other soil enhancers. He sees a possibility of metal accumulation in vegetables grown using this compost.

"We don't know enough about this," Duffy wrote, "and until we know more, I would advise against using this compost on vegetable gardens."

Whereas Bradford officials feel confident their compost is up to PCA standards for safety, they do admit that more time and testing is necessary to improve their product.

The questions is, can this be accomplished before they lose credibility?

tions were restrictive enough to ensure a safe final product from composting facilities.

### The Decision

It was getting late. McKinley folded up his newspaper and thought about his situation. The Bradford facility had its compost regularly tested for heavy metals, and, so far, had passed the tests. However, the soil fertility expert quoted in the newspaper expressed concern about the safety of the compost. McKinley was confused. He took another look outside, the outlines of the shed and barn barely visible now in the dusk. He thought, "I've put so much time into growing these vegetables. I'd sure hate to discard them and have them go to waste. But are they safe to eat? I wonder if there's some way I can test the produce for safety. Will this have an effect on how I manage my garden in the future? What should I do?"

### TEACHING NOTE

#### Case Objectives

Upon completion of this case students will have:

1. A better understanding of issues associated with environmental contamination through waste management
2. Enhanced capability to assess food choices to minimize health risks
3. Enhanced ability to distinguish between scientifically valid information and misinformation
4. Greater confidence to make decisions

*Heavy Metal Veggies* is a deceptively simple case. It provides a forum for discussing a number of issues important to teachers of crop or soil science, environmental science, or food safety and nutrition. Students must consider human and ethical as well as scientific factors in deciding the response that George McKinley should make to his dilemma regarding possible contamination of his garden by heavy metals in MSW compost. The case provides an opportunity to discuss a wide range of topics including solid waste disposal procedures, theory and practice of composting, plant mineral nutrition, metal uptake and translocation within plants, and effects of ingested metals on humans. The case requires that students consider and interpret numerical data and the analytical assumptions and limitations behind the data. The specific emphasis to be brought to the case can vary greatly depending on instructors and their goals within the context of the course where it is used.

Exhibit 6. Pollution Control Agency solid waste management contamination standards for compost.

Contaminant	Concentration
	mg/kg (dry wt.)
PCB	1
Cadmium	10
Chromium	1000
Copper	500
Lead	500
Mercury	5
Nickel	100
Zinc	1000

## Use of the Case

A version of this case was used in an undergraduate environmental science course at the University of Minnesota during winter 1993. In evaluating the case, 75% of the students ranked it "good" to "excellent". Several students noted that the case seemed simple and relatively uncomplicated compared with other cases and discussion exercises in the course. This response was because the version given to the students in this course had been written specifically for junior and senior high school-level students. After discussing this simpler version of the case in the class, the university students served as mentors for high school students studying the case as part of an environmental biology course at a nearby high school. This mentoring approach was effective for reinforcing the university students' comprehension and understanding of the case issues.

The case was also tested in junior and senior high school biology, social studies, and health science classes without university student mentoring. Depending on the class, different issues in the case were emphasized, ranging from environmental studies to human nutrition. Students in these classes prepared and discussed the case and its implications over time periods that ranged from 2 to 5 d in length. When asked how they felt about learning through this case, 65% of these students responded positively. The case presented in this article is somewhat more advanced than the version presented to the junior and senior high students, although the dilemma portrayed is the same.

We found that activities such as small group discussions and role playing enhanced understanding of the case at both the university and high school level. For this case, students were shown samples of MSW compost taken from facilities within the state to help them visualize variations in MSW compost and to reinforce the reality of the case.

This case is suitable for use in introductory soil science, agronomy, environmental science, or nutrition courses. Students may be assigned the case individually or in small, cooperative learning groups. Student response to the case might include a written or oral statement of their decision and rationale, as well as participation in a class discussion of the case facilitated by the instructor. This discussion could focus on questions such as those listed below.

### Questions to Stimulate Discussion and Explore Issues in the Case

**1. What is George McKinley's dilemma?** A dilemma can be defined as having to choose among equally undesirable alternatives. This case depicts a dilemma for McKinley because using his vegetables might have represented a health risk, whereas not using them would have wasted his time, effort, and money.

**2. What unknowns contribute to making this a dilemma for McKinley?** There were several unknowns in this case that caused McKinley to be uncertain as to the safety of his vegetables or the likelihood of heavy metal contamination. For instance, he did not know whether the

compost that he used in the spring was the same as the compost Mary Hansen had used and had analyzed 2 mo later. Although it had come from the same composting facility, characteristics of MSW compost are known to vary over time depending on the kind of waste that was used to make the compost. McKinley did not know how representative Hansen's sample had been of her compost or of his. Thus, he did not know whether the compost he used actually contained contaminants and, if so, whether they were at lower, similar, or higher concentrations than Hansen's. McKinley also did not know whether metals from the compost applied to the garden had actually entered the plants. Even if metals were taken up by the plants, he did not know whether they were translocated to the part(s) of the plants to be consumed. Finally, he did not know whether metals in the edible portion of the plants were at high enough levels to be hazardous to his or other's health. McKinley was relying almost entirely on newspaper accounts for his information, the reliability of which was not known.

**3. What was Jim Duffy stating in his letter and newspaper quote? Do you agree with Jim Duffy's statements?** Jim Duffy was a soil fertility expert at the University. He knew that the processing and use of sewage sludge as a soil amendment had been researched extensively. From this research, guidelines had been established concerning levels of contaminants allowed in sewage sludge. Although some researchers considered the regulations too permissive, Duffy felt the guidelines were useful when applied to sludge. Research on MSW compost itself, however, had been minimal, and Duffy was reluctant to extrapolate results from sludge research to MSW compost. He stated in his letter that more research was needed before he could advocate the use of MSW compost on vegetables.

Duffy also knew that many researchers, as well as the Pollution Control Agency, believed the results from the sewage sludge research were credible and could be used to determine the safety of MSW compost. For example, some researchers believed that risk of heavy metal contamination from MSW compost was negligible. They maintained that it was essentially impossible to consume garden crops that would supply excessive metals, even if a garden was heavily fertilized with MSW compost and humans ate only garden produce for many years.

All researchers agreed that the research on MSW compost itself was incomplete. Duffy cautiously recommended the use of MSW compost on landscape plants only until more extensive research had been done.

**4. How adequate were the PCA guidelines that required compost to be tested four times a year? How valid were the PCA standards for contaminant levels in this compost?** The PCA required quarterly reports from all composting facilities. In these reports, the results from contaminant testing of the compost needed to be included. Facilities could test more often than four times a year. While this allowed the facilities to monitor the compost and its contents, it also allowed them to pick the test results that complied with the guidelines for inclusion in the quarterly report.

The testing was done with sophisticated instruments, and the results of testing the compost for heavy metal contamination were precise. The results were then interpreted against the guidelines established through research on sewage sludge. As noted above, these guidelines were controversial and there was some question whether they were valid for MSW compost.

**5. What options did McKinley have for responding to this dilemma?** The following is a list of possible options that students might give:

- Disregard the potential risks. McKinley may have felt that he had put too much time, energy, and money into the garden to abandon the produce. Furthermore, McKinley might reason that he did not know whether supermarket produce was any safer?
- Do not use the vegetables at all. There was no reason to put his family at risk. It would be difficult to enjoy eating the vegetables knowing the possibility that they were contaminated.
- Get more information—get a second opinion. The newspaper didn't necessarily give all the facts. This option would take time and might waste some of the produce that was ready for harvest now.
- Have some vegetable samples tested for metal contamination. McKinley would need to wait for the results, during which time some produce might again go to waste. There would also be a cost associated with such testing. It is important to explore with students the rationale for such testing and the lack of suitable standards for comparing and interpreting the results.
- Litigate against the master gardener, the Bradford Facility, or the Extension Service. Since McKinley made the decision to acquire and apply the compost himself, it is unlikely that his case against the master gardener, the Facility, or the Extension Service would be strong.

**6. If McKinley could have sold his produce to non-family customers, should this have changed his perspective on his dilemma?** This case provides opportunity to discuss the role of ethics in economic decisions. How would the nature of his decision have changed if selling

the produce was his main source of income? Should he have told his customers about the potential risk of contamination of the produce? Does selling vegetables to customers alter the level of responsibility of McKinley compared to giving it to his family?

**7. Should McKinley have done anything different the following spring considering the likelihood that contaminated compost had been applied to his garden soil?** Since soil contamination was suspected, McKinley might have been more selective about the crops he planted in the garden the following year. For example, vegetables in which the edible portion included the leaves, such as spinach (*Spinacia oleracea* L.), tend to pose greater risk to humans if grown on contaminated soils. McKinley also might have considered moving his vegetable garden to a different location and planting the compost-treated garden space to nonvegetables.

### ACKNOWLEDGMENT

Appreciation is expressed to Dr. Carl Rosen and Mr. Thomas Halbach, University of Minnesota, for their help in clarifying issues in the case, and to the Minnesota Extension Service for its role in reconstructing the facts of the case. We also thank the Minnesota Department of Education for their financial support and encouragement in developing this case.

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# The Beach Dairy Farm Case Study: Management of Rotational Stocking

Craig C. Sheaffer,\* Melvin J. Stanford, Charlene Chan-Muehlbauer, and Douglas Gunnick

## ABSTRACT

In the spring of 1992, Roger Beach was considering whether to use a seasonal milking strategy for his Holstein dairy cow (*Bos taurus*) herd. Beach, his wife Ellen, and their two sons operated a medium size dairy farm in southeastern Minnesota. In 1989, they switched from year-round confinement feeding to a rotational stocking system where cows obtained most of their feed from pasture for about 6 mo of the year. In the spring of 1992, they were considering implementing seasonal milking during the months when pasture was available, which seemed to fit in well with rotational stocking. The change to intensive rotational stocking from confinement feeding was motivated by economic crisis and a challenge to save the farm while improving quality of life; in contrast, the new decision whether to change to seasonal milking was based on a desire for further improvement of farm profitability and quality of life. Changing to seasonal milking would require considerable dairy cow management skill, and the Beaches faced a risk of decreasing profit from what they considered to be a successful operation. Through this case, students will learn terminology and concepts associated with intensive rotational stocking and seasonal milking in contrast to conventional dairy cow feeding. Students will gain understanding of the factors and risks involved in a major farm restructuring decision.

**T**HERE HAS BEEN a dramatic decrease in the number of Midwest dairy farms. In Minnesota alone, dairy farm numbers decreased from 26 000 in 1982 to 14 000 in 1992 (Minn. Agric. Stat. Serv., 1993). Failure of many medium and small sized family dairy farms has been related to decreased milk prices and increased equipment, energy, and feed costs. Increasing farm and herd size is often recommended as a solution for maintaining viable dairy operations, but this is not an option for many families. As an alternative, the Beach family successfully changed from confinement feeding to rotational stocking of dairy cows as a feeding strategy. The Beaches then considered seasonal milking. This case provides insight into the economic and quality of life issues that influence decision making by dairy farmers.

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## THE CASE

Early in 1992, Roger Beach was reviewing the results of his rotational stocking program and considering whether to implement seasonal milking. Beach, his wife Ellen, and sons Mike and Joe operated a 68-cow (*Bos taurus*) Holstein dairy farm on 135 ha (334 acres) in southeastern Minnesota. The farm was on a rolling landscape with a 3 to 7% slope. The predominant soil was a Mt. Carroll silt loam (fine-silty, mixed, mesic Mollic Hapludalfs) with about 15% Seaton silt loam (fine-silty, mixed, mesic Typic Hapludalfs). The Milliken Creek flowed through the property. The Beaches had started a program of intensive rotational stocking 3 yr earlier, in the spring of 1989. Now they were interested in implementing seasonal milking, which involved freshening of dairy cows in the spring when they started on pasture and beginning the dry period at the end of the grazing season in late fall. Seasonal milking appeared to the Beaches to be a natural extension of rotational stocking because cows would have their greatest nutritive requirements in the spring and early summer when the forage growth and quality were highest. They also thought that seasonal milking would fit their philosophy of a sustainable farm operation where most feed was produced on the farm, where labor was reduced, and where the quality of life was improved.

## Farm Background

Roger and Ellen Beach had been farming since 1974. They rented the farm from Ellen's family, who had owned it for three generations. Before starting on the program in 1989, the Beaches had run a typical crop and livestock operation for some time. They had grown about 48 ha (120 acres) of corn (*Zea mays* L.), 44 ha (110 acres) of alfalfa (*Medicago sativa* L.), and 16 ha (40 acres) of oat (*Avena sativa* L.). Yield of corn, alfalfa, and oat were 10.7 Mg/ha (171 bu/acre), 9 Mg/ha (4 ton/acre), and 2.8 Mg/ha (80 bu/acre), respectively. About 28 ha (70 acres), which were not tillable, were in permanent pasture and were used for young stock and dry cows. The permanent pasture was primarily perennial grasses {'Kentucky' bluegrass (*Poa pratense* L.), quackgrass [*Elytrigin repens* (L.) Nevski], and smooth brome (*Bromus inermis* Leyss)} with small amounts of white clover (*Trifolium repens* L.), alsike clover (*Trifolium hybridum* L.), and broadleaf weeds. They fed dairy cows in a stanchion free-stall barn using a confined feeding system. They also had a farrow-to-finish hog (*Sus vittatus*) operation producing 1000 hogs/yr.

The farm had a complete compliment of equipment to produce round or small square bales as well as for chopping silage and haylage for three silos. The Beaches also

owned a combine, grain drill, and corn planter. Most equipment was 10 to 15 yr old.

The crop production strategy on the Beach farm had changed dramatically with the initiation of intensive rotational stocking in 1989. The land that had been in crops before intensive rotational stocking was seeded to a mixture of grasses and legumes to enhance species diversity. In addition to quackgrass—which had volunteered in the fields—smooth bromegrass, tall fescue (*Festuca arundinacea* Schreb), white clover, red clover, and alsike clover were seeded. Fields that were previously in alfalfa had been allowed to evolve into pastures consisting of diverse mixtures of adapted grasses, legumes, and weedy forbes. Corn was no longer produced on the farm.

Beach described his reasons for getting into intensive rotational stocking. "At the height of the farm crisis in the early 1980s, I worked with the Rural Educational Resource Center, advocates who worked with farmers in trouble. I heard all the misery, pain, and agony, and it became very apparent that however good the intent was, they were just refinancing people and putting them in the same scenario that got them into trouble. And unless someone artificially raised prices, farmers were going to go out of business."

By early 1989, Beach was becoming seriously concerned about the future of the farm. He recalled, "I had gotten up to a 9534 kg (21 000 lb) herd average at one time in 1988, and we had some pigs. We were doing everything right according to university extension and I wasn't making money. I looked around and I thought it must be me, because everyone else claimed to be all right. Maybe I should work harder. But I was not making enough profit to survive. If I hadn't been dealing with my mother-in-law, I wouldn't have been able to keep this farm. . . I remember a neighbor calling me up and asking me to go to a meeting [on rotational stocking]. Both my wife and I went to this meeting that changed our lives. What we heard was a couple of guys from Wisconsin talking about grazing, and I don't remember who all was there. Anyway, it was after the '88 drought and we had to buy some forage, and we thought, 'this is going to kill us to have to buy forage on top of everything else.' We decided that we had to do something different—either that or leave the farm. So on the way home we decided to change."

### Intensive Rotational Stocking

The impetus for the large-scale use of confinement feeding of dairy animals in the U.S. began in the post-World War II era of cheap energy and N fertilizers, pesticides, and mechanization of crop production. In addition, confinement feeding provided an opportunity to control feed available to cows. Farmers were encouraged (by government agricultural programs) to utilize new technology, and to maximize production of grain crops. Grain was in surplus and was an inexpensive source of feed. New machinery for harvesting, packaging, and storage of forage crops was available at a reasonable cost. Consequently, the use of pasture as a primary source of feed declined dramatically and the pasturing of dairy cows became regarded as *old fashioned*. Pasture use in the dairy industry was then primarily for nonmilking heifers and

dry cows. The lack of good grazing management often resulted in under- or overutilization of the pasture and ultimately resulted in a decline of the forage resource.

Intensive rotational stocking, as practiced by the Beaches, was a type of rotational stocking in which grazing animals were placed in an individual paddock for about 12 h and were then moved to fresh forage in a new paddock following milking. The time required for cattle to rotate back to a grazed paddock varied with the pasture growth rate; it could be as short as 2 wk in the spring and as long as 6 wk in midsummer. During most of the grazing season, cattle removed forage to a 7- to 10-cm (3- to 4-in) stubble height; however, in the early spring when forage was abundant, the stubble height was greater. Grazing was typically initiated in early May when the grass was about 2 to 5 cm (1-2 in) tall and continued through October. In the spring, some pastures that matured before grazing were harvested as hay.

Beach worked with his local feed dealer in developing balanced rations to meet nutrition needs of cows at different stages of lactation. Ration ingredients during pasturing consisted of pasture forage, corn grain, alfalfa-grass hay, minerals, and vitamins. When cows were milking and off pasture, these same ingredients (except pasture forage) were ration ingredients. The nutrient and fiber concentration of pasture forage was determined by weekly sampling. Dry cows and heifers obtain their total ration from pasture.

Initially, the Beaches used portable fencing and varied paddock size, depending on forage production and need, but more recently they had begun using a permanent paddock system with a paddock size of 1.2 ha (3 acres). However, they still retained the flexibility to graze hay fields, road sides, and other crop land using portable fencing. Water for most pastures was provided through portable tanks and hose. For some pastures, cows obtained water from the Milliken Creek. Fencing and watering cost the Beaches about \$25/ha.

The first year (1989) with rotational stocking, the Beaches' average annual milk production per cow was 7492 kg (16 503 lb), a slight decline from 7625 kg (16 795 lb) in 1988 (Exhibit 1). Both of these levels were a little higher than the average for farms in southeast Minnesota, which was 7204 kg (15 867 lb) in 1988 and 7395 kg (16 289 lb) in 1989 (Exhibit 2). By the end of 1991, the Beach milk production per cow was 8268 kg (18 211 lb), considerably higher than the area average of 7571 kg (16 677 lb). Beach felt that they were making good progress with intensive rotational stocking.

Return over costs per cow had risen to \$687 in 1991, which was much higher than the area average of \$198 for that year (Exhibits 1 and 2). Return to capital and family labor for the Beach farm had declined from \$40 829 in 1988 to \$37 102 in 1989, but then it rose to \$49 527 in 1990 and \$50 337 in 1991 (Exhibit 1). The area average had risen from \$45 774 in 1988 to \$54 709 in 1990, but had declined to \$33 285 in 1991 (Exhibit 2). Some of the farm income in 1991 was still from crops, but Beach believed that the major increase in profitability was from dairy, with some profit also from hogs, which were being phased out. He estimated that the savings in the dairy operation were based primarily on feed and labor

**Exhibit 1. Dairy, farm, and family resource and financial statistics for the Beach farm.†**

Item	1987	1988	1989	1990	1991
<b>Dairy</b>					
Milk produced per cow, kg	6 987	7 625	7 492	7 551	8 268
Price received per kg milk, \$	0.27	0.26	0.28	0.31	0.29
Total feed cost per cow, \$	758	866	844	690	670
Feed cost per kg milk, \$	0.18	0.22	0.22	0.24	0.21
Return per \$100 feed fed, \$	246	220	254	336	363
Return over all costs per cow, \$†	638	249	428	515	687
<b>Farm and family</b>					
Total ha	138	138	138	136	135
Return to labor and management, \$	28 021	28 461	24 601	45 746	37 863
Return to capital and family labor, \$	39 592	40 829	37 102	49 527	50 337
Net cash operating income, \$	44 615	30 023	44 615	38 291	66 931
Total assets, \$	191 795	200 119	209 030	245 130	251 934
Total liabilities, \$	166 670	161 906	169 184	169 952	159 044
Equity, \$	25 125	38 213	39 846	74 178	92 890

† Source: Record analysis for the Beach farm. Farm Business Management Association of Southeast Minnesota, 1991.

‡ All costs include labor, feed, utilities, veterinary, fences, building, and power and machinery.

**Exhibit 2. Dairy, farm, and family resource and financial statistics for farms in southeastern Minnesota.†**

Item	1987	1988	1989	1990	1991
<b>Dairy</b>					
Milk produced per cow, kg	6 915	7 204	7 395	7 517	7 517
Price received per kg milk, \$	0.28	0.27	0.29	0.30	0.26
Total feed cost per cow, \$	657	812	922	894	894
Feed cost per kg milk, \$	0.10	0.11	0.12	0.12	0.12
Return per \$100 feed fed, \$	268	219	221	244	208
Return over all costs per cow, \$†	596	161	390	495	198
<b>Farm and family</b>					
Total ha	173	177	183	187	192
Return to labor and management, \$	49 415	39 253	40 510	45 530	28 258
Return to capital and family labor, \$	50 885	45 774	46 890	54 709	33 285
Total assets, \$	393 448	421 606	435 981	419 812	494 226
Total liability, \$	208 139	204 507	196 909	201 926	212 964
Equity, \$	185 309	217 099	239 071	274 642	281 262

† Source: Annual report Farm Business Management Association of Southeast Minnesota, 1987–1991. Values are an average of 350 to 490 acre farms.

‡ All costs include labor, feed, utilities, veterinary, fences, building, and power and machinery.

with straw, fuel, and electricity also having lower costs (Exhibit 3). Overall, the Beach farm had less assets and liability than area farms. Equity had increased at a greater rate than the area average, partially because of the decrease in liability.

**Environmental Considerations**

Although environmental concerns were not the primary motivation for the Beaches to change to intensive rotational stocking, they believed that intensive rotational stocking had a positive impact on their landscape. For one thing, they had eliminated pesticide and chemical fertilizer usage. Beach found it unnecessary to use herbicides on his pastures because weeds such as quackgrass and dandelion (*Taraxacum officinale* Weber) are nutritious forage crops. Other pasture weeds such as curly dock (*Rumex crispus* L.) and bull thistle [*Cirsium vulgare* (Savi) Tenore] were becoming less of a problem as grass stands thickened. He had also stopped spraying his grain crops during his first year of intensive rotational stocking, and he noticed that his crop yields did not decline. Manure-handling labor and costs had declined greatly during the grazing season. Manure was spread by livestock as they were rotated through the paddocks. Beach felt that this provided for more uniform fertilization over the farm and

**Exhibit 3. Estimated savings in production costs per year from an intensive rotational stocking system compared with production costs with conventional feeding in 1988.†**

Item	1989	1990	1991
	— estimated \$ saved —		
Purchased feed‡	7 156	9 574	1 035
Corn	—	7 350	9 450
Labor (3 h/d × 170 d × \$7/h)	3,570	3,570	3,570
Straw (4 bales/d × 170 d × \$1/bale)	680	680	680
Electricity§	450	450	450
Fuel§	500	500	500
Total savings	12 356	22 124	15 685

† Source: Values were based on calculations by Roger Beach.

‡ The biggest savings have come from reduced purchase of forage. Cows received about 88% of their forage ration from the pasture. The rest of their feed costs (grain, mineral supplement, hay, etc.) were also reduced by not as dramatically as forage costs.

§ The savings in fuel and electricity come from reduced manure-handling and reduced costs of running a haybine, chopper, baler, wagon, silo, etc. during the months of grazing. Since the cows are on pasture, they do not require straw in their stalls, which saves money as well as labor and time.

prevented excess accumulation in lots adjacent to the barn.

Another indicator of environmental quality that was important but difficult to measure was the effect on songbirds and wildlife. Since going on intensive rotational stocking program, Beach had observed that songbirds, which had largely disappeared from his area, were be-

ginning to return. He felt that the forages in pastures provided more nesting sites for the songbirds than did cultivated fields. Also, birds were not harmed by eating insects because toxic pesticides were not being used. Along with the songbirds, Beach was seeing greater numbers of predators, such as turkey vultures (*Cathartes aura*) and foxes (*Vulpes vulpes*).

### Seasonal Milking

Seasonal milking is a dairy feeding system in which the period of herd milk production is coordinated with seasonal pasture production. The Beaches were contemplating a plan to have their cows calve in April with grazing to begin in early May. Pasture would be the primary food source until late December. Cows would be dry in January, February, and March. The date of discontinuing milking and the length of the dry period would vary depending on forage availability, supplies of stored forage, feed costs, and the farm income situation. Shorter dry cow periods were expected to provide more profit, provided feed costs weren't too high. In addition, according to current recommendations from the University of Minnesota, dry periods of longer than 8 wk often reduce subsequent lactation. Seasonal milking was considered to fit in well with rotational stocking, because cows in lactation with high nutrient needs would be able to harvest feed from pasture. In the winter, dry gestating cows would be fed lower quality stored feed.

Improved profitability was one of the Beaches' goals. However, they were not trying to maximize production. Beach said, "My primary objective is to cut spending. The most important thing to me is labor. Even more important than money is saving labor. What I'm trying to do is redesign my farm so that I don't have to work so hard, so that it's fun to farm, and so I can make a lot of profit. But profit is a secondary thing, not the most important. The quality of life is most important. If you don't have money, then you can't have quality of life. But if you're working all the time you can't have quality of life. . . You're going to find that the more in trouble farms are, the more money ranks above labor. I just saw a survey in some magazine that said that 90% of the farmers said they would rather have money, but that's just because they are strapped for money. I'm in the situation now that labor is more important than money."

Beach had been considering seasonal milking for some time. There were several attractions to seasonal milking. Reduced yearly feed costs were expected to be the principal savings. Summer feed costs would be low since most feed for lactating cows would be produced in pastures on the farm. Some grain would be purchased as a feed supplement. In the winter, dry gestating cows would require a lower volume and quality of feed; consequently, less feed would need to be produced and harvested (or purchased) for winter. Beach also figured that some other expenses, such as labor, veterinary expense, fuel, seed, and machinery costs would be lower with seasonal milking.

The main drawback to seasonal milking was that there would be several months of no milk production, and therefore no revenue, because all of the cows would be

**Exhibit 4. Comparison of projected income and expenses for seasonal and year-round milking of rotationally stocked dairy cows.†**

Item	Herd milking	
	Seasonal	Year-round
	\$	
Income‡	128 705	147 095
Expenses§		
Veterinary and miscellaneous livestock	8 000	14 000
Feed supplements	9 000	20 000
Repair and maintenance of machinery	10 000	36 000
Fuel	4 000	8 000
Labor	40 000	50 000
Corn	9 690	14 250
Straw	200	2 100
Hay	3 750	7 125
Dairy Herd Improvement Association	0	1 560
Total expenses	84 640	153 035

† Source: Worksheet estimates prepared by Roger Beach based on Beach farm records, February 1992.

‡ Seasonal milking income based on 75 cows producing 6356 kg of milk/cow. Year-round milking income based on 75 cows producing 7264 kg milk/cow. Milk valued at \$0.27/kg.

§ Additional labor savings could occur if labor were reduced. Beach will add more cows to fill in some of that time (instead of letting someone go) and also to improve profitability.

dry. Under a conventional milking system, cows in the herd are dried up at different times, and a herd consisted of both dry and milking cows throughout the year. According to information from the Animal Science Department at the University of Minnesota, a typical calving interval for a dairy cow in Minnesota was 13 mo. A period of 305 d in milk was used as an average, although it was fairly common practice for dairymen to continue milking a cow up to within 50 to 60 d of calving. Milk production would decline as a cow dried up. Accordingly, a cow on a 13-mo calving cycle would be milked 10 or 11 mo and dry for 2 or 3 mo before freshing again. The average calving interval in the Beach herd had been 12.8 to 12.9 mo, according to Beach's records.

In February of 1992, Beach made estimate of income and expenses for seasonal milking (Exhibit 4). Assuming a 75-cow herd, he figured that with seasonal milking, his cows would average 6356 kg (14 000 lb) of milk per year. He also estimated that dairy expenditures associated with seasonal milking would be about \$84 640, about half the expenditures projected for his present system.

Beach was enthusiastic about the reduction in farm labor that had resulted from his intensive rotational stocking program, and he was very interested in the potential labor savings of seasonal milking. He later observed, "Obviously, seasonal dairying looks great when you look at labor. With year-around milking, we usually worked 5 am to 7 pm, 6 d a week. On Sunday, we have done chores 4 h in the morning and 4 h at night. We get some help in the busy season. We have wanted to do something different. I sure don't want my sons to have to do this. We started looking at things and we realized that we could make a living milking cows on a 40-h work week. . . That's what I intend to do. A 40-h week for every employee, whether that's one or five. . ."

Beach's personal definition of success has changed since he began using an intensive rotational stocking sys-

tem. "I used to think in terms of getting my work done," said Beach. "I measured it by a lot of things—how active and involved I was and also by production goals. My manhood was tied up into this farm. So I was successful if my herd average was  $x$ , and bushels of corn was  $x$ , and if I'm done the same time as my neighbors, or ahead of them if possible. It had nothing to do with spending time with my wife and kids. We didn't talk about it a lot. . . Thinking about quality of life was just a luxury, and I was just trying to survive. I knew I could get a job someplace else. You get so tied up in this spiral that you can't get out.

"We were concerned about what the neighbors might think about rotational stocking, but we decided to go ahead with it. Now, I'm not too concerned about what others think about our change to seasonal milking. We have to be careful not to judge other people's systems. Maybe what they're doing meets their needs. But it's up to them to decide if they want to make changes or not. We should encourage each other to be all that we can be. Too often we end up competing with each other."

### INTERPRETIVE NOTE (SHORT FORM)

Roger and Ellen Beach and their sons, Mike and Joe, operate a dairy farm in southeastern Minnesota. They rent the farm from Ellen's family, who had farmed it for three generations. The farm has dairy cow numbers and crop acreage that is typical of many farms in the region. The Beaches are hardworking and dedicated farmers who had followed recommendations of the dairy industry and university extension. They were successful in terms of milk production but faced an uncertain economic future. They considered their quality of life to be low, because long hours of work limited time for personal and family activities. The Beaches changed to intensive rotational stocking as an alternative feeding strategy and felt that farm profitability and quality of life had improved. They are now considering seasonal milking to complement rotational stocking.

### Case Objectives

This case could provide an understanding of the issues that have caused dairy farmers to consider alternative dairy cow feeding practices. Upon completion of the case, students should:

1. Understand intensive rotational stocking and seasonal milking as alternatives to conventional dairy herd management practices.
2. Understand that decision making by dairy farmers is complex and is influenced by quality of life, philosophical, environmental, and economic issues.
3. Be familiar with reports compiled from farm records.
4. Have considered causes and implications of major transitions in farming.

### Use of the Case

This case was prepared for classroom and extension education. It can be used by students and professionals

interested in sustainable agriculture, dairy science, sociology, agronomy, and agricultural economics. The influence of personal values and economics on producer decision making are examined. In a forage class, the case could be used in a discussion of pasture management. It provides information on intensive rotational stocking of dairy cows as an alternative feeding approach. Farm records are provided to allow a comparison of the Beach farm with others in the area.

### Issues in the Case

Many farm families have adopted farm management practices that emphasize environmental quality, economic viability, and quality of life. The initial changes that the Beaches made to intensive rotational stocking improved farm profitability and quality of life. The change to seasonal milking represents a modification of an already successful activity. Consequently, there are economic and personal risks. The following questions will direct case users in understanding the Beaches, their farm operation, and the decision they face. The authors' insights into these issues are provided in a full interpretive note. An example of author insight is provided for in Question 4.

1. What are the Beaches' objectives?
2. What options do the Beaches have in achieving these goals?
3. How does seasonal milking differ from conventional dairy herd management practices? Why do the Beaches consider seasonal milking to be a natural extension of intensive rotational stocking?
4. What are the quality of life issues affecting the Beach change to intensive rotational stocking and contemplated change to seasonal milking?
5. What risks are associated with a change to seasonal milking?
6. What additional environmental considerations exist with intensive rotational stocking as practiced by the Beaches?
7. How do the Beaches compare with other farmers in the area in terms of milk production, feed cost per cow, feed cost per kilogram of milk, returns over costs per cow, and return to labor and management?
8. What should the Beaches do? Why?

**Author's Insights for Question 4.** Economic survival and quality of life are key issues in decisions by the Beaches. They changed to intensive rotational stocking after recognizing that milk production and high herd averages did not necessarily result in an economically viable enterprise. In addition, with the conventional dairy system, Beach felt overwhelmed by the never-ending labor associated with year-round milking. The Beach family felt that their overall quality of life was low. Beach is no longer under the stress of struggling to survive and now feels he has the power to change his life.

Farmers are often believed to be influenced by peer pressure and often compare their farming practices with those of their neighbors. A little *friendly competition* is not unusual. The Beaches had been concerned about how neighboring farmers would view their change to

intensive rotational stocking, but since they have been successful, they now seem unconcerned about how their neighbors feel about a change to seasonal milking.

Beach's goal is a 40-h work week for all workers on the farm. Achieving this goal on a year-round basis will require balancing barn and field work. The primary labor requirement in the future will be milking, since crop

production will be minimal. The primary field activity in addition to moving fences and cattle will be hay-making.

## REFERENCES

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# Swine Waste Disposal Dilemma: A Case Study

Robert L Mikkelsen\*

## ABSTRACT

The swine industry has grown rapidly in North Carolina in the past decade, with the majority of the growth occurring in a few counties in the Coastal Plain region of the state. With this expansion has come the problem of swine waste disposal. Mr. Blevins, a local farmer in this region, has been raising swine since 1985. The swine waste on his farm is collected in an anaerobic lagoon and then irrigated onto a bermudagrass [*Cynodon dactylon* (L.) Pers.] pasture where cattle are fed using intensive rotational grazing techniques. A study of Mr. Blevins' farm revealed very high nitrate concentrations in the groundwater ( $>110 \text{ mg NO}_3\text{-N L}^{-1}$ ) and high nitrate levels ( $>15 \text{ g NO}_3\text{ kg}^{-1}$ ) in the bermudagrass forage. The soil concentrations of other nutrients such as P, K, Zn, and Cu were also increasing. A case study of Mr. Blevins' operation was developed to encourage classroom discussion and small group analysis of waste disposal issues. The case was the central focus for subsequent lectures in class involving the N cycle. The students were shown a video recording of Mr. Blevins discussing his operation and his concerns for the future. A video of an interview with the administrator for the state regulatory agency was also shown to provide a public policy perspective. The students were asked to make a nutrient management recommendation for Mr. Blevins. A follow-up session was held to discuss the recommendations and review the use of a decision tree for systematically organizing the available information.

THE SWINE INDUSTRY has grown rapidly in North Carolina and there is concern about the proper management and disposal of waste materials produced on the farm. This case highlights the nutrient management problems of one successful farmer and provides students an opportunity to examine issues from the perspective of both the farmer and the state regulatory agency. The data for this case were gathered by monitoring the farmer's production practices over a two-year period (Mueller et al., 1994).

## THE CASE

Mr. Blevins has lived on a farm in Sampson County, North Carolina, for most of his life. Following high school, he attended North Carolina State University and earned a B.S. degree in Agricultural Education and Animal Science. He taught high school in Sampson County for several years before deciding to make a career change. After doing some investigation, he borrowed money to buy land, built two finishing houses, a clay-lined lagoon, and the equipment required to raise swine. In 1985, Mr. Blevins signed a contract with a large regional swine integrator, to raise *farrow to finish* pigs. In this operation, Mr. Blevins receives pigs that have been recently weaned and raises them for 4 to 5 mo until they obtain a weight of 100 to 110 kg. At this point, the pigs are

ready to be delivered to the integrator and transported to market. The two houses allow him to raise 1240 pigs each cycle.

Mr. Blevins says that the swine operation has been profitable for him, and he is glad he made the decision to get into the business before the boom in production occurred a few years later (Exhibit 1). Mr. Blevins cares for the swine by himself, with minor veterinary assistance when needed. In addition to the swine operation, Mr. Blevins has also built six large turkey houses, which he operates with help from his family.

Mr. Blevins rinses the slotted cement floors of the swine house every 4 h by flushing with liquid effluent pumped from the swine lagoon. The lagoon effluent is used to remove fresh manure and urine from the floor and return it back into the lagoon with the drainage. Anaerobic lagoons are common in many swine production facilities and poultry layer units where they are used for manure treatment. The swine manure is *digested* or decomposed within the reduced zone of the lagoon, with methane being a primary by-product (Exhibit 2). The only fresh water used in the operation is the drinking water available to the pigs.

Approximately 18 mo after beginning with his first group of swine, the lagoon began to fill up and reach the top of the bank. Mr. Blevins decided to build a *solid-set* permanent irrigation system on the 2.5 ha surrounding the two swine houses. The soil in this area is a well-drained loamy sand in the surface horizons (Exhibit 3). The irrigation system cost approximately  $\$2500 \text{ ha}^{-1}$  to install. He sprigged hybrid bermudagrass on this land during the spring of 1986 and irrigated it regularly with lagoon effluent through the first summer (Exhibits 4 and 5).

"The growth of the hay was remarkable," says Mr. Blevins. He saw the opportunity to turn *waste* into profit by grazing young cattle on the hay fields. Grazing cattle on the pasture avoids the potential weather damage that frequently occurs to

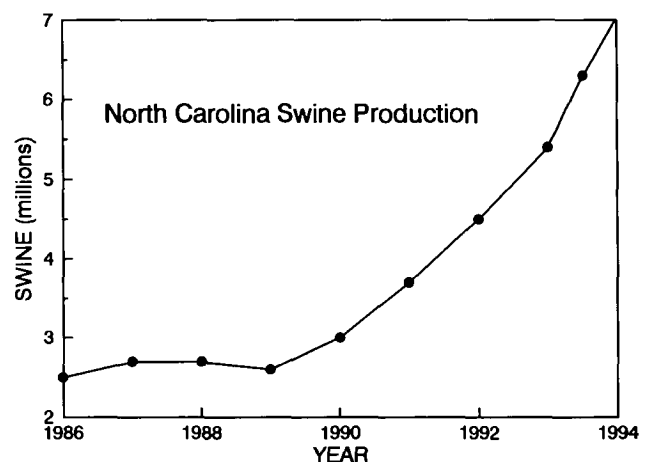


Exhibit 1. The growth of the swine industry in North Carolina from the 1986 to 1994 (NCDA, 1994).

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Abbreviations: PAN, plant-available nitrogen.

**Exhibit 2. Average nutrient content of anaerobic lagoon liquid from swine manure and daily production of 80 kg fresh swine manure (based on 1000 kg of animal weight; from NCSU, 1990).**

Waste	Lagoon liquid composition											
	TN†	NH <sub>4</sub> -N	P	K	Ca	Mg	S	Na	Fe	B	Zn	Cu
Lagoon liquid	660	540	110	535	128	40	48	283	11.5	1.0	7.3	1.5
Fresh swine manure	500	300	375	350	320	68	73	635	15.0	3.0	5.0	1.0

†TN denotes total nitrogen.

**Exhibit 3. Soil profile description of Norfolk loamy sand (Typic Kandiudults) found on Mr. Blevins' pasture.**

Horizon	Depth	Description
	cm	
Ap	0-20	Grayish brown, loamy sand, medium granular structure, medium acid
E	20-33	Very pale brown, loamy sand, medium granular structure, medium acid
Bt	33-210	Yellowish brown, sandy clay loam, weak sub-angular blocky structure, strongly to very strongly acid
C	210-250	Strong brown, sandy loam, mottles, massive structure, very strongly acid

**Exhibit 4. Estimated first-year nutrient availability coefficients for crops fertilized with swine lagoon effluent using various application methods (Zublena et al., 1990).**

Nutrient	Injection	Incorporation	Broadcast	Irrigation
Phosphorus	80	80	70	70
Potassium	80	80	70	70
Nitrogen	90	80	40	50

**Exhibit 5. Typical N fertilization guidelines and N uptake for crops grown in Sampson County, NC (North Carolina State Univ., 1995).**

	N fertilization rate	Crop N uptake
Irrigated corn (silage)	10-15 kg Mg <sup>-1</sup>	3-5 kg Mg <sup>-1</sup>
Irrigated corn (grain)	18-27 kg Mg <sup>-1</sup>	13-15 kg Mg <sup>-1</sup>
Bermudagrass hay	25-30 kg Mg <sup>-1</sup>	20-25 kg Mg <sup>-1</sup>
Rye	25-30 kg Mg <sup>-1</sup>	20-25 kg Mg <sup>-1</sup>
Trees	100-170 kg ha <sup>-1</sup> yr <sup>-1</sup>	10-50 kg ha <sup>-1</sup> yr <sup>-1</sup>

**Exhibit 6. Typical nutrient excretion by grazing cattle (Cullison and Lowery, 1987).**

Nutrient excreted	% of ingested	Dominant pathway and form
Nitrogen	85-90	60% in urine, 80% of urine-N present as urea
Phosphorus	75-80	Mainly in manure, 50% as inorganic P (primarily dicalcium phosphate); organic forms include inositol hexaphosphate and ATP
Potassium	90-95	Excreted primarily in urine as inorganic K <sup>+</sup>

hay in Sampson County associated with excess rainfall. Using the grassland for grazing also avoids the capital investment required for the hay-making equipment. Thirty-three cattle were placed on this land and they grew very rapidly (as much as 0.8 kg gain d<sup>-1</sup>). In fact, these cattle could not graze the grass fast enough to keep up with the growth, so that first year he borrowed additional cattle from his neighbor to manage the rapidly growing bermudagrass. Today, he grazes 50 to 60 cattle each year on this tract.

To improve cattle gains and pasture performance, Mr. Blevins now uses a rotational grazing technique whereby the pasture is divided into six separate paddocks using a move-

able electrified fence. The cattle remain in one paddock until all the forage has been consumed. The cattle are then introduced into the next paddock, while the previous paddock is irrigated and fertilized with swine lagoon effluent (Exhibit 6). This technique generally results in more efficient and uniform utilization of the grass in the pasture than does free grazing. He expects to produce the equivalent of approximately 13 to 18 Mg hay ha<sup>-1</sup> during the bermudagrass growing season (May-September).

Mr. Blevins applies 350 to 400 kg plant-available N (PAN) ha<sup>-1</sup> to the bermudagrass in biweekly intervals through the irrigation system during the growing season. During the autumn, the pasture is overseeded with rye (*Secale cereale* L.) and is irrigated with an additional 170 kg PAN ha<sup>-1</sup> during the period between October and April. The rye provides a winter pasture for the cattle and an outlet for the lagoon effluent produced during the winter. Mr. Blevins owns an additional 3 ha of cropland across the public road near his house that also is available for effluent disposal if needed. However, he has never used it for this purpose, because pumping the effluent across the road is impractical due to the traffic.

Mr. Blevins states that he is following the current university recommendations for waste management (Zublena et al., 1990) and has not noticed any serious problems resulting from his current practices. However, Mr. Blevins is concerned about the potential buildup of metals in his soil as a result of repeated effluent application. He recognizes that "cutting the bermudagrass for hay might remove more of the nutrients from my farm, but I am not interested in being in the hay business. There are too many problems associated with producing hay in Sampson County." He feels that he may need to purchase more land in the future, but the need is not urgent. Although his home is only a few hundred meters from the swine houses, he sympathizes with those who complain about the odor associated with swine production. He is not opposed to regulations regarding waste management and farmland zoning if it protects the ability of farmers to safely and efficiently practice their profession. He feels that he has had excellent support from the North Carolina Cooperative Extension Service and the USDA-Soil Conservation Service in the initial design and subsequent operation of his farm.

A 1990-1991 study of the groundwater beneath Mr. Blevins' pasture revealed high nitrate concentrations in some wells (Exhibit 7). The bermudagrass continues to grow extremely well, but Mr. Blevins has some concerns about the nitrate concentration in the forage (Exhibit 8). He currently is following a nutrient management plan (NCCES, 1994), but feels that additional enforcement from the state may be needed to ensure that all his neighbors are also managing their animal wastes in an appropriate manner. Mr. Blevins would consider other options for effluent disposal if they were



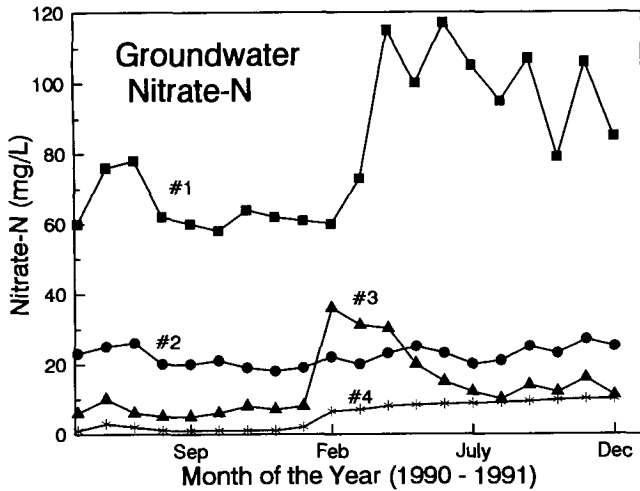


Exhibit 7. Nitrate concentration in groundwater from four wells (#1-#4) beneath the bermudagrass pasture receiving swine lagoon effluent on Mr. Blevins' farm, from 1990 to 1991.

practical and did not severely interfere with his current operation. Neighbors grow corn (*Zea mays* L.) on the north side of his grazed pasture and loblolly pine (*Pinus taeda* L.) on the south.

Mr. Blevins needs to decide how he will manage his swine lagoon effluent in the coming years. He feels that regulatory pressures will continue to increase. He would like to be in a position to pass on the business to his children if they are interested.

### CASE EXHIBITS

To emphasize the importance and magnitude of the potential problems with waste management, a chart depicting the explosive growth of the swine industry in North Carolina is provided (Exhibit 1). Information related to the daily production of swine waste and its nutrient value are also provided with the case (Exhibit 2). The students are provided with a

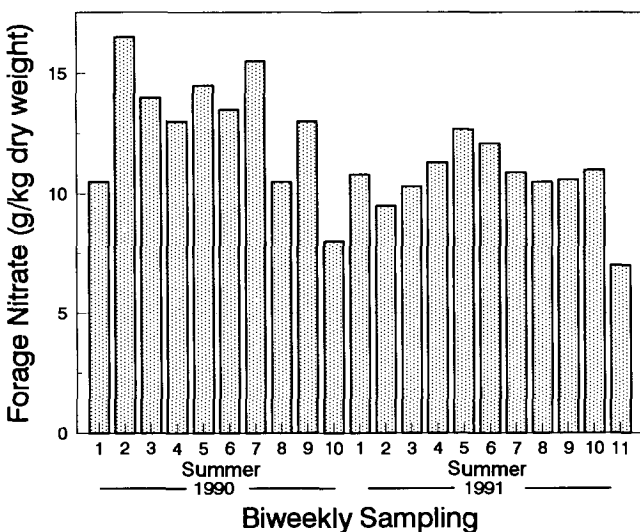


Exhibit 8. The nitrate concentration in bermudagrass samples measured at biweekly intervals during the summer of 1990 and 1991 from Mr. Blevins' pasture receiving swine lagoon effluent.

Exhibit 9. The soil concentration of selected nutrients from the bermudagrass pasture irrigated with swine lagoon effluent (data from June 1990 and December 1992).†

Depth cm	P		K		Zn		Cu	
	1990	1992	1990	1992	1990	1992	1990	1992
	kg/ha							
0-15	232	>420	294	381	2.6	10.5	0.9	5.3
15-30	77	372	366	364	0.8	4.8	0.9	3.3
30-60	8.7	90	707	2770	0.4	2.8	0	3.6
60-90	6.7	27	695	1588	0.5	2.0	0	2.5

† Soils extracted with Mehlich-3 solution (Mehlich, 1984).

description of the soil on the farm for a determination of the nitrate-leaching potential from the pasture (Exhibit 3). This farm is located on the Coastal Plain region of the southeastern USA, derived from coarse-textured marine sediments. The plant availability of nutrients from waste products will vary depending on the method of application used (Exhibit 4). This allows the students to examine the possibility of alternative methods of waste application. Typical fertilization recommendations are presented for several crops and compared with the N uptake by these crops (Exhibit 5). Since the grazing cattle are an important part of the nutrient cycle on this irrigated pasture, typical nutrient excretion patterns are provided for cattle (Exhibit 6). The nitrate concentration of groundwater from four wells in his pasture is given over a 2-yr period (Exhibit 7). The concentration of nitrate in the bermudagrass pasture was determined during two summers and is presented in Exhibit 8. The buildup of various nutrients in the soil receiving swine lagoon effluent is documented in Exhibit 9. The options for managing the N in swine lagoon effluent are presented as a decision tree to provide the students with a logical framework for the waste management options (Exhibit 10).

### TEACHING NOTES

#### Case Objectives

This case can be used to expose students to the management decisions that farmers encounter when dealing with complex production issues. In this case study, the concerns of

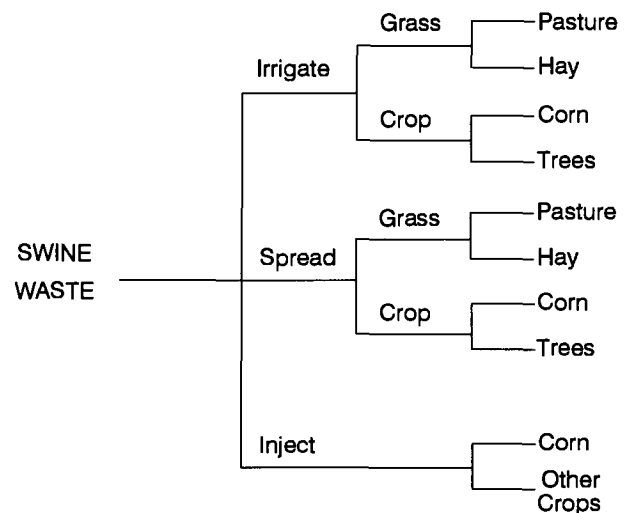


Exhibit 10. Selected options for disposing swine lagoon effluent based on N management decisions.

waste disposal in a rapidly growing industry are examined through the perspective of an individual swine producer. Clearly, the current practices are not sustainable for prolonged periods of time without excessive environmental degradation and potential health risks for the cattle grazing on the bermudagrass pasture.

When the students have completed an analysis of the case, they should be able to:

1. Synthesize multidisciplinary information from a variety of sources regarding nutrient use and management within a farming-grazing production system
2. Be able to understand the complexity and interactions of the N cycle in farm production systems
3. Appreciate the difficulty involved in making recommendations to real-life problems without all of the desired information
4. Address the issues in the case from the viewpoint of a swine farmer and also from the perspective of a government regulator

### Use of the Case

This case can be effectively used by students and professionals involved in a variety of disciplines, such as waste management, soil fertility, agricultural engineering, environmental policy, and animal science. By randomly assigning the students to work in small groups, each student brings to the case a unique background that broadens the usefulness of the final recommendations. The experience of working with a small group can be frustrating for some students, yet it provides good experience in teamwork, delegation, scheduling, and negotiation; skills that are essential for students entering the workplace.

The case has been classroom-tested in a graduate soil fertility class of 31 students with excellent results. Students estimated that they individually spent an average of 6 h in discussion, library research, and report preparation. Additional time was required for group meetings. All of the students either agreed or strongly agreed with the following statements: (i) Did the decision case challenge your ability to integrate information from disciplines that you have studied, and (ii) Do you feel that true-life case studies are a good learning tool?

The multimedia presentation (computer graphics, digitized slides, and videotaped interviews) was well received by the students. In a follow-up survey, one student commented, "The visual presentation helps make the problem seem real and more interesting. This results in a more efficient transfer of case information to the students." Another student responded, "It made it more like watching television. We're all geared toward watching television to get our information." The contrasting opinions expressed during the interviews with Mr. Blevins and the government regulator in the video provided the starting point for a class discussion on environmental philosophy and ethics.

### Author's Analysis and Interpretation

This case provides the opportunity to integrate many interdisciplinary topics. For example, most students will

readily identify the concerns with the nitrate-contaminated groundwater beneath the pasture. However, many of the students will not immediately identify the lack of information regarding the depth of groundwater or the size of the aquifer. The possibility of contamination from poorly constructed wells should also be discussed.

The problems of N disposal on a limited land area are clearly evident. Although Mr. Blevins claims he has enough land to dispose of the lagoon waste, much of the land is across a public road and has never received waste application. Calculation of the amount of waste generated from the swine operation and the rates of application on various crops reveals that he is greatly underestimating the land requirement for proper waste disposal.

The excessively high nitrate concentration in the bermudagrass forage is a serious concern for the grazing cattle. When nitrate concentrations exceed 5 g kg<sup>-1</sup> (dry wt.), there is a potential risk of toxicity to grazing animals due to production of blood methemoglobin (Ball et al., 1991). On this irrigated pasture, the nitrate concentration regularly exceeded 10 g kg<sup>-1</sup> during the growing season.

The practice of intensively grazing cattle on the effluent-irrigated fields is likely to result in inadequate N removal to minimize nitrate accumulation. Cattle recycle the majority of the ingested N back onto the pasture, where it is subject to various fates, including nitrification, leaching, denitrification, volatilization, and plant uptake. Ultimately, the cattle are not removing sufficient nutrients compared with the amount supplied with the effluent (Exhibit 9). Various options for effluent disposal can be explored, using the data provided. For example, the possibility exists that the neighbor's corn or forest land can be utilized for disposal. Mr. Blevins states that he is not interested in raising hay, but the issues regarding this practice can be discussed. Various nontraditional waste management techniques can be considered, such as constructed wetlands and methane generation. The use of a decision tree to organize information in a logical, systematic way was also introduced using the information in the case (Exhibit 10).

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# Should Public Funds Support Biotechnology Development? A Case about Herbicide-Resistant Cotton

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## ABSTRACT

Critical decisions regarding science and agriculture emerge during biotechnology development and transfer in agriculture. One such decision is whether public funds should support development of herbicide-resistant crops. In this case, a weed scientist (Dr. Tam) hypothesized that morningglory (*Ipomoea* sp.) could be controlled through postemergence applications of bromoxynil (3,5-dibromo-4-hydroxybenzotrile) on herbicide-resistant cotton (*Gossypium hirsutum* L.). Dr. Tam's experiments in collaboration with the industrial developer of bromoxynil-resistant cotton (*Gossypium hirsutum* L.) supported that hypothesis. The positive research results and a history of State Agricultural Experiment Station support for biotechnology research encouraged Dr. Tam to propose that public funds should be allocated to develop herbicide resistance in crops. Dr. Phil, the Director of the Bioethics Center, identified arguments opposing Dr. Tam's proposal that were based on principles arising from human duties toward the natural environment, from political and economic responsibilities of public servants, and from concerns for community ideals and attitudes. The opposing arguments caused Dr. Tam to critically evaluate whether the public funds should be used to support research and development of herbicide-resistant crops. Dr. Tam's analysis of the funding question opened debate about a related choice between research goals emphasizing greater productivity and profitability and those favoring diversity, justice, equity, and community. The primary case objective was to enable students to use the case description, human values, and concepts and principles from science and ethics in verbal and written analyses of the decision.

**I**N 1991, State Agricultural Experiment Station (SAES) faculty agreed to participate with industrial partners in field evaluations of herbicide-resistant cotton. This partnership coincided with a national debate among and within university faculty, industrial developers, farmers, processors, retailers, and consumers about the pros and cons of emerging biotechnologies, including herbicide resistance in crops, bST, and the Flavr Savr tomato (*Lycopersicon esculentum* Mill.) (Duke et al., 1991; Holt and LeBaron, 1990; Goldberg et al., 1990). These debates were marked by diverse and opposing world views and were typical of U.S. approaches to managing resource development and new technology (Covello et al., 1988). Intense loyalty within interest groups, lobbying, competing technical analyses and interpretations, diverse value systems that remained implicit rather than explicit, and extensive use of the legal system typified the process in contexts ranging from the farmer's field to the meeting room of

government policy-makers. The debate about herbicide-resistant crops will intensify as genetically engineered species are submitted and ushered through approval processes within and among the USDA, USEPA, and Food and Drug Administration (FDA). The approval of bromoxynil-resistant cotton could be the focus of the decision case, but the associated issue of public funding for development of herbicide-resistant crop species created a narrower and more local focus for the decision (Cook, 1993). The issue of public support for research in crop herbicide resistance is relevant whether students anticipate careers in biotechnology development and transfer or are simply concerned citizens and taxpayers.

## THE CASE (ABRIDGED)<sup>1</sup>

### Background and Values of Decision Maker

Dr. Tam, a professor of Weed Science in the SAES, was invited to participate in a research conference sponsored by Rhone-Poulenc chemical company, Calgene Inc., and Stoneville Pedigreed Seed Company (subsidiary of Calgene). In addition to an overview of each company, the meeting showcased company products [e.g., bromoxynil (3,5-dibromo-4-hydroxybenzotrile), trade name Buctril] (Anonymous, 1989) and herbicide-resistant cotton. The main purpose of the meeting was to solicit cooperation of university scientists in field testing of cotton possessing genetically engineered herbicide resistance (GEHR) to bromoxynil. Dr. Tam was particularly interested in potential uses of bromoxynil for postemergence control of morningglory and other broadleaf weeds in the southern USA. Moreover, Dr. Tam had depended on industry support during a research career that focused on the ecology of weeds in cultural and chemical weed control systems. The meeting presented an opportunity for a research collaboration with industry and for external financial support that would supplement SAES funding of Dr. Tam's research program.

The development of bromoxynil resistance in plants was launched when scientists from Calgene and Rhone Poulenc identified bacteria containing a nitrilase enzyme for degrading bromoxynil (Stalker et al., 1988). The bacteria were isolated from soils contaminated with high bromoxynil concentrations. After characterizing the bacterial gene and protein product of nitrilase, scientists used molecular genetic techniques to isolate and move the nitrilase gene into cotton. The transgenic cotton survived after a postemergence application of bromoxynil, but morningglory, common cocklebur (*Xanthium strumarium* L.), velvetleaf (*Abutilon theophrasti* Medic), and other broadleaf weeds were killed. In addition,

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<sup>1</sup>This is an abridgement of a more complete case. For a copy of the complete text and exhibits, contact the corresponding author.

**Abbreviations:** a.i., active ingredient; FDA, Food and Drug Administration; GEHR, Genetically Engineered Herbicide Resistance; SAES, State Agricultural Experiment Station.

the herbicide reportedly exhibited no soil activity and residues were not a concern in the environment.

Both molecular genetic techniques and traditional plant breeding were used to move the nitrilase gene into diverse cotton varieties and lines. However, the collaborating companies lacked the expertise and facilities for field-testing that were necessary for commercializing the transgenic cotton in diverse environments. The expertise and facilities available within this and other SAESs were a potential resource for facilitating prompt evaluation and release of bromoxynil-resistant cotton varieties. The companies argued that speedy release was in the best interest of all concerned parties because farmers' weed control costs and the total amount of chemicals introduced into the environment would be less for the GEHR technology package than preemergence herbicide applications (Callahan, 1991). Research sponsored by Rhone-Poulenc documented that farmers would face little if any health risk during application of bromoxynil.

After attending the meeting, Dr. Tam was enthused about the opportunity to evaluate bromoxynil-resistant cotton. Both annual and perennial morningglory were serious weed problems in cotton production systems of the southcentral USA and Dr. Tam perceived that postemergence applications of bromoxynil could help control these weeds in GEHR cotton. In addition, research on GEHR was relevant to the SAES strategic plan for improving profits and environmental protection in cotton through integrated pest management. Moreover, the SAES administration was very supportive of scientists' efforts to develop and evaluate new biotechnologies. In a keynote address to the annual SAES staff conference in January 1990, the SAES director stated that there was no place in the future of SAES for scientists who were not actively involved in research related to biotechnology. The director was a strong proponent of collaborative research between the SAES and industry.

Anticipating producer needs for research on bromoxynil and GEHR cotton, and personal opportunities for career advancement, Dr. Tam entered into a collaborative research agreement with Calgene, Rhone-Poulenc, and Stoneville Pedigreed Seeds. Dr. Tam proposed to determine the efficacy of bromoxynil on diverse morningglory species in pure stands and in plots of GEHR cotton. The SAES administration required Dr. Tam and the industry collaborators to submit a memorandum of agreement through the administrative hierarchy and directed Dr. Tam to keep SAES administrators informed about all experiments using the transgenic cotton materials. Dr. Tam and the industry collaborators applied and gained approval for USDA permits that were required for field testing of transgenic plant materials. Dr. Tam executed the experimental protocol specified by the USDA.

During the summers of 1991 and 1992, Dr. Tam documented annual and perennial morningglory control in GEHR cotton at different application rates and dates. In addition, responses of diverse annual and perennial morningglory species to bromoxynil rates and timing were assessed. In the latter studies, postemergence applications of bromoxynil at rates from 0.3 to 1.7 kg ha<sup>-1</sup> of active ingredient (a.i.) effectively controlled one or more of seven annual morningglory species. Annual morningglory control in GEHR cotton was effective when bromoxynil was applied early (1–3 leaves on cotton seedling) postemergence at the rates of 1.5 kg ha<sup>-1</sup> (a.i.)

under conventional tillage. A second postemergence application at rates up to 1.5 kg ha<sup>-1</sup> (a.i.) improved control of sharppod morningglory (*I. trichocarpa* Ell.), a perennial. Although the USDA licensing agreements for field-testing required destruction of GEHR cotton before lint and seed yield could be measured, Dr. Tam's studies indicated that the technology package of postemergence bromoxynil on GEHR cotton could provide safe and effective morningglory control when used in combination with other cultural and chemical controls of broadleaf and grass weeds.

In addition to summarizing and interpreting two seasons of field testing in a research report to the department head and SAES administrators, Dr. Tam used results of the collaborative research as the basis for advocating use of SAES (i.e., public) funds for salary, equipment, and supplies in support of GEHR research and development in crops. Dr. Tam argued that GEHR development could lead to: (i) economic benefits for manufacturers, consumers, and farmers, and (ii) seed and chemical packages that are safe for humans, animals, and environment (Comstock, 1989). Based on interaction with technical and marketing representatives of Calgene and Stoneville Pedigreed Seeds, Dr. Tam perceived that the economic future of the industrial partners depended on the success of bromoxynil-resistant cotton. This technology package would enable cotton producers, without jeopardizing cotton yield and productivity, to delay the decision to apply herbicide until morningglory and other broadleaf weeds were observed in the cotton field.

### Opposition to GEHR Research and Development

Dr. Tam's endorsement of public funding of GEHR development in crops did not go unquestioned by university colleagues. The director of the campus Bioethics Center, Dr. Phil, called attention to views that were opposed to public funding of GEHR. Dr. Phil was a professor of philosophy and nationally renowned for research, educational, and leadership achievements related to social and ethical issues in agricultural research, genetic engineering, and biotechnology development. Dr. Phil's recent writings included books and articles about ethics and agricultural policy, ethical goals for agriculture, the role of states in biotechnology development, and ethical issues for genetic engineers. In addition, Dr. Phil taught undergraduate and graduate courses in agricultural ethics and the philosophy of technology. Although not personally involved in studies of the ethics of public funding of GEHR, Dr. Phil was able to alert Dr. Tam concerning relevant ethical issues that had been identified and organized into three categories by a colleague from another university (Comstock, 1989): In brief, those categories were (i) human duties toward the natural environment, (ii) human political and economic responsibilities, and (iii) human ideals and attitudes as a community.

Comstock (1989) developed a guiding ethical principle that corresponded to each category of ethical issues. Concerning the environment (i.e., Category i), he proposed that humans should respect different values of different things. Beings should be treated in ways appropriate to each species' ecological niche and each human's individual rights. Emerging from Category (ii) was the principle that humans should pursue economic justice and equity first, and economic effi-

ciency, productivity, growth, and entrepreneurship second. Comstock (1989) believed that external environmental costs, which could harm future generations of society's worst-off, should be included in costs of production. The principle concerning community led to the suggestion that humans should form and maintain diverse, just, and beneficent communities. This third principle guarded against the pursuit of policies that would benefit certain politically powerful communities at the expense of marginal or minority groups.

The principles proposed by Comstock (1989) gave rise to four general arguments opposing Dr. Tam's proposal for public funding of GEHR research and development: (i) continued research would lead to increased use of chemical pesticides and more farmworkers and consumers would be injured or killed as herbicide use escalated; (ii) mutant organisms could develop in monocultures of GEHR crops and devastate vast areas of major crop commodities; (iii) a small handful of companies could exploit farmers and consumers by exercising monopolistic control over seed and chemical industries; and (iv) GEHR is intrinsically immoral because it crosses natural species boundaries (Comstock, 1989, 1990). A national report of The Biotechnology Working Group (Goldburg et al., 1989) echoed these arguments against GEHR. Furthermore, this report identified birth defects among the potential risks for users of bromoxynil.

### The Decision

Dr. Tam was confronted with a personal decision of whether to continue spending time and energy researching GEHR if the proposal for public funding of GEHR research and development would be viewed as unethical by the public and rejected by SAES administrators. Dr. Tam had to weigh the obvious benefits of GEHR research and development that were listed in the report to SAES administrators against the four opposing arguments of Comstock (1989). Dr. Tam's 20 yr of research, including 12 yr as a USDA scientist before joining the SAES, were directed toward the unquestioned goals of increasing economic efficiency and productivity. In Dr. Tam's view, new crops and technologies were needed to meet growing global demands for food and fiber. On a regional scale, Dr. Tam thought that slightly higher yields and slightly lower chemical inputs would be associated with GEHR compared with regular cotton and could benefit farmers financially and in competition with foreign producers. Reduced inputs of preemergence herbicides on GEHR compared with regular cotton would be an obvious benefit to the environment. Moreover, Dr. Tam believed that GEHR research would advance scientific knowledge.

If Dr. Tam was to make a decision that satisfied himself as well as the diverse public concerned about this issue, a more holistic approach to inquiry and decision-making was needed than was typical of applied research and technology development in weed science and agriculture. The information and reflection required for this decision extended beyond the bounds of scientific inquiry into ethics and social policy (Cook, 1993). The question was not simply "What could be done?," but "What *should* be done?" Science could explain and predict, but ethics would compel and justify (Comstock, 1989, 1990). Even the definition of *weed* involved judgments made from within Dr. Tam's particular cultural per-

spective. For example, Comstock (1990) presented consequentialist arguments to support qualified opposition to public funding of GEHR research. Comstock's (1990) judgments were founded on human values that originated from concrete considerations such as memories and aspirations of his historical community, i.e., his traditional ideals of what constituted good farming. He referred to places like Iowa where his uncle struggled not only with weeds and loan payments, but with feelings of respect for the soil and with his parents' and grandparents' ideals about what a farm should be.

The decision is either yes, public funds should be, or no, should not be used in support of research and development of GEHR. Of course, there is a large gray area between the extremes of an unequivocal yes or no. The strength of the alternative chosen would reside in the explicit and critical analysis and justification that would be developed to support the decision. The alternative chosen should be accompanied by logical reasoning using scientific description and ethical reflection.

### TEACHING NOTE

#### Case Objectives

In deliberating and responding to this case, students should be able to use personal experiences, human values, and concepts and principles from science and ethics in verbal and written analyses of a decision whether to use public funds for GEHR research and development. Second, students should be able to describe and use a holistic methodology that identifies and evaluates the diverse goals and human values represented in the decision. Third, students should be able to compare and contrast holistic with reductionist approaches to inquiry.

#### Use of the Case

The decision case was assigned late in the semester in an undergraduate agricultural ethics course in 1992. The decision case complemented lecture and readings in a course unit on policy analysis of agricultural research and technology development in the public sector. Students were introduced to public policy analysis and procedural laws and libertarian, egalitarian, utilitarian, and agrarian ethics through lectures and class exercises during 10 wk before the case was assigned. The case description with exhibits and a photocopy of an article discussing ethical and environmental considerations of herbicide-resistant crops (Dekker and Comstock, 1992) were distributed to all students. An essay, a quiz over the case and readings, and written responses to study questions were among requirements that accompanied the case. The case was introduced during one lecture session, and students discussed the decision and supporting arguments during a second class session in 1992. In 1993, students were assigned specific roles (Dr. Tam, Dr. Phil, farmer, Calgene biotechnologist, seed salesperson, and Biotechnology Working Group) while introducing the case during the first class session. Students who shared the same role caucused for the first 15 min of the second class session. After caucusing, one or more students in each group verbally conveyed to the entire class the decision and arguments that their role in the case would advise Dr. Tam to choose. A class discussion followed the statements formulated by each group.

**Table 1. Student responses (SA, strongly agree; A, agree; U, uncertain; D, disagree; and SD, strongly disagree) to evaluative statements after completing the decision case in an Agricultural Ethics course during 1992 and 1993.**

	Response										Statement
	1992					1993					
	SA	A	U	D	SD	SA	A	U	D	SD	
	no. of students										
1	24	8	6	0	0	7	23	7	5	1	There was adequate information available for deciding.
						19	23	1	0	0	This case was realistic.
4	19	11	5	0	0	10	30	4	0	0	This case can be analyzed using the policy analysis approach presented in this course.
2	18	11	8	0	0	9	30	3	0	0	The ethical theory presented in this course can be used to make and support the decision.
						12	22	6	3	0	The in-class presentation of the case stimulated my interest in the ethics of biotechnology policy.
6	25	3	5	0	0						This case was interesting.

In 1993, the case was introduced and roles were assigned to students in a graduate weed science course during 20 min of a weekly laboratory recitation early in the semester. Individual students presented their decision and arguments in a role-play format during a 2-h portion of the laboratory period several weeks later. References for the case (Cooper, 1990; Comstock, 1989, 1990; Holt and LeBaron, 1990; Tauer and Love, 1990; Dekker and Comstock, 1992; Sun, 1986) were placed on reserve when the case description and exhibits were distributed to students. In the role-play exercise, the weed science students represented the roles of Dr. Tam, Dr. Phil, farmer, SAES administrator, Calgene molecular geneticist, representative of Biotechnology Working Group and Stoneville Pedigreed Seed marketing specialist in a group meeting. This group was given the task of reaching consensus within a 2-h meeting about the decision whether public funds, including faculty time and research facilities, should be allocated to GEHR research and development in crops. Students were required to submit a three-page essay describing their role's recommendation for Dr. Tam's decision and supporting scientific and ethical arguments.

From 79 to 98% of agricultural ethics students agreed or strongly agreed with statements that the case or in-class presentation was interesting, realistic, or stimulated their interest in the ethics of biotechnology policy (Table 1). From 91 to 93% of agricultural ethics students agreed or strongly agreed that ethical theory and policy analysis, which were offered in the agricultural ethics course, could be applied to the case in 1993. In contrast, only 51 to 59% of students responded positively that course offerings could be applied similarly to the case in 1992. Less positive responses during 1992 were associated with the instructor-directed class discussion of the case as opposed to student involvement in specific roles and caucuses during the following year.

From 89 to 100% of weed science graduate students agreed or strongly agreed with five evaluative statements that the case was interesting, relevant, realistic, a context for getting involved, and supported by adequate information. But 44% of the weed science students were uncertain and 11% disagreed with a statement that ethical issues and arguments presented in readings enabled them to make and justify the decision presented in the case. In responses to an open-ended question asking what they disliked most about the case, 44% of the graduate students expressed that the reserve readings discuss-

ing moral and ethical issues in technology development and transfer were difficult to understand. In both their oral presentations representing a role and in the essay assignment about the decision whether to fund, none of the graduate students systematically and critically analyzed the human values and ethical principles that were discussed in readings and implicit in their own opinions and arguments.

### Conclusions

Both graduate and undergraduate students tended to choose and justify their recommendation for Dr. Tam's decision using their current knowledge and a blend of their opinion and perceptions of the instructor's opinion, i.e., they wrote without critically analyzing their values in relation to ethical theory much like novice pilots "fly by the seat of their pants." They seemed reluctant to do the reading and critical thinking/analysis necessary to do justice to this decision case. It will be helpful if the instructor verbally reinforces the case description and directions and clearly states expectations of students in behavioral objectives, exercises, writing assignments, and examinations. At least, students should be expected to use ethical theory and reasoning from the readings, in addition to technical and economic arguments, in their verbal and written analyses of the decision concerning public funding of GEHR research and development. In courses where ethical, scientific, and/or policy concepts and principles are taught, students can be expected to include that knowledge in their reasoning.

The case objectives will be most readily accomplished through combining the written case with readings; lecture and discussion concerning the science, ethics, and public policy aspects of biotechnology; an in-class case description and group exercise; an individual writing assignment; and an essay test question. Based on observations of weed science graduate students, few can be expected to accomplish the objectives if the case *stands alone* as a supplement or appendix apart from the regular subject matter and exercises in the course. In short, the objectives of this decision case must be among the objectives of the course in which it is used. This integration is readily achieved in a course that is already focused on agricultural ethics and public policy. In contrast, instructors in agricultural and biological sciences will need to incorporate topics on ethics and holism, and an experiential

exercise, in lieu of science-oriented lecture or laboratory exercises to accomplish the case objectives. The case encourages the students and instructor of the science-oriented courses to shift their focus from reductionist approaches of applied science and technology development exclusively to more holistic, systemic methodologies. Conversely, the case can entice ethics students and their instructor to use theory and observations from reductionist science in policy-level decision-making.

### Exhibits

The six exhibits provide information about the technical requirements and outcomes that are of foremost concern to Dr. Tam and the industrial collaborators. *Exhibit 1*, a letter inviting Dr. Tam to participate in the meeting sponsored by industry, provides details about GEHR cotton and the industry perspective. *Exhibit 2* provides a summary of research documenting that current protocols and protective clothing ensure worker safety during bromoxynil application. *Exhibit 3* gives details of the collaborative agreement between Dr. Tam and the industrial partners. The description of research procedures in *Exhibit 4* illustrates the precautions that were implemented to address public concerns about testing and the risk of escape of the genetically engineered organisms. *Exhibits 5 and 6* provide detailed data concerning the efficacy of bromoxynil for control of morningglory species alone and in different chemical protocols that were applied to GEHR cotton.

### Discussion Questions

1. Explain how a reputable scientist like Dr. Tam can be in favor of using public funds in support of GEHR research and development in crops, but an opposite world view is advocated by Dr. Phil's respected colleague Comstock (1989, 1990)?

*Author's Interpretation.* The values, experiences, beliefs, and education of Dr. Tam differ markedly from Comstock. Stated simply, their world views differ. Their disciplinary biases and approaches to inquiry contribute to differences in purpose and goals and in what they view as problematic with respect to GEHR (Viotor and Cralle, 1992). Dr. Tam has relied on field evidence and experiments to validate theory and new technologies related to weed ecology and control in pursuit of the goals of greater productivity and profitability for farmers. Conversely, Dr. Phil's colleague Comstock (1989, 1990) may have relied more on reflection and abstract thinking to discern the ultimate truth in rights-based theories of ethics that were inherent to his goals for preserving equity and community. The terms and concepts that they use to describe and make meaning of problematic situations differ to such an extent that they will probably find it difficult to communicate.

2. What are your values concerning the decision that Dr. Tam must make? Compare your values to those of Dr. Tam and Dr. Phil's colleague Comstock.

*Author's Interpretation.* A value is a belief upon which a person acts by preference. Values, like all beliefs, have cognitive, affective, and behavioral components: (i) a value is a cognition about the desirable, equivalent to a *conceived* value, and to what has been called a conception of the

desirable. To say that a person has a value is to say that cognitively the person knows the correct way to behave or the correct end-state toward which to strive; (ii) a value is affective in the sense that the person can feel emotional about it, be affectively for or against it, and approve of those who exhibit positive instances of it; (iii) a value has a behavioral component in the sense that it is an intervening variable that leads to action when activated. When a person has a value, they may have in mind either beliefs concerning desirable modes of conduct or behavior or desirable end-states of existence. The intent of this question is to encourage students to identify and name their values and to relate them to their perception of values inherent to the goals and reasoning of Dr. Tam and Comstock (1989, 1990).

3. Presume that Dr. Tam and Dr. Phil, the SAES director, and representatives of farmers, Calgene researches, Stoneville Pedigreed Seed marketing, and the Biotechnology Working Group were brought together to reach consensus on whether public money should be used to support GEHR research and development in crop plants. Describe procedures for working and learning (i.e., human activities) that will enable this group to accomplish their task.

*Author's interpretation.* It is expected that students will describe activities that enable the group members to communicate their diverse human experiences, values, goals, and knowledge. The human activities proposed by students will represent a more holistic approach to inquiry than may be typical for Dr. Tam and other participants described in the case. A soft systems methodology has been used to help scientists evaluate rather than simply pursue goals of greater productivity and profitability (Viotor et al., 1992; Viotor and Cralle, 1992).

4. What *one* human value or scientific or ethical theory could be used as a simple criterion for deciding whether public money should be spent for GEHR research and development in plants? Explain.

*Author's Interpretation.* Public policy in the USA is a composite of diverse procedural law, human values, and ethical theory (Thompson et al., 1994). The readings associated with the case illustrate that the decision about public funding of GEHR research and development is a complex question about public policy. The USDA decision to ban expenditure of federal money on development of GEHR is an interesting epilogue to this case.

### ACKNOWLEDGMENTS

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# Trees of Sogolonbougou: A Decision Case of Sustainable Agriculture in the Semiarid Tropics

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## ABSTRACT

Critical environmental problems facing sub-Saharan African nations include soil erosion, land degradation, and desertification. These problems are exacerbated by a number of factors including traditional shifting cultivation (*slash and burn*) practices of the region. Since 1986 the practice of burning to prepare fallow fields for the planting of crops has been prohibited by law in the nation of Mali. Despite this, subsistence farmers continue to burn because they feel that they have few alternatives for clearing bush and preparing land for cropping. In the spring of 1988, Djokolo Coulibaly, the leader of a small village in western Mali, was confronted by an agent of the Malian Forest Service concerning a bush fire sighted on land belonging to Coulibaly's village. The case focuses on the conflicting goals, viewpoints, and priorities of the forest agent and Coulibaly concerning conservation of the forest ecosystems, desertification, and family and village needs. The case provides a basis for inductive discussions of natural resource and agricultural management policy issues locally, regionally, and internationally. The case also serves to increase student understanding of the environmental implications of subsistence agricultural practices characteristic of many semiarid tropical areas. The case has been used successfully in a general education agricultural ecology course at the University of Minnesota.

THE SUSTAINABILITY OF AGRICULTURE in many areas of the semiarid tropics is threatened. Population in these regions, while still a relatively small proportion of the world's

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total, is growing rapidly, resulting in increased demands for food. Although irrigation has provided one avenue for enhancing food production in some regions, this option does not exist in most areas. Aggravated by high temperatures and low, erratic precipitation, agricultural lands in the semiarid tropics can be subject to widespread degradation and erosion, leading in some cases to desertification. In response to declining land productivity and increasing demands for food, subsistence farmers in the semiarid tropics have often intensified their shifting cultivation practices to bring more land into production. This has resulted in shortened fallow periods between agricultural cycles and reduction or elimination of natural space between farmland. Such intensification has also resulted in greater reliance on fire as a rapid means for land clearing. Estimates by the United Nations Environmental Program indicate that 20 million ha (49 million acres) in arid and semiarid areas are degraded to an unproductive state each year as a result of erosion and desert encroachment (Dover and Talbot, 1987). Although activities other than agriculture, such as firewood gathering, also contribute to such degradation, the practice of shifting agriculture without adequate revegetation and replenishment of the soil between agricultural cycles is of great importance (Grainger, 1984).

The case reported in this article was based on an incident observed by the senior author while working in Mali. It was developed to introduce concepts and provide a basis for discussion of natural resource and agricultural sustainability issues in a general education agroecology course at the University of Minnesota.

## THE CASE

Monday, 16 May 1988

The day was just beginning in the tiny village of Sogolonbougou when a Toyota land rover pulled into the

village. Everyone was immediately curious since Sogolonbougou, located approximately 50 km northwest of the Malian capitol of Bamako, was remote enough that passing vehicles were rare in 1988. Two people stepped out of the land rover. One was a driver and other was Amadou Diarra, an agent of the Service des Eaux et Forêts (Agency of Water and Forests, or Forest Service). The Forest Service was charged with responsibility for managing the nation's forests and enforcing forest protection laws.

The village of Sogolonbougou had never had a very good relationship with the Forest Service. Since a national forest law was passed in 1986 (Exhibit 1) forbidding the use of bush fires to clear lands for agricultural fields, the villagers had tried to out-manuever the Forest Service agents by burning at times when they were least likely to be observed. The villagers resented the Forest Service's enforcement of this law, which also included regulation of hunting. In their role as police, the forest agents had forged an unpopular relationship with the villagers, who felt their basic rights of property ownership and self-determination with respect to burning, cutting trees, and hunting were being violated. Sometimes the people of Sogolonbougou were successful in their efforts to evade detection by the Forest Service agents, but sometimes as in 1988, they were not.

Diarra and his driver knew that their arrival would be more visible to the villagers at an early hour and that it would be easier to locate the village leader before he and the other men went to work in their fields. Diarra wanted to see the chief, because the Forest Service had recently spotted a bush fire in the vicinity of Sogolonbougou. The fire appeared to have been set for the purpose of preparing a field for agriculture. Since the forestry codes prohibited use of fires to clear lands, Diarra intended to impose a fine on the village for this violation.

Djokolo Coulibaly, the village leader, knew from Diarra's uniform that he was an agent of the Forest Service. Coulibaly also knew why Diarra was there, and he resented it. The month of May was the time for burning fields before the village farmers planted their crops and the rainy season began. It was a practice that the village farmers had been using for many generations.

One of the critical environmental issues facing the nation of Mali in the late 1980s was soil erosion and desertification. With the shifting agriculture system practiced in the area of Sogolonbougou in the 1970s and 1980s, the fallow periods had been shortened to a point where natural woodland vegetation was seldom fully reestablished between agricultural cycles. Trees that were lost were no longer able to help control erosion and retard desertification. Some experts concluded that, although aggravated by drought, the root causes of desertification were human activities such as improperly managed bush fallow agriculture.

Diarra knew the detrimental effects of bush fallow practices. He knew that burning eliminated seedlings of fire-tender tree species, and allowed only fire-tolerant species to persist. Fire-tolerant species usually have thicker bark, but even these could be damaged or stunted if the bush fire was too intense. Burning also changed other characteristics of the natural vegetation favoring perennials over annuals. Vegetation that was burned was not available to be returned to the soil as organic matter. Although ash contributed some nutrients to

the soil, much of the organic matter was lost through the process of burning.

Coulibaly, on the other hand, knew that his village must practice extensive agriculture if his people were to survive. At the levels of productivity that the village farmers could expect to achieve with their harsh semiarid climate and poor soil conditions, they simply could not produce adequate quantities of food for the village without clearing and utilizing bush fallow fields. Burning a field that had been fallow was the traditional way of clearing the land before planting. This slash-and-burn or bush fallow agricultural system was the simplest, fastest, and least laborious way to prepare bush land for agricultural fields. The alternative of clearing land by hand was deemed to be too laborious and impractical by the villagers. Coulibaly did not look forward to the conversation with Diarra that was about to occur.

### Background on Forest Regulations in Mali

The forestry laws of Mali in the late 1980s had their conceptual roots in a 1935 colonial law whereby French authorities asserted their authority over the management and regulation of all forest resources in their Sahelian colonies. The forest code enacted by Mali in 1986 was the principal postcolonial law by which the state retained control over forest resources (Exhibit 1). Both the 1935 and 1986 laws were established ostensibly to protect forests from abuse by practices such as firewood cutting, charcoal production, overgrazing, lumbering, and harmful agricultural practices, and to restore lands that had been degraded. Persons engaging in prohibited activities involving forests were subject to fines, imprisonment, or both. Management of forests within the sub-Saharan region of Africa in the late-1980s involved mostly enforcement of governmental regulations. The Forest Service was the principal enforcement agency and many of its personnel were recruited from military and police forces because of their experience with enforcement. Only limited staff and resources were devoted to extension and development activities, although the Forest Service had some infrastructure to help villages establish tree nurseries to aid in revegetation of deforested areas.

Forest regulations applied both to trees on individual farms as well as on state-owned lands. This included both naturally established and farmer-planted trees. If farmers wanted to cut trees from their lands, permits were needed. The forest codes, in effect, removed any legal basis for community or individual ownership or rights over the trees on their property.

Forests were defined by the code as "an association of biologically interdependent trees . . . that exert an influence over a more or less large territory." Within this definition, the forests of Mali included all populated regions of the nation except urban areas, permanently cultivated farmlands, farmlands that had been fallow for less than 5 yr, and private property that contained no trees. Although farmlands appeared to be excluded from the regulations, certain sections of the code were interpreted to permit regulation of tree use, even on private farms.

The state forests were defined in two ways: the *classified forest* and the *protected forest*. Use rights were more restricted in classified forests. Classified forests were primarily for the purposes of conservation, especially of soil. Rights specifi-

## PREFACE

Forestry legislation is an important factor in forest and natural resources policy in most Francophone Sahelian countries. Forest codes provide the legal and administrative framework for forest policies, which rely heavily upon direct state regulation of public and private use of forests and forest products. Codes also regulate crop and livestock production in areas under their jurisdiction. Forest codes define the distribution of rights to forests and forest products between the state and individual users. In most cases, the balance of use and management rights is held by the state and falls under the administrative authority of forestry and water departments . . . .

This publication provides an accessible guide to the forest codes of Senegal, Mali, and Niger. It was prepared with the hope that those interested in forestry policy in these countries will find it useful in understanding relationships between tree and forest tenure rules, as defined by forest codes, and farmer and community investments in forestry and agroforestry . . . .

## INTRODUCTION

The spirit and essential provisions of the 1935 Decret survive in the present forest codes of the independent Sahelian states. Forest codes in Mali, Niger, and Senegal consist largely of lists of restrictions or prohibitions on forest use. Allowable uses are regulated through a system of permits granted by forest services. Persons engaging in prohibited uses (or otherwise allowable uses for which an individual has not secured a permit) are subject to fines and, in some cases, to imprisonment.

Thus, forest management policy in the Sahel is based principally on regulation of use through enforcement of restrictions. Forest codes are the legal instruments by which states assume ownership of resources, and which empower states to manage forest resource use through administration of rules and regulation. Forest services throughout the Sahel are preeminently policing agencies. Only very limited staff and material resources are applied to extension and development activities based upon participatory approaches such as social forestry or farm-level agroforestry.

Regulation of forest use extends to trees on individual farms. This includes naturally established species and trees planted by farmers themselves. Farmers may be required to secure permits to cut or use trees they have planted. In other words, use rights to trees planted or cultivated by farmers are shared with the state . . . . The forest codes have circumscribed any legal basis by which communities can claim ownership or regulatory rights over trees. The emergence of community-based management of forest use is forestalled by the forest codes . . . .

## FOREST LEGISLATION IN MALI

The central legislative text regulating the management and exploitation of forests in Mali is Loi 86-42, enacted 30 Jan. 1986. This text articulates official policy toward forest use and management. Additional legislative texts regulate such activities as tax rates for the clearing of forested land (Loi 86-65), the use of fire within the forest domain (Loi 86-66), fishing (Loi 86-44), and hunting (Loi 86-43) . . . .

### A. Forest Domain and State Forest Domain

Loi 86-42 delineates both a *forest domain* and a *state forest domain*, although the difference between the two domains is not made clear. The defining component of the forest domain is *forests*, defined as "an association of biologically interdependent trees . . . that exert an influence over a more or less large territory" (Article 1). The code also defines reforested village lands and woods that are "sacred" or "protected" for "socio-religious" reasons as forests (Art. 51). In addition to forests defined in the foregoing manner, the forest domain includes perimeters de reboisement (reforestation perimeters), that is, any area that is being reforested or restored (Art. 5). For all intents and purposes, the forest domain of Mali includes all populated regions of the country with the exception of built-up (urban) areas, currently cultivated farmland, farmland less than 5 yr in fallow, and unwooded private property (Art. 6) . . . . It is clear in the code that state jurisdiction over vegetation extends beyond the forest domain. For example, although farmland is excluded from the forest domain, subsequent sections of the code empower the forest service to regulate the use and exploitation of trees on farms.

The state forest domain is defined as consisting of two parts: the *classified forest domain* and the *protected forest domain* (Art. 15). The difference between these two subdomains is that the former is subject to site-specific regulations in addition to the restrictions listed in the forest code as applying to classified forests, while the latter is regulated by the less-restrictive provisions of the forest code applied to protected forests. Use rights are much more restricted in the classified forest domain than in the protected forest domain.

### B. Classified State Forest Domain

The classified forest domain consists of three categories: classified forests, perimeters de reboisement, and perimeters de protection. The latter two terms are defined, respectively, as, planted parcels or parcels restored through silvicultural activities (Art. 2), and parcels made ineligible for clearing . . . . Classified forests are created for the broader purpose of protection and conservation. In general,

classified parcels have in common that the classifying decret is formulated according to the unique circumstances of the individual plot and includes a listing of the particular sets of rights and restrictions to be applied to the classified parcel . . . .

Classification of a particular parcel of land is intended to restrict rights of exploitation of forest products . . . . The code also lists general restrictions that apply throughout the classified forest domain. Rights specifically withheld within the classified domain are those allowing for the production of agricultural crops and those that would permit the pasturing of domestic animals within that portion of the classified domain in the Sahelian region of Mali . . . .

Parcels within the protected forest domain (which includes the unclassified portion of the state forest domain) may be classified as seen fit by the Service des Eaux et Forêts (Agency of Water and Forests, that is, the Forest Service) (Art. 20).

### C. The Protected State Forest Domain

The protected forest domain is a residual category that consists of the "unclassified" portion of the state forest domain. The protected forest domain is by far the largest component of the state forest domain. In addition to the use rights granted within the classified forest domain, the production of food crops and the grazing of domestic animals—presumably even within the Sahelian zone—are allowed within the protected forest domain.

Within the protected domain, the clearing of land for purposes of agricultural production is subject to a number of restrictions (Arts. 7-14). No clearing may take place without authorization from the local administration, which is advised on such matters by the Service des Eaux et Forêts. Protected species of trees (see below) are not to be removed without special permission. Trees must be cut at ground level, and fire may not be used as a means of tree removal. Clearing is prohibited in sloped areas, on dunes where there is a risk of erosion, near waterways and wells, in areas where certain species of trees considered to be of economic importance predominate, and in certain areas where there are concerns for health or national defense.

The pasturing of domestic animals is allowed in the protected forest domain. However, in the Sahelian zone the cutting of trees and bushes to provide forage for animals is strictly prohibited. Debranching may occur as long as the branch is at least 1.5 m above ground level (Art. 40).

### D. Protected Species of Trees

Article 37 lists 10 species of trees that are not to be cut or used without authorization, that is, without first obtaining a permit from the Service des Eaux et Forêts . . . . Many of the trees . . . are considered to be of particular value and importance as agricultural trees. The *Acacia albida*, for example, has long been valued by farmers for its beneficial effects on crop production. Others are important for their wood or for products such as shea butter or palm oil.

Article 38 adds four species of trees for which use rights have been only partially restricted. These trees are not to be used for firewood but may, presumably, be exploited for other uses.

### E. Permits and Fines

The commercial exploitation of forest products is strictly regulated in Mali through a system of permits and fines. A permit must be obtained before engaging in any commercial activity that involves forest products, with a single exception: the harvest of fruits, honey, food and medicinal plants, and kapok is permitted for commercial purposes (Art. 36). Otherwise, any commercial use of forest products requires a permit from the Service des Eaux et Forêts.

The permits required for the commercial exploitation of forest products are not to be issued without charge (Art. 46). An exception is made for that part of the classified forest domain registered in the name of village collectives, in which commercial exploitation is subject to the acquisition of a permit that is to be granted free-of-charge (Art. 52). Noncommercial activities requiring a permit include the clearing of land for agricultural production (Art. 7) and the use of a "protected" tree (Art. 37 and 38) . . . .

Permits are issued only to individuals who are properly registered before exploitation (Art. 43). Permits specify areas, time periods, types and quantities of products to be harvested, as well as permitted methods of exploitation (Art. 44). They may be issued for the exploitation of products in either the classified forest domain, the protected forest domain, or both, according to the judgment of the forest service (Art. 44) . . . . Any violations of the terms of an exploitation or a circulation permit, or failure to obtain a permit when required, are subject to fines, jail terms, or both, as specified in Articles 65 to 71.

### F. Police Powers

The code gives broad police powers to forest agents in their pursuit of suspected violations of forest legislation . . . .

Loi 86-42 specifies in detail the penalties—jail terms and fines—to be imposed on violators of the code. The distribution of revenues gained through the collection of fines is as follows: 10% to the person who reports the offense (in practice, this is almost always the forest agent), 5% to the forest agent, 10% for distribution among the management personnel of the regional forest service, and 75% for the Forestry Fund . . . .

cally withheld from landowners or villages whose lands were designated as classified forests included production of agricultural crops and pasturing of domesticated animals. Forest classification was at the initiative of the Forest Service and usually involved review and approval by a commission of governmental agency officials, including the regional director of water and forests, representatives of the Department of Lands and the Departments of Agriculture and Livestock, as well as a village leader and advisor from the affected lands. Objections to the classification of a particular parcel of land could be presented to the commission. The commission's decision regarding the classification of forest land was binding. Collection of fruits and wild foods, medicinal plants, and honey on classified forest lands was specifically permitted as long as these activities did not harm the vegetation. However, in some circumstances such as where the state undertook restorative activities, the area was automatically designated as a classified forest, and no other administrative action or review was needed.

Protected forests represented the largest proportion of the forest domain. On such lands the production of food and grazing of livestock was permitted. However, the clearing of such lands for agriculture was restricted and could not be done without permission of the Forest Service. Protected species of trees could not be cut and fire could not be used as a means of tree removal. Clearing lands for agriculture was prohibited on soils and terrain subject to wind or water erosion or near waterways and wells. Although pasturing of animals on protected forests was permitted and branches could be cut from some trees for animal feed, no trees could be cut down for animal forage.

### Background on Sogolonbougou and Its Agriculture

Approximately 400 Malians lived in Sogolonbougou in the spring of 1988. These people lived under the leadership of their chief, Coulibaly, and a village council, which was comprised of eight elders. As in most Malian villages, the council members and the chief were among the oldest men in the village. Coulibaly was in his late 70s. The chief and his council were appointed to deal with governmental matters such as Forest Service code violations when they involved the entire village.

The Forest Service expected to detect bush fire violations in the spring in the central region of Mali. This area receives 500 to 1100 mm of precipitation during the rainy season, which usually begins in late May and ends in early September. Sogolonbougou practiced subsistence agriculture and adequate rains were necessary for the crops to grow so that the people of the village would be adequately fed.

The primary crop grown in Sogolonbougou, as well as in much of sub-Saharan West Africa, was pearl millet (*Pennisetum glaucum* L.), which is a drought-tolerant cereal that grows on limited water in poor soil conditions. The traditional view was that millet could be grown just about anywhere, but fields still needed to be prepared, particularly if they had been fallow for several years. Most millet was produced in continuous or shifting cultivation fields located within a 0.4- to 3.2-km (0.25- to 2-mile) radius of the village. The millet was planted in hills in a more-or-less random pattern. Most fields were small, 0.5 to 1 ha (1–2 acres) in size. Millet was seldom rotated

with other crops on the bush fallow fields, although cowpea (*Vigna unguiculata* L.) was grown as an intercrop with millet in some fields. Few, if any, of the bush fallow millet fields received any animal manure or irrigation water. Millet was planted just before the beginning of the rainy season, and it was always a gamble to know when to plant since the first rains of the season were often erratic. Millet grain was harvested in October or November and the crop residues were also used for building materials, mats, fuel, and forage for animals.

In addition to millet, the people of Sogolonbougou grew tomato (*Lycopersicon esculentum* Mill.), onion (*Allium cepa* L.), tobacco (*Nicotiana tabacum* L.), and corn (*Zea mays* L.) in irrigated gardens located immediately around the village. These crops were sometimes grown on ridges created with traditional tools. The ridges helped keep the crops from being washed away or flooded when heavy rains came. Goat and cattle manures were sometimes applied to the fields closest to the village. Weeds were either pulled by hand or hoed when the millet was about 30 cm (1 foot) high.

### Characteristics of Shifting Agriculture

In most agricultural systems the same land is cropped year after year, creating an ordered, somewhat permanent landscape. With shifting agriculture, however, a farmer removes the natural vegetation, usually trees, bush vegetation, or both, and burns the debris. A crop is then sown with minimal land preparation. After a 2- or 3-yr cropping cycle, the land is fallowed and allowed to revert to a natural vegetation cover again. Ideally, the period of fallow is long enough to fully restore the natural vegetative cover and soil fertility that was lost during the cropping cycle. Such shifting cultivation systems were traditionally practiced in areas with low human population densities and an abundance of land.

There were both advantages and disadvantages of bush fallow agriculture to the farmers of Sogolonbougou. From Coulibaly's viewpoint, burning was the fastest, least laborious way to prepare a fallowed field for planting. Although fast and effective, slash-and-burn agriculture could cause harm to the environment, particularly if the fallow period was not long enough to allow regeneration and restoration between cropping cycles.

Shifting cultivation had been traditionally practiced in Mali with minimal environmental impact for decades and even centuries. However, as human population rose in West Africa during the 20th century, there was increasing demand for human food and livestock feed. More trees were needed for fuel and construction materials. As a result, people in Mali often overharvested and grazed forests, and the farmers brought more land into the production of food crops each year. This was accomplished by shortening the duration of fallow in the shifting agriculture practices used. The United Nations estimated that woodlands in the semiarid tropics of Africa were cleared at the rate of 2.7 million ha (10 million acres) per year in the 1970s and 1980s (Grainger, 1984). Most experts agreed that, whatever the cause, removal of trees at a rate greater than regrowth or replanting was the greatest single cause of desertification in sub-Saharan Africa in the 1980s. Desertification was of great concern to the Malian Forest Service in 1988, just as clearing and planting enough land to grow millet was

## Exhibit 2. Background information for the nation of Mali.

### GENERAL

Total area: 1240000 sq km (478800 sq miles)  
Climate: Subtropical to arid; hot and dry February to June; rainy, humid, and mild June to November; cool and dry November to February  
Terrain: Mostly flat to rolling sandy plains in north; savanna in south, rugged hills in northeast  
Land use: 2% arable land (negligible % irrigated); 25% meadows and pastures; 7% forest and woodland; 66% other  
Climatic data (Bamako):  
Temperature (°C/°F):  

	Mar.	June	Sept.	Dec.
	31/88	29/84	27/80	25/78

  
Precipitation (cm/in)  

	0/0	15/6	22/9	0/0
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### POPULATION DATA

Population: 8665500 (1988), average annual growth rate 2.9%  
Projected population by year 2000: 12000000  
Religion: 90% Muslim, 9% indigenous beliefs, 1% Christian  
Language: French (official); Bambara spoken by about 80% of the population  
Infant mortality rate: 180 per 1000  
Life expectancy: 42 yr—men and women (1985)  
Literacy: 10%  
Urban population: 18%

### GOVERNMENT

Type: Republic; single-party constitutional government  
Capital: Bamako  
Administrative divisions: seven regions and the capital district

### ECONOMY

GDP: \$1.1 billion  
Inflation rate (consumer prices): 8% (1985)  
Agriculture: millet, sorghum [*Sorghum bicolor* (L.) Moench], rice (*Oryza sativa* L.), corn, peanut (*Arachis hypogaea* L.), cotton (*Gossypium* spp.), livestock  
Exports: \$174.5 million (1985); livestock, peanut, dried fish, cotton, skins  
Imports: \$294.6 million (1985); textiles, vehicles, petroleum products, machinery, sugar, cereals  
Monetary conversion rate: 318 francs = U.S. \$1 (1988)

important to Coulibaly and the subsistence farmers of Sogolonbougou.

In May of 1988, at the end of a long, extremely hot, dry season, the Sogolonbougou village council faced the problem of how to clear sufficient area of bush to ensure adequate crop production to meet village needs for the coming year. Although the chief and council were accountable for agricultural practices in the vicinity of the village, they did not dictate those practices. But Coulibaly knew that if a forest agent spotted a bush fire in the vicinity of his village, he and the Council would be held responsible for the fine of 50000 francs (about \$157), since the specific farmer responsible for that fire was often not identified. Since the average yearly income of a Malian was only \$260 (Exhibit 2), this fine could not be taken lightly. The Council's options were to either pay the fine or permit the chief to be put into jail.

Of course, there were ways around the fine—ways that both Diarra and Coulibaly knew well. In many cases the gift of a goat or a some chickens would send the agent on his way. Although Diarra's job with the Forest Service was considered a good one, his responsibilities extended much beyond his immediate family and beyond what his government paycheck could be stretched to cover. In this Moslem country, the family unit was large and strong, and the heads of households were often responsible for grandparents, aunts, uncles, cousins, and others related to their family. People like Diarra, who were fortunate enough to have government jobs, were expected to support their extended families. Although Diarra received up to 15% of any fine he collected as payment for

discovering and handling the violation (Exhibit 1), it was often in the agent's personal interest to work something out with the villagers he found in violation of the forest laws.

Coulibaly also had responsibilities and expectations. Resentful of Diarra's monthly paycheck, he was not inclined to work out a deal with any forest agent. But he had learned from experience that these agents meant business and he would have to pay either a fine or a bribe, or expect to spend time in jail until the fine was paid by the village. Remembering an earlier unpleasant and humiliating arrest for a forest code violation, Coulibaly was torn between his distaste for the forest agent and the practicality of paying the fine or negotiating a deal to settle the issue. He was angry and frustrated at having to pay anything at all for using a traditional farming practice that he felt was so essential to the well-being of his village.

Diarra realized that working out a deal was going to take more time than he had anticipated. He wanted to collect something, a fine or a bribe, and leave. He became angry as Coulibaly delayed his decision. The two men began to argue.

"You have very little shame!" Coulibaly shouted. "You bring shame to your family for treating an elder in this manner! You should leave this village immediately and not return until you are able to show respect to the people of Sogolonbougou!"

Diarra angrily responded, "And when you and your village are able to show respect for the forestry laws, I'll have no reason to waste my time here! The fine is 50 mille, Coulibaly, and you know what you can do about it. Pay or come with me!"

## TEACHING NOTE

### Case Objectives

This case depicts a seemingly isolated incident. Yet it provides a basis for broader, inductive consideration of issues involving environmental degradation in semiarid tropical nations. Upon completion of this case students will:

1. Be familiar with environmental issues of land degradation and desertification in sub-Saharan Africa
2. Be familiar with the practice of shifting agriculture in developing nations
3. Have approached a difficult environmental dilemma from the perspective of traditional subsistence farmers whose livelihood is directly affected by deforestation laws
4. Have identified with the forestry agents whose goal is to protect the land from degradation and desertification
5. Have considered how deep-seated, value-related conflicts might be resolved

### Uses of the Case

The case is suitable for use in environmental biology, general ecology, or agricultural ecology courses. The case has been assigned in conjunction with viewing a video depicting agricultural practices and environmental problems in sub-Saharan nations (an example is a segment from Annenberg/CPB, 1990). A set of slides depicting traditional millet production systems in sub-Saharan nations is also used to introduce the case. Students have been asked to prepare for the

class discussion of the case by studying individually or in small groups beforehand and by answering questions designed to familiarize them with the case and its issues. Following discussion of the case by the entire class, which concludes with enumeration of Coulibaly's and Diarra's options in the situation, students have been asked to write a one- to two-page summary of the action/decision that *they* would follow if they were Coulibaly and Diarra, along with their rationale.

The case has been used twice, to date, in a general education agroecology course at the University of Minnesota. The case is used in the course to illustrate concepts introduced in lectures on agroecosystems and natural resources and to provide students with experience applying concepts to a specific dilemma. It is one of three cases in the course that consider natural resource issues in relation to agriculture.

Overall, students in the course rated the case good to very good ( $n = 48$ ) on the end-of-term course evaluation. A number of students expressed satisfaction with the case, describing it as "interesting" and "enlightening." Others appreciated the broader, international perspective that it provided to the course. However, some students felt that the case provoked a discussion that was too concerned with political aspects. Yet, one student liked the case precisely because "it brought more human aspects into it—Diarra taking bribes, etc." A number of students expressed frustration because the case did not lend itself to a ready resolution of the underlying problems. Although some resolutions such as paying the bribe or fine were apparent, the students recognized that these did not address the fundamental aspects of the problem and did not improve the longer-term well-being of the people of Sogolonbougou or the sustainability of their agroecosystem.

#### Discussion Questions and Issues in the Case

Possible questions that could be used to orient students to the case or to discuss the case and its issues:

**What is the nature of the dilemma portrayed in this case?** There are multiple levels to the dilemma in this case and multiple decision makers, Diarra and Coulibaly. On the surface it appears to involve an incidental confrontation between the village leader and the forest agent. Of course, some of the discussion will focus on resolving this specific problem, but of greater interest is considering the ineffectiveness of the Malian forestry codes at protecting forests while at the same time respecting the needs of subsistence-level villages and farmers to produce the crops and animals they need to survive. It is a case of a governmental attempt to legislate a complex and difficult problem. Parallels can be readily drawn to examples of similar situations in developed nations where problems are legislated without attending to underlying causes and needs in the situation. At another level, this case can provide opportunity to discuss regional and international development policies and address broad natural resource and agricultural concerns. Consistent with the inductive nature of case education, the teacher has the opportunity to begin at the level of the village and to progress to the considerations and implications at regional and even global levels.

**How effective do you think the Malian forestry code is for preventing bush fires? Explain.** The top priority of the Malian government and the people is self-sufficiency for food. This goal, however, becomes more elusive as drought

and resource depletion through desertification continues. Since trees and forests are intimately linked with and enhance crop and livestock production, it is in the interest of all Malians to protect and preserve forest ecosystems. However, bush fallow agriculture has been practiced for centuries by farmers in Mali as the most practical means for clearing lands and preparing fields for crop production. Without alternative means of field preparation, farmers are restricted to producing crops only on continuously cultivated fields near the village, which are not sufficient in area or productive capacity to satisfy food needs. The Malian law concerning deforestation is well-meaning insofar as it considers the needs of the nation to protect its forest ecosystems, but it falls short in not providing alternative strategies for village food production.

#### How would you change the law to make it better?

Because of the serious long-term implications of desertification for the nation of Mali, the government must take steps to preserve and protect the bush forest ecosystems. One way to improve the current situation would be to change the forestry agent's role from one of regulator and law-enforcement to that of education and development assistance. Forest laws alone will not stop the practice of bush burning. Efforts need to be made to educate traditional Mali farmers about the importance of preserving bush to counter the effects of desertification. Agents should be trained in implementing strategies for helping villagers to establish nurseries and to plant/protect trees. These agents should also work with villagers to identify strategies for assuring adequate production of food crops without farming marginal or ecologically fragile bush lands. Many traditional Malian agricultural fields and bush fallow lands are on coarse-textured soils where fertility and water holding capacity are limited. Alternative practices need to be developed and extended to farmers. These alternative practices would allow farmers to incorporate greater quantities of organic matter to enhance soil water holding capacity and structure; more organic matter would also increase availability of nutrients, especially nitrogen, to grain crops such as pearl millet. Incorporation of leguminous plants in the rotations is one means of achieving these goals.

**What are some of the causes and consequences of desertification in Mali?** One of the causes of desertification in Mali is overpopulation. As population grows, more land is needed for cultivation, especially if productivity of individual fields are stagnant or declining. To compensate, fields that would normally remain in bush are pressed into use for crop production. Fallow rotations become shorter, causing soil fertility to decline and reducing the ability of the bush to regenerate between agricultural cycles. Higher populations also increase demand for fuel wood (a primary energy source at the village level) and livestock grazing, which further contributes to depletion of the forests.

Burning fields in preparation for planting suppresses establishment of tree seedlings of fire-tender species. Only fire-tolerant species survive, although even these may be stunted by burning. Organic matter is combusted by burning and only ash is returned to the soil. Thus, much needed nitrogen and carbonaceous organic matter are lost, which further limits the nutrient status, water holding capacity, and structure of the soil. Lack of trees to deter wind erosion also favors encroachment of the desert.

**Who should be held responsible for land degradation and desertification in Mali?** Everyone has a stake in countering the encroachment of the desert and conserving soil in Mali. Making fields fertile and productive within this harsh agricultural environment is a joint responsibility of the forest agents and the farmers. Food sufficiency is essential to the long-term well-being of the nation of Mali; therefore, all citizens should favor policies that promote conservation of soil and other natural resources consistent with development of better food production systems for farmers.

**What modifications might be made to the cropping systems of Sogolonbougou to make them more sustainable consistent with the need for better forest management and resisting desertification?** To reduce the reliance on shifting cultivation, fields closer to the village would have to become more productive. Agricultural and forestry agents should work with the villagers to introduce cropping system alterations that enhance soil fertility and other soil properties, especially on the continuously cropped fields close to the village. Construction of water storage structures in or near the village could also permit limited irrigation of some fields, which should enhance production and increase the number of crop options that could be grown.

Traditional bush fallow practices are likely to continue into the future, despite the Malian forest codes, because of the importance of production from fallow fields for meeting current food needs. Modifications such as *alley cropping* (a practice that fosters coexistence of bush and agricultural lands) might be introduced to reduce the detrimental consequences of shifting cultivation. Field sizes should be restricted to retard erosion. Importantly, revegetation with desirable tree species at the beginning of the fallow period should be practiced and the length of the fallow periods between agricultural cycles should be long enough to assure full recovery of the forest. Selective harvests of desirable tree species for fuel, building materials, and livestock forage could be practiced on such reforested lands.

**What would you do if you were Coulibaly and Diarra and why?** Coulibaly does not have much of a choice in the immediate situation. He knows that his village must continue to practice shifting cultivation if his people are to survive. His immediate dilemma is how to respond to the agent who has come to collect the fine for burning. Although a shouting match has occurred, he could attempt to reestablish a conciliatory tone with the agent and a more constructive dialogue to resolve this immediate problem. He might pay the fine to clear the air, but then work to establish a plan for improving production capabilities on continuously cropped fields near the village while implementing alternative bush agricultural practices such as alley cropping. It is unlikely, however, that Coulibaly, as an illiterate village leader, has much knowledge of such practices, and the extension education resources at his disposal are very limited.

Within the context of his culture, Coulibaly could also pay the agent a gift (bribe) with the understanding that the agent would not bother him or his village during this production season. Of course this solution would do nothing to resolve the larger problem of stopping bush deforestation and desertification. It is equally unlikely that anything would be served by Coulibaly going to jail for not paying either the fine or the bribe.

Diarra might have preferred to receive a bribe rather than the fine, since a fine needed to be shared with the Forest Service. Unfortunately, incentives for Diarra to assist the village to improve its agricultural practices were lacking. He was paid substandard wages, and bribes were a way of increasing his income. His many responsibilities for providing for his immediate and extended family should not be taken lightly in the context of the Malian culture. Ideally, Diarra would collect the fine and then work with the village leaders and farmers of Sogolonbougou in an educational program to improve their shifting cultivation and reforestation practices. This scenario, unfortunately, had little likelihood of occurring, considering the circumstances in this case.

Resolution of this case is frustrated by a cycle of confrontation, disincentives, and fatalistic despair. There are strong interpersonal and institutional barriers that hinder resolving this case in a way that fosters long-term improvement of the situation. This, unfortunately, is typical of many problems confronted in resolving environmental dilemmas in developing nations. In deliberating this case, students should be encouraged to consider how such cycles of confrontation and disincentive also exist within the USA and other developed nations, especially in relation to environmental dilemmas. An associated assignment for the case might be for students to research a contemporary dispute involving agricultural or forestry practices in a developed nation and describe how attempts to achieve conservation or environmental goals without attending to fundamental needs or perspectives of industry, communities, or individuals have fared. Such attempts are often viewed as being restrictive or unfair, just as the forestry codes were regarded by the people of Sogolonbougou. Examples of such disputes include the debates over wetlands and timber logging in the USA.

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## EDITORIAL

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### Teaching with Decision Case Studies

John G. Graveel\*

During the last 10 years, how often have you heard students say, "How does this relate to real life?" Decision case studies are a way to bridge the gap between class material and the real world. Students are more motivated to learn when they use decision case studies to apply their studies to real-life situations. This past summer I had the opportunity to participate in a case studies conference entitled, "Teaching and Learning with Cases: Promoting Active Learning in Agricultural, Food and Natural Resources Education." The conference was held in Chaska, MN, from 6 to 8 July 1995. Conference coordinators with expertise in decision case teaching and writing came from Michigan State, Oregon State, and the University of Minnesota.

Since it was my first case studies conference, I was interested in how I might use decision case studies in my teaching program. Topics discussed at the conference included: course design when using case studies, cooperative learning and group dynamics, and assessment of students when using decision case methodologies. According to Steve Simmons from the University of Minnesota,

Decision cases are a teaching tool. Like most tools they serve certain purposes very well and others less so. If your goals are to help students develop analytical and synthesis skills, apply concepts, learn to solve problems, develop mature judgment, and enhance communication skills, case teaching is an excellent tool to use.

During the 3 days at the conference, we were given ideas about how to write decision cases and learned how to teach a case. According to Simmons (1994), there are four phases in a decision case study. These are: a general discussion about the case to heighten student interest, an assimilation phase in which students study the case, an in-depth discussion of the case, and the conclusion.

After the conference I was anxious to use the decision case method. My first opportunity was in the introductory (AGR 101) course, Lectures in Agriculture. This is a fresh-

man course designed to introduce students to the various departments in the College of Agriculture. I used a simple case entitled "Heavy Metal Veggies," designed for high school seniors or beginning college freshman. The case involves using potentially contaminated commercial compost on a vegetable garden. Although I was not able to address all four phases of the decision case in the 50-min period, I had time to introduce the case, have the class read it, and break into groups to discuss the case. The students thoroughly enjoyed the challenge of arriving at a decision about use of compost on the vegetable garden.

There are good case studies available for use from the Program for Decision Cases at the University of Minnesota. This fall I used more sophisticated cases, such as the Trees of Sogolonbougou in the Environmental Seminar course. In the Environmental Science course this spring I plan to use cases such as, (i) High Nitrate Showdown at Clear Lake, (ii) "One Size Does Not Fit All" Pesticides and the Baby Food Industry: A Case Study, and (iii) the Minto-Brown Island Park: Farming the Urban-Agricultural Interface.

The Minnesota conference has heightened my interest in using this method of teaching and has provided me with another valuable tool to encourage interactive learning. From my initial experience with decision cases, students now are more enthusiastic participants instead of passive note takers. I feel they are learning more because they are more involved. The students enjoy taking concepts from the text and lecture and putting them to use. The problem-solving techniques and communication skills students use in decision case studies not only make it easier to understand the material, but are necessary skills for daily life.

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Your comments concerning the content of this editorial or other published material in this journal are welcome at any time. Please send your Letter to the Editor to: Dr. John G. Graveel, Department of Agronomy, 1150 Lilly Hall of Life Sciences, Purdue University, West Lafayette, IN 47907 (jgraveel@dept.agry.purdue.edu).

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# The Future of Walnut Creek Farm: A Decision Case Study

Craig C. Sheaffer,\* Melvin J. Stanford, Charlene Chan-Muehlbauer, and Douglas Gunnick

## ABSTRACT

In February 1993, Paul and Mary Mitchel were preparing for the liquidation sale of their 75 Holstein dairy cow (*Bos taurus*) herd and contemplating the future of their farm, which had been in the family for three generations. The farm was located on the southwestern edge of the Minneapolis suburbs. The area was experiencing extensive housing development that had increased land values and property taxes. Their dairy operation had been profitable and more efficient than many farms in the area, but the Mitchels wanted to develop a farm business, which placed a high value on family and which would be large enough to support Paul, Mary, two teenage children, and two sons who live off the farm. Although the Mitchels were emotionally attached to Walnut Creek Farm, they were considering selling the farm and relocating to a larger farm more suitable for rotational grazing, combined with seasonal milking, as a strategy for achieving their financial and family goals. With this strategy, the Mitchels expected to have greater net income than with confinement feeding and year-round milking because of lower production costs. The farm equipment and facilities of Walnut Creek Farm required replacement, and there were potential problems providing adequate pasture for a large herd on dispersed farm lands. Through this case, students will learn the importance of family goals and finances in decision making and become familiar with intensive rotational grazing and seasonal milking as milk production strategies.

A MAJOR THREAT to a viable agriculture is the loss of agricultural land due to sprawl of new housing. With housing development, land values and property taxes increase resulting in farming becoming less profitable than other uses of the land. Most states do not have legislation protecting farmland, and therefore farm families are faced with difficult choices, especially if their farm has been in the family for several generations. This case provides insight into financial, technical, and social factors affecting these choices.

## THE CASE

In February 1993, Paul and Mary Mitchel were preparing for the voluntary liquidation sale of their Holstein dairy cow herd in March and were considering the future of their farm, which had been in the family for three generations. The

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Mitchels and their two children, Ruth (14 yr) and John (11 yr) operated the 75-cow Walnut Creek Farm in southcentral Minnesota. Two married sons, Peter (a biologist) and Timothy (an engineer), lived in neighboring towns and were interested in returning to the farm to work. An important goal for Paul and Mary was to provide an opportunity for all three families to farm together.

The Mitchels were considering several strategies to support their family on Walnut Creek Farm. Paul had been to several seminars on intensive rotational grazing and was considering using this new approach to feeding dairy cows in combination with seasonal milking. This approach was appealing because it required less equipment, facilities, and manure handling than the conventional confinement system that the Mitchels had been using. In addition, from everything Paul had seen, he believed more profit could be made from pasture feeding than from confinement feeding. Paul felt that in the future, additional cows could be added to the herd, which would allow full-time employment of his sons, Peter and Timothy.

Paul felt that a realistic herd number to support the extended family on intensive rotational grazing was 150 cows. Although the Mitchels planned to hold onto some registered heifers and yearlings, going back into dairying would involve buying additional animals. With costs of more than \$1000 per heifer or cow, this would be a sizeable expense. Milking a herd of 150 cows would involve modernizing the aged milking parlor and purchasing additional equipment for barn cleaning. These costs might run as high as \$50 000. Permanent perimeter fencing would also be required for grazing on the farm, because most old fencing had been removed when the land had been cropped. Paul had estimated fencing and watering costs to be about \$61/ha (\$25/acre). This would include use of multiwire electrified high-tensile perimeter fence with portable electric fence for interior division of paddocks.

In combination with their dairy operation, the Mitchels were considering developing a market for farm-grown products. Their proximity to major urban growth would provide a market for high-quality meats and vegetables. They had worked with a local butcher and sold meat from culled animals to neighbors. They had developed a profitable niche market and were now considering raising steers for slaughter and marketing. They also discussed the potential for raising chickens (*Gallus gallus*) on pastures because a dairy farmer in southern Minnesota had a profit of \$4 to \$5 per bird by grazing. Timothy, the son who was a professional engineer, was even looking into fish farming. A daughter-in-law was considering opening a farm market in an abandoned grainery on the farm near the intersection of two busy highways (County Road 77 and 2nd Street N.E., Exhibit 1).

Selling Walnut Creek Farm and relocating was being considered by the Mitchels. Income from land sale would provide an opportunity to establish a larger farm capable of

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Abbreviations: DHIA, Dairy Herd Improvement Association.

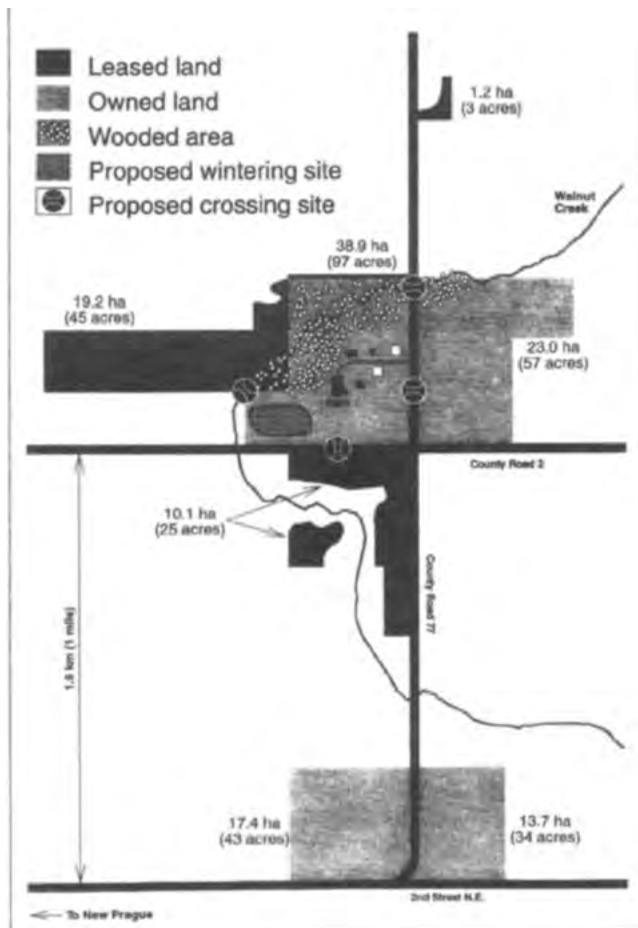


Exhibit 1. Walnut Creek Farm.

supporting the family. A nearby farm family had recently divided a field into 4.1-ha (10-acre) lots and sold each lot for \$30 000 to \$50 000. They used the proceeds from that sale to buy a larger 97-ha (240-acre) farm on good land in Wisconsin. Based on the prices received by their neighbor, the land of the 93.1-ha (230-acre) Walnut Creek Farm would be worth a substantial amount, not counting the value of houses and facilities. The Mitchels currently owned a 64-ha (160-acre) farm in northern Minnesota. The land had been farmed by Mary's family, but now was used primarily for hunting. The farm had a small house and barn, was surrounded by perennial grass pastures, and had potential for expansion because most pasture land in northern Minnesota sold for only about \$740/ha. Instead of investing into Walnut Creek Farm, it might be most practical to move to northern Minnesota and develop a new, efficient facility.

**Farm Background.** The Walnut Creek farm had been purchased by Paul's grandfather in 1934 during the depression, and Paul was born in the house his family lived in. After military service and earning a B.S. degree in dairy science and agricultural economics from the University of Minnesota, Paul returned to the farm in 1964. From 1964 to 1969, Mary and Paul lived in a trailer on the farm while Paul worked part-time on the farm and full-time for Cannon River Breeders, a commercial dairy cow insemination com-

pany. When Paul's father retired in 1969, Paul and Mary purchased the farm and began farming full-time. There was no doubt that Paul was attached to the farm. He said, "The longer I'm here, the deeper my roots are." Paul's elderly mother still lived on the farm in her own house and was happy to be near Paul and his family.

Walnut Creek Farm was located within 3.2 km (2 mi) of New Prague, MN, on the southwestern edge of the Minneapolis suburbs. The area, which had once been primarily farm country was now dotted with new housing, most of which was situated on large lots. The land was being populated by commuters who were willing to drive 1 h to escape living in the big city or its immediate suburbs. The completion of a new bridge across the Minnesota River would reduce commuting time to the area, and Paul expected a continued increase in the area's population within the next 20 yr. Because of the potential for development, land prices and property taxes had increased. So far, property taxes had not increased for Walnut Creek Farm, because the farm was somewhat protected from shifts in taxes. The Mitchels had enrolled the farm in the *Green Acres Program*, which was legislated by the state of Minnesota to provide tax relief from property taxes and exemptions from sewer and other improvement taxes. The program also stipulated that if the farm were sold and converted into housing development, all tax relief for the past 3 yr would have to be repaid.

When ownership was transferred to Paul and Mary in 1969, Walnut Creek Farm had 48.6 ha (120 acres). In 1992, it consisted of 95 ha (234 acres), with an additional 28.3 ha (70 acres) rented. The long-term status of the rented land was uncertain because it might be sold or the owner's son might elect to farm it. For now, the Mitchels used the following crop rotation on the 114.6 ha (283 acres) of tilled land they farmed:

- 1 yr of corn (*Zea mays* L.)
- 1 yr of oat (*Avena sativa* L.) used as a companion crop for alfalfa (*Medicago sativa* L.) establishment
- 2 yr of alfalfa harvested for hay or silage

Following the second year of alfalfa, corn was again planted. Of the total farm land area, about 24.3 ha (60 acres) were in corn with the remainder in alfalfa-grass [*quackgrass* (*Elytrigei repens* [L.] Nevsk.), smooth bromegrass (*Bromus inermis* Leyess), and timothy (*Phleum pratense* L.)] mixtures. Although his dad had been one of the first in the area to use herbicides for weed control, Paul quit using herbicides and other pesticides in corn when he became sick following a season of their use. For control of weeds in corn, he used a combination of crop rotation, late planting, and timely cultivation and still managed to achieve 7.5 Mg/ha (120 bu/acre) grain yields. Alfalfa yields averaged 11.4 Mg/ha (5.1 ton/acre). Crop nutrient needs were supplied by manure application and by plowing down alfalfa. The farm building site and adjacent woodland consisted of 8.5 ha (21 acres). Portions of the woodland contained a planting of valuable black walnut trees (*Juglans nigra* L.) whereas other portions were open and contained Kentucky bluegrass (*Poa pratensis* L.), smooth bromegrass, reed canarygrass (*Phalaris arundinaceae* L.), and quackgrass, which had been used for grazing of dairy calves and heifers.

Most of the farm buildings and equipment were old. The tie-stall barn had been built in 1971 and the barn cleaner, manure pit pump, and silo system were installed at that time. Paul still owned the John Deere chopper, which he purchased in 1969, and did not want to invest much in equipment; he had operated a custom silage bagging business for the past several years; he used this system for making his own silage and found that silage quality was high and cost of silage production relative cheap compared with more permanent silage structures.

Paul had used his knowledge of dairy management, feeding, and breeding to develop a registered holstein herd with a production average of more than 9080 kg (20 000 lb) of milk per cow per year; some cows produced in excess of 10 896 kg (24 000 lb) of milk (Exhibit 2). The overall herd production level was greater than the area average of 7862 kg (17 318 lb) and the state average of 6674 kg (14 700 lb). The daily ration was balanced to meet nutritional needs and consisted of about 11.4 kg (25 lb) of high moisture corn; 27.2 kg (60 lb) of alfalfa grass haylage; 2.3 kg (5 lb) of a protein supplement, which was often corn gluten meal; plus vitamins and minerals and soybean [*Glycine max* (L.) Merr.] hulls. Paul and Mary also had a successful business selling registered Holstein females and bulls.

In December of 1991, the Mitchels had decided to sell their entire herd of registered Holstein cows. This decision had been a hard one, and had been made despite the advice of their neighbors who said, "Once you get out, you'll never get back into dairying." The Mitchels, however, thought they had several good reasons for the sale. Their facilities and equipment for continued confinement feeding of dairy cows were antiquated and in need of replacement. They had grown tired of the hassles and expenses of maintaining a registered operation, and the herd liquidation was a good way to recoup some of the cost incurred over the years. Also, since 1991 when his two older sons left the farm, Paul had depended on hired help to provide labor. Although he considered the hired workers to be efficient, Paul had grown tired of the management and paperwork associated with Worker's Compensation and Social Security. The Mitchels also wanted to get their two youngest children involved in the farm business and felt that a clean break from the old milking operation was a good opportunity to start anew. The break would give Paul "time to think about things and get it all together." Finally, funds from the sale could be used to pay off debt owed on the low-interest loan provided by

**Exhibit 2. Milk production variables in 1992 for Walnut Creek Farm compared to area averages.†**

Item	Walnut Creek Farm	Area avg.
Herd size	75 cows	54 cows
Milk produced/cow (kg)	9430‡	7862
Milk fat (%)	3.6	3.5
Price/kg milk (\$)	0.28	0.27
Total costs/cow (\$)§	2605	1769
Feed cost/kg milk (\$)	0.11	0.12
Net return per cow (\$)	444.06#	355.03

† Source: Farm Business Management Association, Center for Farm Financial Management, Austin Technical Institute, Austin, MN. Results of FINPACK financial analysis.

‡ DHI rolling herd average 10 Dec. 1992, was 9892 kg.

§ Total costs include direct costs of feed, veterinary, livestock supplies, hired labor and utilities, and overhead costs.

# Return per cow including dairy calves sold and cull sales was \$984.27.

Paul's parents when he purchased the farm in 1969. Paul's elderly mother might need the money. Based on similar sales of registered cows in the state, Paul hoped to receive over \$1500 per head for the sale of the herd, but this was not guaranteed.

The Mitchels had decided to retain some registered stock to allow some sustained income and flexibility if they chose to return to dairying. These animals included 28 bred heifers, 19 yearlings, and 27 bull calves. Paul felt that if they resumed dairying, he would try to develop a registered herd that would have good performance on pasture.

**Family Goals and Finances.** Quality of life and quality time with the family were very important to Paul and Mary. They took several family vacations every year, which was atypical for the majority of dairy families. In addition, Paul was an avid and successful hunter and he and his sons committed time to deer (*Odocoileus virginianus*) hunting each year. The Mitchels had also recently remodeled their home, which was the original house on the farm. Paul said, "We've always maintained a pretty high standard of living." In addition to income from the farm, the family also derived income from Mary's full-time job off the farm. She was a talented artist who worked for a design company in a nearby town.

The 1992 net cash income for Walnut Creek Farm of \$62 392 (Exhibit 3) was well above the 448 farm average of \$35 319 (Exhibit 4) reported for south central Minnesota and close to the \$64 267 reported for the 90 farms with the highest return. Net farm income for Walnut Creek of \$38 831 was substantially above the 448 farm average of \$28 391 but below the \$67 219 average reported for the 90 high return farms.

In terms of size, Walnut Creek's total 121 ha (300 acres) were substantially less than the 448 farm average of 207 ha (511 acres) reported for 1992 (Exhibit 4). The highest return farms had an average size of 338 ha (834 acres), indicating that the more profitable farms were also, on the average, larger than the less profitable farms.

Walnut Creek farm assets at the end of 1992 of \$877 892 were substantially above the 448 farm average of \$478 911 (Exhibit 5). Walnut Creek net worth of \$681 116 was more than double the average reported farm net worth of \$255 709.

#### **Intensive Rotational Grazing and Seasonal Milking.**

Intensive rotational grazing and seasonal milking were relatively new concepts in Midwest dairying. They were most often practiced by farmers who believed in sustainable farming methods and contrasted with the conventional confinement feeding strategy, which used stored and purchased feed to provide most of the dairy cow ration. Although Paul had been using some sustainable agricultural practices, such as not using pesticides in corn production, his interest in rotational grazing increased when he attended a seminar on Holistic Resource Management. Paul said, "That seminar opened my eyes on how to make money without damaging the environment and on having family as a priority." In summarizing confinement barn feeding, Paul said, "It seemed like I was just trading dollars in costs for dollars in income."

Paul was considering use of seasonal milking, which consists of a synchronization of calving and subsequent milk production for all cows in the herd. In Paul's system,

**Exhibit 3. Income and expenses for Walnut Creek Farm in 1992.†**

Items	Value
Cash farm income	
Alfalfa hay‡	\$ 150
Bull calves‡	130
Dairy steers‡	24 397
Dairy heifers‡	2 635
Milk‡	204 662
Cull breeding livestock	13 354
Misc. livestock income	259
Deficiency payments	3 174
Custom work income	10 719
Patronage dividends	2 107
Other farm income	<u>1 921</u>
Gross cash farm income	\$263 508
Cash operating expenses	
Seed	\$ 6 290
Crop insurance	122
Crop miscellaneous	2 670
Purchased feed	38 472
Breeding fees	8 373
Veterinary	9 495
Livestock supplies	13 684
Livestock marketing	5 928
Interest	16 592
Fuel and oil	7 016
Repairs	13 243
Custom hire	9 839
Hired labor	37 075
Land rent	4 510
Machinery and building leases	401
Real estate taxes	4 405
Farm insurance	4 646
Utilities	8 957
Dues and professional fees	5 720
Miscellaneous	<u>3 678</u>
Total cash operating expenses	\$201 116
Net cash farm income	\$62 392
Less: Decrease in inventories	<u>-21 086</u>
Net operating profit	\$41 306
Less: Depreciation, net	<u>-2 475</u>
Net farm income	\$38 831

† Source: Farm Business Management Association, Center for Farm Financial Management, Austin Technical Institute, Austin, MN. Results of FINPACK financial analysis.

‡ Income derived from sale of 1.8 Mg alfalfa hay, 1 bull calf, 30 dairy steers, 3 dairy heifers and 707 251 kg of milk.

cows would calve in late April with pasture as an important food source from May until October. In addition to pasture, cows would be fed about 6.8 kg (15 lb) of a corn–mineral–vitamin mixture each day during milking. Heifers would obtain all their nutrients from pasture with no supplementary feeding during the grazing season. The late fall and winter ration for milking cows would consist of alfalfa–grass haylage harvested on the farm and stored in plastic bags and some purchased energy and protein ingredients to provide a least-cost balanced ration. Dry cows and heifers would be fed alfalfa–grass hay, and haylage. Paul expected cows to be dry about 4 to 6 wk but would make a decision regarding length of the dry period when he looked at profit from the dairy operation.

Paul felt that overall, seasonal milking in combination with rotational grazing would reduce feeding and maintenance costs. As Paul said, “This is a bare bones approach to dairying.” Paul recognized that milk production would be lower. “My goal is to achieve 5675 kg (12 500 lb) herd average with 150 cows,” but he felt that he could make more money than with his current confinement feeding operation. Using some informal estimates based on an assumed herd size of 80 cows and a herd average annual milk production

**Exhibit 4. Average income, expenses, assets, liabilities, net worth, and size (ha) for farms in south central Minnesota in 1992.†**

Item	448 farm‡ avg.	High§ return	Low return
Cash operating income	\$207,634	\$342,662	\$164,204
Cash operating expense	<u>172,315</u>	<u>278,395</u>	<u>141,456</u>
Net cash income	35,319	64,267	22,748
Inventory change	<u>5,644</u>	<u>22,205</u>	<u>-8,355</u>
Net operating income	40,963	86,472	14,393
Depreciation and other adjustments	<u>-12,572</u>	<u>-19,253</u>	<u>-15,779</u>
Net farm profit or loss	<u>\$28,391</u>	<u>\$67,219</u>	<u>-\$1,386</u>
Total assets	478 911	605 769	481 833
Total liability	223 202	310 279	204 112
Net worth	255 709	295 490	277 721
Hectares owned	75	75	84
Hectares rented	129	263	100
Hectares operated	207	338	185

† Source: Farm Business Management Association 1992 Annual Report, South Central Minnesota, Austin Technical Institute, Austin, MN.

‡ Farms include dairy and crop enterprises.

§ High and low return represent the top and bottom 20% (90 farms) in returns.

**Exhibit 5. Assets, liabilities, and net worth for Walnut Creek Farm on 31 Dec. 1991 and 1992.†**

Item	1991	1992
Total assets	\$863 749	\$877 892
Total liabilities	<u>208 958</u>	<u>196 755</u>
Net worth	\$654 791	\$681 116
Assets (at current value)		
Breeding livestock	\$197 655	\$205 138
Machinery and equipment (net)	90 747	91 277
Buildings and improvements (net)	137 500	137 500
Other assets (net)	61 167	67 842
Land	<u>376 680</u>	<u>376 135</u>
	\$863 749	\$877 892

† Source: Farm Business Management Association, Center for Farm Financial Management, Austin Technical Institute, Austin, MN. Results of FINPACK financial analysis.

of 6356 kg (14 000 lb) per cow, and using approximations for costs of feed, housing, supplies, and utilities based on his past experience, he projected a possible annual net return of \$100 000.

Paul was excited about rotational grazing and was willing to convert all his cropland to pastures. Fields that were in alfalfa–grass mixtures or permanent pasture could be immediately adapted to grazing, while corn ground would have to be reseeded. For grazing, Paul planned to seed a mixture of forages including red clover (*Trifolium pratense* L.), alfalfa, smooth brome grass, tall fescue (*Festuca arundinaceae* Schreb.), and timothy. He hoped that quackgrass, which was widely distributed on the farm, would become an important pasture component and that grasses would constitute at least 50% of the pasture forage. Paul had fenced some pasture land in the spring of 1992 and rotationally grazed calves and heifers in 1992. He liked their performance on pasture and believed that all animals were tamer than when raised in confinement. The rotational grazing system he used with his heifers consisted of rotating animals to fresh forage about every 2 to 3 d with a rest period of about 30 d before grazing pasture regrowth. With rotational grazing of dairy cows, Paul felt cows should graze a paddock of forage for only 12 h and leave about a 10- to 15-cm (4- to 6-in) stubble. He was tempted to try his dairy cows on pasture, but he resisted because he wanted to maintain high levels of

milk production before the sale. A drop in milk production would decrease the value of his milk cows and reduce his return at the sale.

Because much of his equipment was old and costly to replace, Paul liked the idea of animals harvesting the majority of their own feed during the spring and summer. He would hire neighbors to bale hay for winter feeding and to chop forage while he made silage using his own silage bagging equipment. Paul wanted to winter his dry cows as inexpensively as possible. He was planning to have the animals stay outside near a wooded area by the barn, which was sheltered from the wind (Exhibit 1). Also, he had a large open shed that cows might use for shelter under very adverse conditions. Paul still wasn't sure what effect this wintering would have on his pasture, especially during wet periods when animal trampling might destroy the sod and turn pastures into mud. He said, "A critical time for us will be the spring, deciding when to start milking and dealing with the mud."

A major drawback to rotational grazing was the logistics of animal movement on Walnut Creek Farm. There were only 10.9 ha (27 acres) of open pasture immediately adjacent to the barn. About 19.2 ha (45 acres) of leased land to the west of the barns were separated from the farm by a deep stream and would only be accessible on a daily basis if a bridge were built. An additional 33.1 ha (82 acres) of owned and leased land was separated from the barn by two busy highways. The cost of an under-the-road culvert was about \$20 000, so Paul was seeking alternative methods of getting the cows across the road. He thought he could get permission from the county to cross the road with milking cows and to install cattle crossing signs. In any case, cows would have to do quite a bit of walking to reach pastures from the barn.

It appeared that there also would be difficulty providing adequate pasture for a herd of 150 cows plus replacement animals on Walnut Creek Farm. Assuming an average cow weight of 590 kg, a 170-d grazing season (1 May–15 October), and an alfalfa–grass pasture with a 11.2 Mg/ha (5 ton/acre) yield, 53 ha (131 acres) would be required (Undersander et al., 1991). This quantity of pasture was available on Walnut Creek Farm, provided roads and the stream could be crossed, but Paul did not plan to maintain pastures with a high alfalfa content. With pastures containing red clover, alfalfa and at least 50% tall fescue, timothy, smooth bromegrass, and quackgrass, yields likely would be 20% less than for an alfalfa–grass hay field; consequently, land requirements would be greater. In addition, pasture would need to be supplied for replacement animals.

Paul still had to wrestle with developing a milking and barn feeding system that would not aggravate health problems, which he and his sons had. Paul said, "One of the reasons I wanted to quit milking was to quit doing knee bends; to avoid back problems, which my Dad had." He felt that a good parlor system might partially alleviate that problem. In addition, both Timothy and Peter suffered allergies, which might arise from feed handling and from the cows; therefore, consideration had to be given to ventilation of the milking and feeding systems.

**The Future.** The Mitchels were committed to providing an opportunity for the whole family to live and work together

on a farm. Although Paul was confident that a farming enterprise focused on rotational grazing could be profitable, a decision needed to be made regarding the location for the farm. There was uncertainty whether Walnut Creek Farm would provide the necessary pasture to generate income to support three families. With aged facilities, high land values, and a limited number of animals to move, it might be an excellent time to relocate to a new farm.

### INTERPRETIVE NOTE (Short Form)

Paul and Mary Mitchel and their two teenage children operated Walnut Creek Dairy Farm on the southwestern edge of the Minneapolis suburbs. Although the farm had been in the family for three generations and had an excellent record of milk production and profitability, there was a question regarding its future. The area had a good potential for development and population growth in the future, and land prices had already increased. In addition, Paul and Mary were trying to expand the operation to include two sons and their families who did not live on the farm. They placed a high value on family and on quality of life and were trying to decide how to employ their whole family on the farm.

#### Case Objectives

This case should provide an understanding of the factors influencing decision making by farm families. Upon completion of the case, students should:

1. Understand the importance of personal goals in decision making by farmers.
2. Become familiar with intensive rotational grazing and seasonal milking as milk production practices.
3. Understand farm financial records.
4. Estimate the potential of Walnut Creek Farm to support three families.

#### Use of the Case

The case was prepared for classroom and extension education. It can be used by students and professionals in farm management, agronomy, sociology, and dairy science. It is of particular interest to those studying sustainable agriculture, which requires integration of multiple disciplines into decision making processes. The influence of personal values and economics on decision making are examined. The following questions will direct case users in understanding the Mitchels and the decision they face. The authors' insight into these issues are provided in a full interpretive note. An example is provided for Question 2.

1. What are the Mitchels' objectives?
2. What options do the Mitchels have in achieving these objectives?

**Authors Insights.** The Mitchels need to carefully consider whether they can provide full and profitable employment for their whole family on Walnut Creek Farm. The Mitchels plan to use intensive rotational grazing for feeding of their dairy cows. They must carefully consider whether they should sacrifice the farm and purchase a larger farm that would facilitate participation of the entire family in a dairy operation.

Paul's ultimate goal is to milk 150 cows with a herd average of 5677 kg of milk per cow. This would provide a total yearly production of 851 499 kg of milk. At 1992 prices of \$0.27/kg, this level of milk production would provide a gross income of \$229 918. In 1992, with 75 cows fed in confinement feeding, average milk production was 9988 kg per cow. This resulted in gross income of \$216 810. The key to increased profits will be the ability to reduce feed and maintenance costs for the cows.

With intensive rotational grazing, pasture will provide a significant amount of feed to the cows. Unfortunately, only about 10.9 ha (27 acres) are immediately adjacent to the barn. Access to 52.3 ha (129 acres) of additional grazing land is made difficult by roads, a creek, and distance from the barn. The 31.1 ha (77 acres) that are nearly a mile away might provide hay production, but are unfenced and have no water supply.

Using formula to estimate carrying capacity derived from Undersander et al. (1991), it appears that there may be difficulty providing adequate pasture for a herd of 150 cows. Assuming average cow weight of 590 kg, a grazing season of 153 d (15 May–15 October), and alfalfa–grass pasture

with a 11.2 Mg/ha (5 ton/acre) yield, 53 ha (131 acres) would be required. Paul had been successful in achieving similar yields with pure alfalfa stands used in hay production, but yields would be less for mixtures containing a high proportion of grass.

3. Evaluate the productivity and profitability of Walnut Creek farm in relation to area farms and Dairy Herd Improvement Association (DHIA) guidelines.
4. How are intensive rotational grazing and seasonal milking different from conventional confinement dairy herd management practices?
5. Are there any environmental concerns from using the rotational grazing and animal wintering strategy proposed by the Mitchels?
6. What should the Mitchels do? Why?

## REFERENCES

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# Scientists Teach Science in Elementary Schools: Case Studies

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## ABSTRACT

Science and engineering offer opportunities for young people to have successful and rewarding careers, but students—especially minorities—are choosing other careers. The reasons are many, but fear and misunderstanding of science may contribute to the problem. The *Science Advisor* (SCIAD) program was initiated in the public school system in Las Cruces, NM, to improve science and technology literacy, and to increase the number of highly qualified scientists needed for society's future well-being. This paper reports on two case studies of this program. A SCIAD is a scientist from New Mexico State University, the NASA White Sands Test Facility, or another local industry who is assigned to a school to teach grades K through 8. The SCIAD advisor spends at least 10 h/mo working with students and teachers. Elementary and middle-school activities vary from direct teaching to helping teachers install an electronic bulletin board system. The SCIAD program is voluntary for both the scientists and teachers. Adoption of SCIAD program materials has ranged from excellent in the middle school system to less than ideal at an elementary school, where the teaching structure is not as conducive to introducing new science experiences and methods. As originally conceived,

SCIADs were supposed to be resources for teachers. However, from the beginning, the teachers wanted the SCIADs to actually teach the new science material to the students. As the program evolves, the teachers are assuming greater responsibility for the science materials introduced by the SCIADs into the school system.

EMPLOYMENT OPPORTUNITIES are diverging into two major types: low-skilled, low-education positions, and higher-skilled, higher-education positions, with a corresponding dichotomy in economic remuneration. High-skill jobs command high salaries, and low-skill employees suffer economically. In the future, many of these high-skill opportunities will require science and engineering training (Anonymous, 1992). These fields are not only economically rewarding, but also make important contributions to society's well-being. Unfortunately, even as the demand for scientists and engineers increases, fewer students pursue these professions. Many young Americans choose business or law instead of science or engineering. Furthermore, a disproportionate number of minority students are by-passing careers in science and engineering.

The marketplace, usually a major influence in the career choices, has not spurred more students to choose science

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**Abbreviations:** SCIAD, Science Advisor; GBS, goal-based scenarios; NASA, National Aeronautics and Space Administration; WSMR, White Sands Missile Range; SCORE, Service Corps of Retired Executives.

and engineering (Sivertsen, 1993). The reason may be that mathematics and science are perceived as difficult and, consequently, are avoided (Kober, 1993). Encouraging science and mathematics in elementary and secondary schools may be the key to improving overall scientific and technologic literacy, and increasing the number of students who choose such careers (National Science Board Commission on Precollege Education in Mathematics, 1983). Science should be presented to students not only as information to learn, but also in the context of future careers.

Students may lose interest in science, because science in the schools is learned through memorization instead of by performing experiments. Scientists have always learned their craft through experiments, and young, future scientists should also learn about the wonders of science by doing science experiments—the best approach to overcoming their fears of a seemingly complex process. Furthermore, “learning by doing” speeds the learning process, and likely will increase interest in science careers (Linn, 1992). Science classes, even in elementary school, could be taught using goal-based scenarios (GBS). This means that the target skills being taught should be developed in the context of reaching a goal, such as decreasing pollution in our rivers (Schank and Cleary, 1994). The steps in goal-based scenarios are:

1. Identify a set of target skills.
2. Develop missions that require the target skills.
3. Choose a focus.
4. Create a cover story that envelops the mission.
5. Plan the operations.
6. Build learning environments to support the target skills.

Recently, the science curriculum in Las Cruces, NM, was revised to teach science by conducting experiments. However, the system is not without limitations. Supporting science textbooks appear to be written by authors who do not present science in a problem or goal-oriented approach. Furthermore, many teachers are not experienced in applying science to solve problems. Consequently, scientists were recruited to teach science and the scientific method to the teachers and students. The idea was teachers first must feel comfortable with an approach before teaching the students.

The SCIAD program was initiated in New Mexico to present science in a hands-on environment and provide role models to young people. SCIADs are scientists and university professors who spend time working with teachers and students in grades K through 8. The program addresses grades K through 8 with the view that young, impressionable students can benefit most by interacting with working scientists. The SCIAD program was first implemented in northern New Mexico schools during the 1990–1991 school year by the national labs at Sandia and Los Alamos, which have an obvious stake in maintaining the supply of future scientists. The program was expanded to southern New Mexico in cooperation with the National Aeronautics and Space Administration (NASA) White Sands Test Facility and the Atmospheric Science Lab at White Sands Missile Range (WSMR) in 1993. At this same time, New Mexico State University (NMSU) agreed to participate and supply scientists for the program in Las Cruces, NM.

## BACKGROUND

The SCIAD program is designed to introduce science to a large number of students, not just a select group (e.g., advanced placement students). Therefore, it was recognized that teachers should be the primary communicators of the science curriculum. SCIAD's goal is to help teachers become more knowledgeable and comfortable teaching mathematics, science, and engineering through continued association with a science advisor.

The SCIAD program is designed to: encourage science and technology literacy for large numbers of students; increase the number of highly qualified mathematicians, scientists, engineers, and technicians; and provide scientists and engineers as role models for children, as well as adults. It was recognized that teachers have special skills needed for communicating with children and that scientists have special skills and knowledge associated with science. Thus, a team composed of a science advisor and a teacher could help fulfill SCIAD's objectives. This paper reports two case studies from the SCIAD program. These two studies were selected, because they represent examples of the interaction between SCIAD and teachers with a general education license and teachers licensed to teach science.

The original scope of work was for SCIAD to help teachers, students, and parents determine staff and school needs in terms of:

1. Supplying required science competencies.
2. Providing in-service training for teachers.
3. Developing lesson plans with hands-on activities and demonstrations.
4. Maintaining science equipment.
5. Installing school computer hardware and software.
6. Supplementing equipment and educational material through the Las Cruces Public School Science Resources Center.
7. Starting science clubs.
8. Writing newsletters.
9. Supporting science fairs.
10. Providing summer workshops for teachers.

SCIAD program participation is voluntary for both SCIADs and teachers. Teachers must request a SCIAD, and a scientist must volunteer to participate. The science advisor agrees to spend 8 to 10 h/mo at the school working with students and teachers; however, some SCIAD faculty spend more than 20 h/mo working at the schools. In addition, there is a strong financial commitment by organizations employing the volunteers, because their salaries are paid by their employers. New Mexico State University justified the expenditure of time and financial resources based on the concept that SCIAD interaction with students and teachers would increase students' interest in science and eventually increase enrollment at NMSU.

The SCIAD program has relied primarily on scientists and engineers currently employed at research institutions (Table 1). More than 90% of the volunteers are currently employed. If these 58 people contributed 10 h/mo for the academic school year, then more than 2.5 scientist-years were contributed. This is a tremendous resource available to schools close to a major university or research institution.



**Table 1. Source of Science Advisor (SCIAD) participants and the public schools served in the Las Cruces school system. More than one SCIAD may be assigned to a school. Thus, the total number of schools served is less than the number receiving advisors.**

SCIAD institution	Faculty (no.)	Public schools served (no.)	
		Elementary	Middle
NMSU†	24	12	5
WSTF‡	24	9	7
ARL§	10	6	2
Retired	5	5	0
Total	63	23	8

† New Mexico State University.

‡ White Sands Test Facilities (Johnson Space Center).

§ Army Research Lab-White Sands Missile Range.

How can schools without these resources compete? Almost any community has medical professionals and engineering or manufacturing firms, which could supply volunteers. Some communities could draw on military bases for expertise. Additionally, a program could be modeled after SCORE (Service Corps of Retired Executives) using the knowledge and experience of retired scientists and engineers to help in the school system. Nationwide, there are more than 13 000 SCORE volunteers. A nationwide community of SCORES (Service Corps of Retired Engineers and Scientists) could be an invaluable asset to school systems, especially in cities lacking universities or research institutions.

While the SCIAD program was conceived and developed at the school district level, each school was considered an autonomous organization and allowed to establish its own group of committed teachers and determine the major activities of the science advisors. These activities took different routes depending on the interests of the teachers, the SCIAD advisors, and the administrative support at each school.

### CASE STUDY: EAST PICACHO ELEMENTARY SCHOOL

At East Picacho Elementary School, the teachers requested the science advisor actually teach science to the 4th and 5th grades. The SCIAD agreed to teach to seven classes of approximately 30 students each. Shortly thereafter, a second science advisor was assigned to the school to teach science to the 1st through 3rd grades.

The SCIAD program is designed to support existing curricula established by the New Mexico State Board of Education (Table 2). Nevertheless, while SCIAD advisors were encouraged to support existing study areas, they were not limited to simply satisfying the state's science requirement. Consequently, the activities (Table 3) at East Picacho Elementary School varied from using water wheels to using computers to identify weed species. Some of the SCIAD programs supported the curriculum requirements of the 1st through 5th grades, while others presented new materials outside the teaching requirements of the curriculum. Presentations supporting the existing program are more likely to be adopted in the future by teachers.

The teachers at the elementary school encouraged the SCIAD to help familiarize them with computer operations. However, this effort was hampered by space constraints, as well as computer software and hardware, that differ from

**Table 2. Required science subject areas in the Dona Ana Co. School District, New Mexico (Guzman et al., 1993).**

1st grade	5th grade
Dinosaurs	Geology: reading the environment
Light, color, and sound	Matter and its changes
Plants, animals of the desert	Oceanography
Your healthy body	6th grade
2nd grade	Ecology
Insect life cycles with focus on butterflies	Electricity
Solids, liquids, gases	Alternative energy sources
Rocks and minerals, environmental awareness	Paleontology
First aid, nutrition	Space technology
3rd grade	7th grade
Forces and machines	Science methods and tools
Solar system	Cellular structure and function
Weather	Zoology and classification
Dental health	Human body
4th grade	8th grade
Plants, animals, arthropods	Astronomy
Light, color and sound	Geologic processes
Human body systems	Chemistry
	Geology

**Table 3. Topics taught at East Picacho School in 1993 and 1994.**

Year	Principle	Technique
1993	Physics of evapotranspiration	Surface temperature measurements
	Weed science	Computer ID program "Weeds"
	How animals learn	Dog with trainer
	Water pollution and hydrologic cycle	Climate station and hydrologic model
1994	Groundwater pollution	Irrigation scheduling computer model
	Can you drink the water? (Part I)	Water analysis (organisms)
	Science fair competition	Plant science in experiments
	Can you drink the water? (Part II)	Water analysis (chloride content, pH)
	Physics of water wheels and levers	Construction of a water wheel and demonstration of levers

school to school because of each school's autonomy. East Picacho Elementary School purchased a Macintosh-based system with a central server and 20 dumb terminals, where the software was controlled under contract to a private corporation. As a result, it was difficult for the SCIAD to install new software on the Macintosh system.

The programs developed at NMSU and others used by SCIAD advisors were DOS- or Windows-based, which were not compatible with the Macintosh system at the school. To enrich the students with programs developed at NMSU, the university loaned IBM machines to the school. However, this caused problems because space available for the machines was limited and teachers lacked training in DOS-based systems. Consequently, the time needed to introduce new computer technology to the school system greatly exceeded the time initially allocated by the SCIAD advisor to the school system, and the DOS-based programs were not used by many of the teachers.

One program the students enjoyed was a presentation by "Prof. Leifsen Stimz" on environmental factors affecting seed germination. This is important not only for agriculture, but also for home gardening and protecting the environment. The students consider possible factors including sowing depth, seed size, temperature, salt, and watering frequency. They design an experiment to test the hypothesis, and write the results of the experiment. Seeds of bean (*Phaseolus vulgaris* L.), corn (*Zea mays* L.), sunflower (*Helianthus annu-*

**Table 4. Evaluations for SCIAD advisor at East Picacho Elementary School from one fourth grade class for Fall semester, 1994.**

Number of evaluations for one Fourth Grade class: <u>20</u>			
	<u>Good</u>	<u>Fair</u>	<u>Poor</u>
1. Instructor is knowledgeable.	75%	25%	0
2. Instructor is interesting.	60%	35%	5%
3. Instructor is positive and exciting.	60%	35%	5%
4. Instructor is friendly and understanding.	85%	15%	0
5. Instructor is well organized.	75%	15%	10%
6. What did you like best about the presentation(s)?			
<u>No. of Students:</u>	<u>Comments:</u>		
11	Working with computers		
3	Learning about weeds		
2	Learning about plants		
1	Working with computer, books, and group		
1	Finding information		
1	Looking for plants in book		
1	Illegible		
7. What are two things you learned from the presentation?			
<u>No. of students:</u>	<u>Comments:</u>		
6	How to look up weeds in the computer and weeds are interesting		
4	Some plants are poisonous		
3	How to press plants in a book		
3	Learned that you can identify almost all weeds		
1	How to find page number on the computer		
1	How to keep plants healthy and how they grow		
1	Plants and flowers come in different colors		
1	Learned about unique characteristics like "spikes on blossoms"		
1	Lots of plants look the same		
1	Learned about plant families and how to describe plants		
8. What else would you like to learn about the topic?			
<u>No. of students:</u>	<u>Comments:</u>		
6	Pressing plants		
4	Identify plants		
3	Weeds		
2	How to collect plants or weeds		
2	How to grow plants		
1	Roots of plants		

us L.), and pecan [*Carya illinoensis* (Wang.) K. Koch] are good selections for this project.

In order to evaluate the effectiveness of the SCIAD advisor's interaction with students and teachers, the SCIAD advisor at East Picacho Elementary School developed an evaluation form. The students were asked which activities were interesting and presented at a level they could understand. The general response of the students was enthusiastic (Table 4). However, comments from the teachers were less positive. The teachers felt the material did not always meet the goals of the school district, and certain material was difficult to understand.

A frequent criticism from the teachers was the SCIAD presented too much material for the students and teachers to assimilate. There might be two remedies to this predicament. First, create a seventh period at the end of the day by shortening the standard six periods. This has been done successfully at some schools for extracurricular activities, such as soccer, chess, language, and art. Perhaps, a science activity would be popular. A second approach would be to focus the year's science activity around one goal, such as, "Can the World Feed Itself?" This goal could easily be developed into a year-long series of science experiments. A year-long activity would still allow the students to learn by doing, and to develop critical thinking skills. Furthermore, this type of activity would allow the students to better understand the role scientists play in solving national problems.

A significant problem encountered by SCIAD advisors, is that they are not trained to teach at the 4th- and 5th-grade

**Table 5. Topics taught by Science Advisor (SCIAD) advisor at Vista Middle School**

Year	Principle	Technique	
1993	How computers work	Disassemble a computer	
	Light and its principal properties	Use prisms	
	Metric system compared to the English measurement system	Use rulers, weights, and volumetric flasks	
	Pulleys and how they work	Use single and double pulleys to lift weight	
	Electricity principles and how magnets work	Construct electric motor	
	Fluorescence	Observe objects under UV lamp	
	Weather	Learn about remote sensing and a demonstration of fog formation	

level. As a result, students are sometimes overwhelmed by the material presented. The SCIAD advisors tried to present material as if the students already understood the scientific method—instead of just learning the approach that scientists use to solve problems. The teachers, unfamiliar with research, also had difficulty understanding what the SCIAD advisors were trying to accomplish. Revising the teaching curriculum toward goal-based scenarios would improve the communication problems between SCIAD advisors and teachers.

Interaction between the SCIAD and teachers at the elementary school level is perhaps the most difficult because of the disparate educational backgrounds of the partners. More realistic goals on the part of both parties might improve students' learning. Furthermore, developing a single, goal-based activity for a semester or year-long learning exercise should facilitate learning.

#### CASE STUDY: VISTA MIDDLE SCHOOL

Two science advisors were assigned to assist the science teachers at Vista Middle School (grades 6–8). The middle school had more science resources available compared to the elementary school. In addition, several volunteers work with the school so the program has a broader scope of activities. One of the science advisors presented projects and demonstrations in the classroom (Table 5). The second science advisor presented workshops on computer literacy to teachers, published a technology newsletter (Technorap) that contained information about computer resources, created a computer bulletin board (Eagle Talk) for communicating with other classrooms within Vista and with other schools using Wildcat software, and supplied shareware tutorials on such subjects as history, geography, chemistry, and computer science.

Over a 2-yr period, he trained 75 teachers in the school. Fourteen of these teachers currently use computer technology in the classroom. He also introduced the students and faculty to the Internet system and to electronic communications outlets (e.g., Prodigy and America Online), with an understanding that math and science literacy also depends on the ability of students to use computers effectively. The school's computers were not initially networked. However, a recent SCIAD activity has been to support the Novell network within the building. Adapting of computer technology into this school along with the associated software training, has had a great deal of success.

One measure of SCIAD's success is to look at the number of students and faculty who had signed on to the bulletin

board to get scientific information or "chat" with friends—170 over a 2-yr period. There are approximately 1000 students in the school.

The teachers at the middle school are more science oriented than the teachers at the elementary school and have more freedom in developing their class material. Teachers at the middle school are already developing courses using goal-based scenarios. Consequently, one team of teachers at Vista developed a course around the goal of getting man into space and determining the effect of the space environment on biological development. The class constructed a dummy orbital shuttle. The dummy shuttle was walk-through size containing a computer for communicating with mission control, simulated wiring panels with replaceable electronic boards, and equipment allowing plant and animal experiments.

While on their shuttle missions, the student astronauts called up the electronic bulletin board (mission control) and talked using the chat mode. This would not have been possible without SCIAD's help. The students typed information on the computer in the simulator, and the operator at the electronic bulletin board (mission control) responded. One of the exercises simulated a failure in the heating system. Actually, the teacher lowered the temperature in the simulator by controlling the thermostats in the classroom. The astronauts used the computer link to report the problem and ask questions on how to replace the electronic board controlling the cooling system. Mission control provided instructions on which electrical panel in the simulator needed replacing, and the faulty circuit was replaced. At that point in the simulation, the teacher raised the temperature in the simulator. The target skills of understanding biology, problem solving, and computer technology were integrated using the goal-oriented scenario and SCIAD's help was essential for this class program.

The Internet focus includes: accessing national news and educational resources, e-mail, and the World Wide Web (WWW). Several science classes routinely use the Prodigy service to access on-line encyclopedias. While the students enjoyed using the computer, the teachers appreciated the speed and ease of accessing and printing information from on-line rather than sending a student to the library to gather material for an assignment. One of the most popular SCIAD classroom presentations was on weather forecasting. The SCIAD advisor had students compare weather forecasts available in the daily newspaper with forecasts available on Prodigy and with those provided by sophisticated facilities at WSMR.

The faculty have been given the most access to e-mail and many of them have established regular communication with colleagues across the country. E-mail has made it possible for teachers to maintain contacts made at conferences and workshops. Communication between SCIADs and faculty is also done by e-mail.

One of the unexpected uses of Prodigy and e-mail has been with students suspended or expelled from school. These students generally lose contact with teachers and sometimes fail to return. During the past 2 yrs, at least six students have been allowed to continue their classwork via e-mail supplemented by occasional home visits. All of these students returned to school. Teachers believe the school con-

tact via e-mail facilitated their return to school by maintaining progress in their classes and improving teacher-student relations.

A WWW home page was created for Vista.<sup>1</sup> The initial information was prepared by the SCIAD. However, two teachers requested additional information to be added to the page. The goal for the upcoming year is to train school faculty and students to create WWW information. Two students are training with the SCIAD this summer.

Integration of computers into Vista's curriculum also has been significant. Most English classes require using word processors. The commercial programs SIMLIFE and SIMCITY have been used as major projects in science and social studies classes. Computer games were even included in the school intramural sports activities. The SCIAD advisor is currently working with the school music teacher to integrate computer song writing and play back into the band class.

## DISCUSSION AND RECOMMENDATIONS

Most elementary teachers do not have a clear understanding of the basic processes that control the science they teach. Their training to teach at the elementary level includes a limited number of basic science classes. Furthermore, most teachers have not learned science through experimentation but rather through reading. Consequently, teachers are not familiar with conducting experiments to achieve goals. When the SCIAD advisor sets up an experiment, such as students growing plants, it is necessary for the advisor to return to examine the results of the experiment and help the students and teacher present the results in a clear and concise manner.

Most experiments do not work the first time for scientists—or for students or teachers. Consequently, time must be allocated in the school system to repeat the same experiment until the results are meaningful. Often, students are not given time to learn from their mistakes. If the experiment does not work, the students go on to other material. This is not science, nor is it learning (Kober, 1993). Learning by experimentation takes time. Students may not learn as many facts through this process, but they will learn how to think and solve problems through experimentation. Factual knowledge is ephemeral; problem solving is permanent. A SCIAD program that does not show students how to be successful in conducting experiments and writing up the results, but simply introduces students to new experiments, does not help fulfill the needs of an effective science curriculum.

If teachers wish to teach science through observing and experimenting with materials and processes of the natural world, they and their students need to learn how to write the results of these experiments. It is important they be able to discuss in writing why the observed results occurred in terms of basic processes, be it plant growth or physical or chemical processes. Students also need to analyze and describe the results of a scientific investigation (Sivertsen, 1993). There are many books available about different projects for student science fairs (Beller, 1982; Blackwelder, 1980; De Vito and Krockover, 1980; Durant, 1991; Lanners,

<sup>1</sup> The Vista M.S. homepage may be accessed at: [http://taipan.nmsu.edu/vista/vista\\_home.html](http://taipan.nmsu.edu/vista/vista_home.html).

1987; Morgan, 1977; Nelson and Lorbeer, 1955). Durant (1991) has details on writing research reports. The SCIAD program can also help here.

One of SCIAD's major constraints is money for science equipment. SCIAD advisors are able to bring sophisticated equipment to the school to conduct informative experiments. However, the school system cannot afford this equipment or materials to conduct these experiments. Consequently, SCIAD advisers need to encourage and help teachers to write grants to purchase science equipment.

As with many "add-on" programs, the SCIAD program suffers because teachers are often overworked and have too many subjects to cover in a brief period. Furthermore, the classroom is probably not a good setting for the teachers to switch modes and become students themselves in order to learn science and how to develop a GBS curriculum. The process of teaching science to children and learning science as adults should be separated. Consequently, teachers prefer SCIAD advisors to teach the material to the students rather than be trained themselves to teach the material. This approach does not work because the SCIAD is not trained to teach at the elementary levels. The lack of time and resources for teacher training is particularly damaging to the process of introducing computer technology.

The system at Vista seemed to work better, because the teachers had a better understanding of the level of science that university professors normally undertake. As a result, more faculty were willing to incorporate the material into their curriculum. In addition, the teaching structure is different between elementary and middle schools. At the middle school, one teacher teaches four classes of the same material and is often licensed to teach science. The Vista SCIAD program attempted to use this to its advantage. In this program, the first class is taught by the SCIAD advisor. In the second class, the teacher helps and by the fourth class, the teacher conducts the class. At the elementary school, each teacher is responsible for the science material or one teacher teaches science to two classes, but never to four classes. Elementary teachers with a science affinity are reluctant to take on the responsibility of helping other teachers learn the material because of time constraints or personality problems.

Time spent working with the SCIAD advisor can overcome this problem, but the SCIAD's time needs to be spent with the teachers not necessarily teaching the students. A possible solution is to hire graduate students (perhaps from the College of Education) to work with both the SCIAD advisor and the teachers. This would result in more contact time to educate the teachers on the scientific aspects of the program and to help them get past their fears or lack of understanding with using the scientific method to teach science. One possible reason the elementary school adoption rate for incorporating new science material into the curricu-

lum has been low is that lesson plans have not been prepared for the teachers. Also, the SCIAD did not work with the teachers to develop a GBS course. Without these lesson plans, the teachers do not feel comfortable repeating what the SCIAD advisor has done. Again, time constraints limit the availability of university professors to both teach and prepare the associated support lesson plans the elementary teachers need and feel are essential for the program to be successful.

An ongoing evaluation system to determine how effective the SCIAD program is with reaching its and NMSU's goals is needed. However, evaluating any ongoing program is difficult when the goals are to change the viewpoints and attitudes of people that will enter college 6 to 8 yrs later. While SCIAD's long-term effectiveness cannot be assessed at this time, certain short-term conclusions can be drawn. The students are enthusiastic about the program. Students appreciate greater involvement in science-type activities and enjoy the computer use. Both the students and teachers appreciate the break from traditional classroom activities. Exposure to other professionals may ultimately lead students to careers in science.

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# Those “Rascally” Rabbits: A Biological Control Decision Case

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## ABSTRACT

As society has become increasingly wary of conventional chemical pest control methods, interest has grown in the use of biological control (biocontrol) approaches using microorganisms, insects, or diseases for pest management. These biocontrol methods are often considered to be more specific for the pest organisms and, thus, safer for the environment. This case considers the dilemma faced by New Zealand’s Parliamentary Commissioner for the Environment whether to recommend introduction of the biocontrol virus, myxomatosis, into wild rabbit (*Oryctolagus cuniculus*) populations to reduce their numbers and mitigate adverse effects on grazing lands and rural landscapes. The decision whether to import myxomatosis was controversial with many viewpoints ranging from defining the role that the rabbits played in landscape degradation to debating the effectiveness of this particular biocontrol agent. The case was developed for use in introductory biology, ecology, or pest management courses and can serve to link discussions of biology to societal perceptions, norms, and expectations. It also helps to introduce an international perspective into class discussions. The case serves as a basis for introducing principles of population biology and epidemiology. Students also gain an appreciation from the case for the importance of improved communications and understanding between agricultural and nonagricultural sectors of a society.

**B**IOLOGICAL PEST CONTROL (biocontrol) methods are frequently touted for their specificity and low adverse impact on the environment, compared with conventional chemical methods (Flux, 1986). Not all biocontrol initiatives, however, have been favorably received. In 1987, The New Zealand Parliamentary Commissioner for the Environment had to decide whether to recommend the importation of a controversial virus (specifically *myxomatosis*) to reduce wild European rabbit populations in some areas of the country. The rabbit was considered one of the most serious vertebrate pests in New Zealand. Facing declining government support for subsidized rabbit control and rising conventional control expenses for land owners, some were advocating using myxomatosis as a low-cost biocontrol approach. However, a survey of the public had shown that five of seven respondents opposed the introduction of myxomatosis (PCE, 1987). This case considers the Commissioner’s decision whether to recommend use of myxomatosis virus for rabbit control.

## THE CASE

In 1987, the New Zealand Parliamentary Commissioner for the Environment, Helen Hughes, chose to use her inves-

tigative powers to conduct an Environmental Impact Report concerning the use of myxomatosis to control rabbit populations in some areas of the country. Myxomatosis is a disease of wild and domestic European rabbits caused by infection with myxoma viruses occurring naturally in rabbit species in South America and California (Ross et al., 1989). The disease is vectored by the European rabbit flea (*Spilopsyllus cuniculi*). The Commissioner and her investigative team, as stipulated by the Environmental Protection and Enhancement Procedures, were required to conduct their study within a 3-mo period and to submit recommendations to the Minister of Agriculture and Fisheries (MAF) by the spring of 1987. Although the Commissioner did not have authority to force public officials such as the Agriculture Minister to accept her recommendations, she was certain that her recommendations would be important in the establishment of MAF policy towards myxomatosis.

## Elements of the Controversy

Controversy over the introduction of myxomatosis centered mostly on whether the disease was a humane and effective means for controlling rabbits. One farmer who had observed an earlier trial use of myxomatosis to control rabbits in the 1950s remarked:

“I was farming in South Otago in the early 1950s when the flea was used there, and I never in my worst dreams ever thought New Zealanders would ever consider using it again... It is a most inhumane, cruel thing to do to any creature. They scour till exhausted, are blinded and cry with pain when they bump into bushes, stones, etc. Their stomachs hang out of their sides or bottoms, and can take two or three weeks to die—and that is a long time in the life of a rabbit. It’s like a person dying slowly of cancer, but the unfortunate rabbit has no morphine or pain killers.” (PCE, 1987)

Although few denied the existence of a problem of too many rabbits in certain areas, some questioned its extent. For example the Department of Conservation concluded:

“The rabbit is not seen to constitute a threat to the majority of land throughout New Zealand and thus does not warrant the introduction of myxomatosis.” (PCE, 1987)

Similarly, opponents of myxomatosis felt that the true cause of the land degradation in most areas was not overgrazing by rabbits, but rather poor management of sheep (*Ovis aries*) grazing by farmers. They maintained that improving grazing practices was the key to solving the problem—in other words, sheep were the issue, not rabbits (PCE, 1987).

Others, however, regarded rabbits as extremely destructive and needing control. The Agricultural Pests Destruction Council (APDC) stated:

**Abbreviations:** MAF, Minister of Agriculture and Fisheries; APDC, Agricultural Pests Destruction Council.

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"If rabbits are not contained and controlled in the problem areas they will increase and spread out within five years onto contiguous areas where they will have an even greater effect on agricultural production." (PCE, 1987)

Another observer noted:

"I believe the reasons against the introduction of myxomatosis are emotive and stem from Watership Down and Beatrix Potter visions of the rabbit. In this finely balanced environment, they (rabbits) can only be called VERMIN." (PCE, 1987)

Land degradation in high rabbit population, semiarid areas of New Zealand had been extensive. A rabbit's daily food requirement was estimated to be about 500 g (1.1 lb) of vegetative matter (Bell, 1991a). High populations of greater than 21 rabbits per ha (>9 per acre) could thus consume more than 10 kg ha<sup>-1</sup> d<sup>-1</sup> (9 lb acre<sup>-1</sup> d<sup>-1</sup>) of vegetation (Ross and Arthur-Worsop, 1987). Rabbits also could cause damage to pastures, field crops, vegetables, and trees. It was clear to some that controlling rabbits would bring substantial benefits to farmers:

"One way to assess the benefits of pest control is to quantify the production of this country prior to effective control and compare it with the present-day production. Some of the increase can be attributed to better management, improved pasture species, and use of fertilizers, but these techniques were being applied prior to 1955 in some cases, and nowhere were they successful until the rabbit was first brought under control. Our assessments say it is reasonable to claim production increases of the order of 300% to 400% through effective pest control." (PCE, 1987).

Accordingly, some argued that myxomatosis was "the last resort for ensuring farm viability." Lagging farm incomes were often compared with the rising costs of conventional rabbit control:

"(Rabbit control) Rates have increased 220% in the last three years on our very rabbit-prone country and these increases will have to continue to offset the taxpayer fund reductions. Rate increases are rising faster than net incomes." (PCE, 1987)

Farmers, of course, also had their detractors. For example, one person stated:

"The only people here who want myxomatosis are a handful of farmers with so much land that they cannot control what lives on it. Some of the runholders who have the rabbit problems have hundreds and thousands of hectares. I do not think their concern is with the land but more with the money that they think they are going to save by having myxomatosis rather than other forms of rabbit control." (PCE, 1987)

Similarly, another opponent of myxomatosis noted:

"Who needs it... A small group of farmers (whose) poor farming practices and overstocking of sheep on unsuitable country, coupled with rabbit board mismanagement, have allowed pockets of rabbits to explode out of control." (PCE, 1987)

Public relations and tourism image were also factors affecting the decision whether to recommend the introduc-

tion of myxomatosis. The landscape in rabbit-prone areas was considered unique and needing to be preserved to retain its tourism appeal. It was felt by some that tourists visiting farms in the area would be annoyed by the large numbers of rabbits and degraded landscape attributed to them. For example, the Central Otago Regional Pest Authority stated:

"This region has a unique landscape which must be protected for this and future generations. Unless successful methods are available to control the rabbit then inevitably the landscape and the environment will suffer with ultimate cost to the nation both directly and indirectly..." (PCE, 1987)

Others, however, were certain that using myxomatosis would itself have negative effects on New Zealand's tourism image and the aesthetic qualities of the landscape. For example, one opponent of myxomatosis stated:

"I suggest that the short-term gains in agricultural production and savings in APDC funding that might be obtained if myxomatosis can be successfully introduced are negligible compared with potential long-term adverse effects. New Zealand's greatest earner of overseas funds is its 'clean, green' image. All of our agricultural exports and the tourism industry trade on it. It will be eroded by the introduction of myxomatosis to the detriment of us all..." (PCE, 1987)

Similarly, the Department of Conservation Head Office noted:

"The majority of the New Zealand public would be particularly upset to find diseased animals on public lands in the course of their recreational pursuits." (PCE, 1987)

It was in this climate of controversy and strongly differing opinions that the Parliamentary Commissioner faced her decision whether to recommend introduction of myxomatosis.

### Background on the Rabbit Problem

New Zealand consists of two main islands, the North and the South. The specific areas with severe rabbit infestations were mostly on the South Island.

Before the arrival of Europeans, there was only one grazing animal in New Zealand, a large bird, which later became extinct because of overhunting. Many species of grazing and game animals were introduced by the settlers, among which was the European rabbit introduced during the 1840s and 1850s. Because there were no natural predators, rabbit populations grew rapidly and were cited for causing degradation of large areas of pastures. Rabbits were given official "pest" status and legislated against in 1876 when the Rabbit Nuisance Act was passed. Through the Agricultural Pest Destruction Act of 1967, rabbits were further classified as pests of national importance (Bell, 1991a). Control of rabbit populations was vested in the Pest Destruction Boards and the APDC.

In 1971, the policy of total eradication of rabbits was changed to one of control within reasonable financial limits. Two reasons for this change were:

- Rabbit populations had been reduced to low levels in many areas and pest boards were unable to reduce them further with present control methods.
- Cost of control was increasing and continuing a policy of eradication with existing control methods was perceived as being too costly for farmers and the government.

Although populations had declined nationally by the 1980s, rabbits were still numerous in certain areas on the South Island. A solution to the problem in these areas of high infestation was thought by some to be the importation of myxomatosis as a biocontrol agent.

### **Risks Associated with Introducing Myxomatosis**

There are risks whenever one uses biocontrol. The issue is whether the benefits outweigh the potential risks. Introduction of myxomatosis was thought by some to have several potentially adverse effects. Some of these concerned the effectiveness of the disease itself, such as:

- Some rabbits might survive a mild disease epidemic and acquire immunity.
- Genetic resistance to the disease might be selected for in some populations.
- A mutation of the virus might alter its host range.
- The flea vector might die out after release, which would limit the effectiveness of the biocontrol strategy. The fact that rabbits in New Zealand often do not live in communal colonies meant that transfer of fleas (and myxomatosis) from one rabbit to another might be hindered.
- Rabbit populations might begin to recover several years after the initial impact of the virus, thus nullifying the effectiveness of the biocontrol strategy.

Other perceived risks were related to the reduced rabbit numbers that might result from successful introduction of myxomatosis:

- Predator numbers might further decline if they were unable to find sufficient food, which might lead to a rise in other pests.
- There might be an increased incidence of the noxious weeds on which rabbits feed.

Another factor cited by opponents of myxomatosis introduction was concern that the disease and/or the flea vector would spread to nontargeted animals, and particularly to the domestic Angora rabbit farming industry or to the kiwi bird, the national symbol of New Zealand. One governmental ecology division worker stated:

“...the kiwis might be susceptible to either the flea or the virus, because kiwis have a mammalian body temperature and live in burrows. They are the only birds known to be affected by cat parasites, for example, and cats will carry rabbit fleas.” (PCE, 1987)

### **Benefits of Myxomatosis**

There were several benefits cited by those favoring the introduction of myxomatosis. These included:

- Increased productivity of the land and less land degradation because of overgrazing and burrowing by rabbits.

- Less loss of grazing time during poison baiting operations.
- Reduction in the use of nonselective poisons for rabbit control, most of which posed significant risks to other animals and humans.
- Reduced problem with “bait-shy” rabbits whereby rabbits would no longer eat poison-coated carrots.
- Testimonials from farmers who had experienced the 1950s trial of myxomatosis in New Zealand, or more recently in Australia, indicated that myxomatosis could effectively reduce rabbit populations and had proven to be “the most economical and effective weapon they have for pest (rabbit) control.” (PCE, 1987)

### **Rabbit Biology**

Rabbits are nocturnal animals spending most of the day under ground and emerging at twilight. Their home range is as much as 2 to 3 ha (5–7 acre), depending on sex, with males having a larger range. Rabbits usually remain within their established range. Rabbits move in slow hops but when chased or disturbed they can hop rapidly in twists and turns seeking shelter. Within their ranges, they have well-marked runways or paths. They deposit feces and urine in communal latrines or mounds.

A rabbit’s grazing and digestive process is similar to ruminants such as sheep and cattle (*Bos taurus*). Rabbits ingest special membrane-enclosed fecal pellets containing a high bacterial content and undigested cell walls of grazed plant material. These are swallowed whole without breaking the membrane and the bacteria continue fermenting the plant material within the pellet until the membrane breaks down and mixes with freshly ingested plant material (Bell, 1991a).

Given favorable conditions, rabbits breed all year. In semiarid areas, however, the main breeding season is from spring to early summer. The rabbits’ gestation period is 28 to 30 d and litter sizes range from 3 to 7. The usual litter size is 5 to 6. If conditions are favorable, the number of litters per year may be up to 7, but is typically between 3 and 6. On improved pastures where almost continuous breeding can occur, the number of young ranges from 37 to 47 per female per year. In drier, less productive areas, the breeding season is shorter and the number of young per female per year may be only 23 (Bell, 1991a).

A rabbit’s life expectancy is 18 mo, but in semiarid areas 5 to 30% of a population can live to more than 2 yr of age (Bell, 1991a). The most common causes of death are disease and predation. In semiarid areas where the breeding season is shorter and there are fewer young rabbits, the predator population can decline, which reduces the potential to regulate rabbit populations through predation. In situations where rabbit populations decline rapidly, as might occur with successful introduction of myxomatosis, predators might shift feeding habits and prey upon other wildlife (Bell, 1991b).

### **Early Releases of Myxomatosis**

In 1896, myxomatosis was first described as killing laboratory rabbits in Uruguay. Approximately 50 yrs later, it was discovered that wild rabbits also carried the virus but

had become immune to it. The disease only became evident when susceptible rabbits such as the European species were introduced.

Following introduction of myxomatosis into Australia in the mid-1900s, New Zealand conducted two successive trial releases of the virus on both the North and South Islands during 1953 and 1954. Only localized outbreaks of the disease were reported and none spread to other areas. This was thought to have resulted from a lack of suitable indigenous vectors (Williams, 1983). The vectors known to spread myxomatosis are two mosquito species and the European rabbit flea, none of which were indigenous to New Zealand (Bell, 1991b).

Since the 1950s, control of rabbits had been with cultural and conventional methods such as rabbit-proof fences, shooting, trapping, and poisoning. In 1976, a proposal to reintroduce myxomatosis with the European rabbit flea as primary vector was made for Central Otago (Bell, 1991b). However, this proposal was not adopted and debate regarding biological control of rabbits ensued.

### Biology of Myxomatosis

Myxomatosis is caused by a pox virus of the orthopox group. It is a species in the genus *Leporipox*. This is an enveloped virus (host specific) spread by arthropod vectors and is specific to rabbits. There are several strains of myxomatosis and they are differentiated by comparison of their pathogenicity in susceptible rabbits (Gumbrell, 1986).

Once a rabbit has been infected, the virus may begin to multiply within 5 h. After a week, visible signs of the disease become apparent, such as swelling of eyelids, anal and genital areas, lumps on the skin and a general weakening of the body. During this time, the rabbit is infectious to other rabbits. Death usually follows within 6 d (Bell, 1991b).

In countries where the virus already exists, or where it has been introduced such as Europe, Britain, and Australia, the disease has steadily become less effective even though it may have caused a large initial kill. Two proposed reasons for this are:

- The genetic make-up of the virus may have changed and become less virulent, and
- Genetic resistance to the disease may have developed within the rabbit populations.

The causes and conditions that result in myxomatosis outbreaks are not well understood, but there is evidence that a latent (non-active) form of the virus is carried by rabbits that were previously infected by the disease but subsequently recovered. This form can be reactivated when the rabbit is under stress and can then be transmitted to other rabbits to cause a disease outbreak. Because of its unpredictability with respect to frequency, immunity, and disease virulence, most experts do not believe that myxomatosis would completely eradicate rabbits (Bell, 1991b).

The original myxomatosis strain identified was highly virulent (99% kill of susceptible rabbits). However, less virulent viruses soon appeared in the field. Such strains were more easily spread by insect vectors since the animals that they infected lived longer. As a result, the less lethal strains

became more prominent in the field and made it difficult to introduce more lethal strains.

Any population that is continuously exposed to the same disease develops a level of resistance because of the wide range of genetic diversity in the population. A small percentage of the population will survive when a new disease is introduced. It is this percentage of the population that forms the genetic basis of the new population and would be expected to have higher resistance to the disease than the original one. During the first years after introduction of the myxomatosis disease in the 1950s, genetic resistance appeared to increase rapidly within rabbit populations.

In addition to genetic resistance, immunity can result when an animal produces antibodies that successfully protect against the disease after infection. Immunity to myxomatosis is acquired either actively or passively. Active immunity results when the rabbit is infected by the disease agent, produces antibodies, and then recovers. The degree of immunity depends on the intensity of the initial infection. Passive immunity is acquired by young rabbits through antibodies passed on by their mothers and protects the young for a few weeks. Active immunity is thought to be less important than passive immunity since rabbits have short life spans. However, if there is an outbreak among a population of young rabbits that are still protected by passive immunity, most would be expected to survive, acquire active immunity, and thus be less susceptible to future infections (Bell, 1991b).

The following factors are among those that affect the spread and virulence of myxomatosis:

- Environmental temperature, (the myxoma virus is temperature sensitive).
- Nutrition and the general health of the rabbits.
- Density, type, and distribution of the insect vector.
- Density and distribution of rabbits.
- The proportion of susceptible rabbits in the population.

There are two methods of disease transmission within rabbit populations, direct contact with rabbits infected with myxomatosis and through activity of the insect vectors (Bell, 1991b). The European rabbit flea is unique because it requires the blood of pregnant does to begin its own reproductive cycle. Once a litter is born, the fleas move onto the young. Their eggs are laid and hatch in the fur. The larvae emerge in response to movement and pupate three times before becoming adults. The adult fleas emerge 15 to 100 d after the first litter of rabbits is born. Fleas do not flourish in semiarid or arid conditions and, therefore, often cannot be relied on to spread the disease in such areas (PCE, 1987).

Under the 1967 Animals Act, the Ministry of Agriculture and Fisheries had the responsibility to ensure that the importation of any species into New Zealand was carefully administered. However in the past, conflicts often arose because the Ministry had few detailed procedures for deciding whether importation should be approved.

### Comparative Costs of Control Methods

Approximately \$11 million NZ (\$7.3 million U.S.) were expended by the Agriculture Pest Destruction Council for rabbit control during the year ended 30 Mar. 1987 (Ross and



Arthur-Worsop, 1987). Lands on the South Island had been categorized in order of decreasing severity of rabbit numbers as "intractable, severe, and rabbit prone." Most of this land was used as pasture for sheep and cattle. Average farm sizes in these areas ranged from 5536 ha (12 300 acres) to 9562 ha (21 300 acres) with an average stocking density of 0.7 sheep ha<sup>-1</sup> (0.3 sheep acre<sup>-1</sup>) (Saunders, 1993). This rate had generally declined over time because of poor wool prices and pasture degradation caused by overgrazing.

Rabbit control costs had been subsidized by the government based on the intensity of the rabbit problem. This government subsidy was matched dollar for dollar by the land owners. However, a problem with this arrangement arose when the government decided to cap their subsidy at \$7 million NZ (\$4.6 million U.S.) and established a plan to reduce this cap each year until 1993/1994, at which time the subsidy would stop altogether. This "user-pays" approach to rabbit control was officially adopted in 1984. The costs faced by landholders if they paid the full amount for control without government subsidy were estimated to range from \$5.00 ha<sup>-1</sup> NZ (\$1.48 acre<sup>-1</sup> U.S.) to \$9.50 ha<sup>-1</sup> NZ (\$2.81 acre<sup>-1</sup> U.S.) (Saunders, 1993). These estimates assumed that conventional control measures such as poisoning, trapping, and night shootings would continue. In addition, landowners faced other costs because of rabbits such as (Ross and Arthur-Worsop, 1987):

- Erection of rabbit proof fences estimated at \$6.25 m<sup>-1</sup> NZ (\$4.50 yd<sup>-1</sup> U.S.)
- Improving existing fences to make them rabbit proof at \$2.15 m<sup>-1</sup> NZ (\$1.55 yd<sup>-1</sup> U.S.)
- Inspecting and maintaining rabbit fences
- Taking land out of production and making it accessible for controlling rabbits.
- Pasture restoration after degradation by overgrazing.

On the other hand, the *total* cost of introducing myxomatosis into highly infested areas was estimated to be about \$3.2 million NZ (\$2.1 million U.S.) with additional costs of \$500 000 NZ (\$330 000 U.S.) annually thereafter (PCE, 1987). This cost would be spread out over a period of 6 yr. This amount per year was considerably less than the expenditure by the government for subsidized conventional rabbit control. In the longer term (defined as 30 yr and more), it was recognized that the overall effectiveness of myxomatosis might decline, which meant that conventional methods of rabbit control would still need to be continued, but likely at a reduced level. Thus, the Ministry of Agriculture and Fisheries concluded that myxomatosis would be a relatively cheap and effective method of controlling dense rabbit populations.

### The Decision

In the winter months of 1987, the Parliamentary Commissioner for the Environment had to decide whether to recommend introduction of myxomatosis for rabbit control to the Agriculture Minister. It was evident that there was significant public opposition to introducing the disease on moral grounds. But rabbit numbers were high in several areas and increasing pest control costs for some landowners was a concern. Some had also raised questions about the

effectiveness and environmental impact of introducing myxomatosis. Her report was to be issued in September of 1987. What should the Commissioner recommend?

## TEACHING NOTE

### Case Objectives

Upon completing this case, students should have:

1. A better understanding of the advantages and limitations of biocontrol strategies in agriculture.
2. A better understanding of decision making in relation to sensitive issues involving public perception and opinion.
3. A better global awareness of pest management issues.
4. A better understanding of animal population biology and the difficulties associated with introduction of exotic species for pest control.

### Use of the Case

This case was developed by undergraduate students in conjunction with a term project for a course in cropping systems management. The case was developed for use in an introductory agroecology course, but may also be suited to introductory biology, ecology, or pest management courses. It can serve to bridge discussions of biology and societal concerns while also introducing an international perspective. The case can also serve to stimulate discussion of principles of ecology, population biology, and epidemiology, although other reference materials concerning wildlife biology may be desirable to include with the case if it is used for this purpose. Examples of wildlife ecology texts that might be used in conjunction with this case include Caughley and Sinclair (1994) and Robinson and Bolen (1989). Finally, students gain appreciation from the case for the need for improved communication and understanding between agricultural and nonagricultural sectors of society.

The case was class-tested in a senior-level agricultural management course composed of students with majors in agriculture, natural resources, and environmental sciences. It was used in an introductory agricultural ecology course for nonagricultural majors in winter, 1996. The following is an approach that can be used for teaching this case:

- Students are assigned the case several days before it is to be discussed in class and are asked to review the case.
- Study questions; additional research topics; outside readings on population biology, pest management, and epidemiology; or text readings might also be assigned to help students prepare for the in-class discussion of the case.
- The instructor may wish to begin the in-class discussion of the case by dividing the class into small groups (three or four students per group) and assigning an introductory question (such as no. 1 below) for discussion within the groups. This can serve to "prime" the discussion and helps assure that the full class discussion will begin without a lag.
- When the small group discussions are proceeding well and the discussion is lively, the instructor can intervene and initiate discussion of the case by the entire class using questions such as nos. 1 through 6.

- The instructor may conclude the discussion by pressing for a consensus decision during the class. As an alternative, the instructor may suspend the discussion after the students have identified their major decision response options (question no. 6). The students (individually or in their small groups) can then be asked to prepare a written or oral response stating their decision and their rationale for the decision.

### Discussion Questions and Issues in the Case

**1. Why was this decision a controversial one for the Commissioner?** This question helps elicit the issues in the case and helps define the problem. The case provides a large number of quotes expressing various views on the question of introducing myxomatosis. The Commissioner, as an officer of the government, needed to try to make a recommendation that addressed the interests of all parties—a very difficult task. Some within the scientific community opposed myxomatosis and questioned its effectiveness and environmental impact. Others within agriculture, and particularly landowners most affected by the rabbit infestations, maintained that their livelihoods were in jeopardy without availability of a lower cost control measure such as myxomatosis. The Commissioner was also aware that the New Zealand government was reducing and ultimately eliminating its cost-sharing role in rabbit control. There was strong sentiment among landowners that the least the government could do was approve introduction of myxomatosis to help buffer the impact of the new “user pays” policy. Environmentalists and animal welfare advocates, for the most part, opposed myxomatosis release because of its ecological uncertainty, questions regarding its effectiveness and because of the “inhumane” disease signs that it produced. There were also questions about whether rabbits would be the only animals affected by the disease and/or the flea vector.

**2. What factors would influence the effectiveness of myxomatosis as a biocontrol approach if it was released?** This question will help lead students to consider population biology, ecological and epidemiological aspects of the case. Factors affecting initial infection, spread of the disease, its effectiveness in killing rabbits, and the likelihood of its being sustained as an effective control method over years are all considerations within this question.

**3. If myxomatosis was shown to be completely effective and posed no danger to nontargeted organisms, do you think that some within New Zealand would still oppose its release? Explain your answer.** This question is intended to explore the nonscientific basis for opposing the introduction of myxomatosis. Students are likely to conclude that opposition to myxomatosis existed even apart from questions of the disease’s biological effectiveness and specificity. Chief among such opposing arguments was the concern that use of myxomatosis was inhumane or “unnatural.” The case states that some regarded the disease signs as abhorrent. Furthermore, some regarded rabbits as a “scapegoat” for poor grazing practices by landowners. The case states that some believed overgrazing by sheep, not rabbits, was mostly responsible for the degraded landscapes in some areas.

**4. What other nondisease biocontrol options might exist for controlling rabbits?** This question permits students to discuss the concept of “biocontrol” beyond the use of disease or insect agents. Examples of other biocontrol approaches proposed to deter or control rabbits in New Zealand included (PCE, 1991):

- Enhancing the presence and activity of predators.
- “Peppering” the rabbit-infested landscape with ash from rabbit skins or testes.
- Sowing “nonforage species” that would be unpalatable to rabbits.
- Breeding forage species with toxins that cause infertility in rabbits.

Each of these approaches had limitations with some, such as peppering, lacking scientific or research backing whereas others, such as enhanced predation, would provide only inconsistent control. Options such as breeding forage species containing rabbit toxins would have been expensive and time-consuming.

**5. How important is myxomatosis economically for landowners who desire to control rabbit populations?** This question will cause students to consider the question of myxomatosis introduction from the perspective of the landowners. Although the economic data in the case are incomplete, they provide a basis for discussion of the likely economic consequences of rabbit control to landowners with and without myxomatosis. It is important to recognize that the economic impact to landowners of rabbit control costs, such as those quoted in the case, may seem low to students accustomed to agriculture in more humid areas. But low stocking rates on marginal lands, depressed wool and sheep prices, and the large numbers of acres needed to support sheep production in low-precipitation areas all serve to make such costs significant. Also important were the costs to the government of developing and introducing myxomatosis. Figures that were available indicated that introduction of myxomatosis, if successful, would be considerably less costly on an annual basis than continuing to subsidize conventional control measures. Also worth discussing are the secondary “costs” to landowners and to the nation if the release of myxomatosis proved to be unsuccessful, as it was in the 1950s, or resulted in negative publicity in the media and adversely affected New Zealand’s commercial and tourism image.

**6. What were the Commissioner’s options?** It is important to impress on the students that the final decision whether to release myxomatosis did not rest with the Commissioner. Her’s was an advisory role to the Agriculture Minister, but she was certain that her recommendations would be important in guiding establishment of the MAF policy on this matter. She had responsibility for final approval of the findings and recommendations to be included in her agency’s report. She needed to follow the timetable stated in the Environmental Protection and Enhancement Procedures, which meant that she had to submit her report within 3 mo (by September of 1987). There was no room for complacency.

The Commissioner’s options ranged from recommending that introduction of myxomatosis not be approved to

approving its introduction with few restrictions. She felt that if myxomatosis was not approved, illegal introduction of the disease and the flea might result.

She also had several intermediate options. One was to not to make an overt recommendation and to defer the decision entirely to the MAF. Within this option she might have listed precautions that should be taken *if* the Agriculture Minister chose to approve introduction of the disease. As another option, she might have proposed an increased level of citizen involvement in developing a long-term solution to land degradation, including calling for destocking or retiring of severely affected lands, while developing a comprehensive land management plan. Within this option, myxomatosis might have been kept in reserve as a control measure “of last resort.” This option presupposes that land degradation had multiple and complex causes and that alternative rabbit and land management options existed and needed to be further investigated and implemented.

**7. What did the Commissioner do?** The instructor may choose not to raise this question with the students. There is often value in *not* revealing the actual decision for a case since it may shift the focus of the discussion away from the students taking “ownership” of the decision. It may also create an impression that there is a “correct” or final response to the case. However, some students will likely be curious as to the outcome of the case and the instructor may choose to share the actual decision with them after discussing the case.

The Commissioner issued her report to the Ministry of Agriculture and Fisheries in September of 1987. She concluded that there would be “no winners for this very emotive issue.” In the end, the Commissioner recommended to the Agriculture Minister that “the European rabbit flea/myxoma virus complex should not be introduced into New Zealand as a means of rabbit control.” Her rationale for this decision was multifaceted but included:

- “Myxomatosis is considered to be a national solution and the scale of the problem does not warrant it.”
- “The introduction of the fleas and the virus are irreversible actions.”
- “There is still a biological risk involved...”
- “There is still strong public opposition...”

- “At best it can only be viewed as a medium term solution.”

In addition, the Commissioner made other recommendations that resulted in the establishment in 1988 of a Rabbit and Land Management Programme for a 5-yr period to promote sustainable land management in “at-risk” areas.

In June 1993, the Agriculture Minister formally declined an application to introduce myxomatosis. Efforts are currently underway by the Australian and New Zealand governments to evaluate an alternative virus biocontrol agent, which is thought by some to be more specific and humane than myxomatosis.

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# Exterminators: The Politics of Chemical Fumigation—A Case Study

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## ABSTRACT

Chemical usage for pest management has been a sensitive issue for many years, representing a multitude of divergent opinions. The risks associated with chemical applications may pose a global threat to humanity and the environment. In Virginia, many incidents of misuse have been documented including the pollution of the Chesapeake Bay, the death of wildlife, the destruction of residential property, and a deterioration of consumer health. Yet until the 1986 death of the Watsons, an elderly couple residing in southwest Virginia, little attention was given to the toxic nature of chemicals. When the Watsons died because of an inappropriate application of Vikane, a fumigant, public fury was fueled. A series of reports entitled "Pests, Poisons, and Risks" in *The Roanoke Times & World News* generated public safety concerns. The goal of this case is to actively involve participants in the chemical controversy. Students are presented with various viewpoints portrayed by media reports and fellow classmates. Students are encouraged to defend their stance, while considering ethical issues surrounding opposing views. Ultimately, the participant must address the dilemma with a synergistic decision of providing safe and effective pest control services, while meshing the desires of consumers, exterminators, agriculturalists, and government officials.

CHEMICAL USAGE for pest management has been a sensitive issue for many years, representing a multitude of divergent opinions. The risks associated with chemical applications may pose a global threat to humanity and the environment. The goal of this case is to actively involve participants in the chemical controversy.

## The Case (Abridged)<sup>1</sup>

One Sunday morning I sat down in my easy chair with a piping hot cup of coffee and the Sunday newspaper. Instantly my attention was drawn to the front page story entitled "Pests, Poisons, and Risks." As a part-time farmer, I have always been aware of the public concern about pesticide usage. As I focused on the article I began to wonder what we farmers had done to deserve front page coverage. I scanned the article, and to my relief, discovered that agriculture was not the topic of discussion, instead, home exterminators were the focus. According to the *Roanoke Times & World News*, "bad things can happen when an exterminator visits."

<sup>1</sup> This is an abridged version of the original case. The complete case consists of 9 pages of text, 16 pages of exhibits, and a 15-page interpretive note. For a copy of the complete case contact the corresponding author.

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Mary Bishop, a staff writer, reported that Virginians have suffered at the hands of exterminators. Homes have been made unlivable, health has been ruined, and elderly have been cheated out of thousands of dollars. These instances have all been because of lax laws and regulations governing pesticides in Virginia. Pesticide misuse had even resulted in the death of an elderly Galax couple (Exhibit 1).

I took a sip of coffee, and eased back in my recliner. I was filled with mixed emotions. I was relieved that the agricultural industry was not responsible, yet I was outraged that exterminators were capable of inflicting human death. My heart sank thinking about the Watsons, who lost their lives during a routine fumigation. The Orkin sales supervisor had reassured them, "It's not dangerous, don't worry." If only Orkin had taken the proper precautions and monitored the house for Vikane levels, perhaps the Watsons would still be living.

After reading about the tragic death of the Watsons, I began to follow the pesticide series in the *Roanoke Times & World News*. I wondered if the death of the Watsons, along with the long list of other claims ranging from poor health and property damage to money theft, would influence the pesticide industry.

Mary Bishop's articles had elevated anxieties and skepticism among Virginia residents concerning the application of home insecticides. Several articles reported that the laws were not successfully monitoring the handling of pesticides in Virginia. According to Bishop no training or experience is needed for pesticide application. She stated, "In Virginia it is harder to become a hairdresser than an exterminator. Beauticians in Virginia must undergo extensive training and pass an examination. But to set up shop as an exterminator you need only a business license and sometimes not even that. You don't have to have any experience, training, or knowledge of pesticides."

She continually alluded to the fact that the state of Virginia did not control the pesticide industry. Virginia officials did not even know how many exterminators were operating statewide. Andre Perdue, head of the Roanoke Valley Pesticide Control Association, told Bishop, "We have people out there right now operating out of a trunk of a car without any insurance. This industry is wide open for it. You don't have to have any certification to be an exterminator. You can start an exterminating business tomorrow."

Bishop reported that once such a business is established, inappropriate handling of chemicals results in little or no reprimands. In one article, she wrote, "The restaurateur in Virginia whose service personnel sell beer to a minor can lose his ABC license. The pest-control company whose personnel render a home unfit for human habitation can go down the road and sell its services to another customer. Something is wrong."

Over 2.5 yr, 67 complaints were filed against exterminators at the state office of pesticide regulation (Exhibit 2). Of those cases, 41 were found free of pesticide misuse, and a

# Fumigation 'loaded gun,' experts says

By MARY BISHOP  
STAFF WRITER

GALAX—Hubert and Freida Watson's house was one of the show-places of Galax.

They designed the white-columned brick colonial in the early 1970s with architectural details they got from trips to Williamsburg and a Tidewater plantation.

They furnished it with Victorian antiques. An out-of-state professional decorated it.

They installed an elevator.

Solid walnut paneling went into the dining room.

The den was paneled with wormy chestnut.

Hubert Watson cut and dried the wood himself so it would be just right.

Wood, after all, was his life's work.

Until they retired, Hubert Watson owned Sawyers Furniture Co. here. Freida Watson, the company vice president, ran the office.

So it was no small matter when a man with Orkin Exterminating Co. in Roanoke told them that wood-boring beetles were eating their house.

The Watsons gave the go-ahead for an \$8,000 fumigation.

On Sept. 25, 1986, the men from Orkin put a huge red-orange tarpaulin over the Watsons' five-bedroom house at the corner of Roseland Road and Bona Vista Lane.

It was an astonishing sight—like a giant fluttering piece of fabric art. The Watsons' next-door neighbor took a picture.

The Watsons abandoned their home—usually buzzing with their 13 grandchildren—and stayed with a daughter overnight.

Orkin workers pumped the house full of Vikane, or sulfuryl fluoride. The colorless, almost odorless gas permeates wood-furniture, wood-work, everything—to kill wood-eating bugs.

A former Orkin sales supervisor remembers reassuring the Watsons about the fumigation when he settled with them on a price.

"...I met the people, and the last thing I said to the people before I left their home was, 'It's not dangerous, don't worry,'" Emmett Lee Farmer testified in an unrelated lawsuit last year.

Another Orkin worker said that the Watsons could move back in after 3 the afternoon of Sept. 26. And they did.

Within a few hours, according to federal court documents, the Watsons were sick. They experienced nausea, chills, weakness—all symptoms of Vikane poisoning. On Sept. 28, Hubert Watson had a severe spell of coughing. His wife called the rescue squad, but he was dead by the time he got to the hospital.

Hubert Howard Watson was 73 years old.

Richard Haskin, a neighbor who visited Freida Watson shortly after

Hubert Watson died, recalled that she needed help getting to the phone to take condolence calls. Haskin said she was weak and coughing.

By the time of her husband's funeral, Freida Settle Watson, 65, lay dying in Twin County Hospital. She died Oct. 2.

A state medical examiner says Vikane killed the Watsons.

Hubert Watson's body was embalmed without an autopsy. So, the medical examiner said, he could not chemically confirm Vikane as the agent of death.

But Dr. David H. Oxley, deputy chief medical examiner for Western Virginia, says Hubert Watson's physical problems were the same as those of his wife, whose body was given a full autopsy. In an opinion filed by a federal judge in U.S. District Court in Roanoke, Oxley was quoted as saying both died of "respiratory failure secondary to massive severe pulmonary edema due to exposure to a toxic agent (Vikane)."

In layman's terms: They stopped breathing because of fluid buildup in their lungs.

## 'It's a loaded gun'

Industry officials say Vikane has been used in millions of fumigations and that deaths are rare. They say victims usually are burglars trying to loot a fumigated house that's still vacant or somebody who has intentionally entered an unsafe house to commit suicide.

Some states make exterminators post a guard at houses during fumigations. Virginia does not require guards unless the pesticide label does.

"Fumigation is no small matter. It's a loaded gun," said William Robinson, a Virginia Tech expert on household pests who wrote the Virginia Cooperative Extension Service's manual on fumigation.

A state pesticide inspector testified that Orkin workers acknowledged not using an air monitor to see if the Watsons' house was safe for occupancy, as recommended on the Vikane label.

"They didn't even make an attempt to monitor it," Douglas S. Vaught, the former Grayson County commonwealth's attorney, said in an interview. Vaught went to church with the Watsons and prosecuted the local case against the exterminators.

Farmer, the former Orkin sales supervisor, said in an interview that the company's Roanoke office didn't own a monitor. When Orkin officials from Richmond visited the Watsons' house after the couple died, Farmer said, he was told to go to Virginia Tech and pick up a monitor owned by another exterminator.

Industry leaders and state regula-

tors say virtually no exterminators

used the air monitor recommended by Vikane's manufacturer. "We were told that the whole industry, not just Orkin, but the whole United States, wasn't using monitoring equipment at that time," said William E. "Billy" Walls, Virginia's chief pesticide regulator who investigated the Watson case.

An inspector with the state Office of Pesticide Regulation said the Orkin men didn't follow other label instructions:

■ They didn't remove waterproof-covered cushions and mattresses. Removing cushion's can be crucial. Theoretically, someone sitting on cushions hours or days after a fumigation can be subjected to puffs of trapped gas.

■ They didn't use a strong-smelling warning agent along with the Vikane. Chloropicrin, a pungent chemical that makes the eyes tear, is supposed to be used with the odorless Vikane so exterminators and homeowners can know whether a house has been aired out completely. The smell is also supposed to help keep intruders out.

In April, a federal grand jury in Roanoke indicted Orkin Exterminating Co. Inc. on five counts of misapplying Vikane. On Aug. 8, a federal judge ruled the company failed to use a monitoring device to determine whether it was safe to enter the Watsons' home after the fumigation. The other four charges against the company were dismissed.

Assistant U.S. Attorney Richard Pierce said the agreement to drop four of the charges was worked out after Judge James C. Turk ruled Orkin could only be punished on one charge.

Turk had decided before the trial that because all five charges were related, the most severe punishment Orkin could face would be a fine of \$500,000—whether for one conviction or five, Pierce said.

A sentencing hearing is scheduled for next month. At that time, arguments will be heard as to whether the Watsons' deaths were a direct result of Orkin's actions. If so, Orkin could face the \$500,000 fine. Otherwise, the maximum fine will be \$100,000.

Judith Donner, an Orkin spokeswoman at the company's headquarters in Atlanta, has declined comment since the federal charges were filed.

## Shaking up the industry

The Watsons' deaths sent a shudder through the national pest control industry.

Dow Chemical Co., Vikane's maker, previously recommended air-monitoring instruments for use with Vikane. Now, it makes exterminators prove they own an air monitor before they buy Vikane.

Dow has declined to talk about the case. Gary Hamlin, public affairs manager for North American Agricultural products, a Dow subsidiary, said only that Dow denies responsibility for the Watsons' deaths. Orkin has also denied responsibility for the deaths.

Right after the Watsons died, an

Orkin spokesman in Atlanta told reporters the Watsons had heart problems. The couple's doctor of many years said that was not true, and Richard Haskin, the Watsons' next-door neighbor, testified in court they were active, vibrant people.

"Oh, these were very vital people, not elderly at all," said the Rev. Robert B. Hudson, their former United Methodist minister.

Daymon Robertson and Ron Mullins, the Orkin workers who supervised the Watson fumigation, pleaded guilty in Grayson County Circuit Court last year to a misdemeanor charge of pesticide misuse. They received suspended sentences.

The men surrendered state permits for general, wood-infesting and food-processing pest control for five years. Robertson still works for Orkin in Roanoke, and Mullins is with Orkin in Charlottesville.

When the Watsons died, there was no requirement that anyone in a company be state-certified in fumigations to use Vikane. That's now required by federal law.

Involuntary manslaughter charges against the two exterminators and against Orkin as a corporation were dropped by Vaught, the former prosecutor, so federal authorities could bring indictments.

Under Virginia law, the stiffest penalty for a corporation in a wrongful death case is a \$1,000 fine for each count. A violation of pesticide label directions poses a fine of \$500. The maximum state punishment Orkin would have faced for the two deaths would have been \$2,500.

The executor of Freida Watson's estate sued Orkin and Dow in federal court last year for \$2.5 million, alleging that she dies as a direct result of her exposure to Vikane. That trial is set for December.

## Having nightmares

Emmett Lee Farmer, the former Orkin sales supervisor, said recently he will never forget the last time he saw the Watsons. Farmer is now with Brown Exterminating Co. in Pulaski County.

"...then two days later the man's dead," Farmer testified in an unrelated lawsuit, "and that just ate me out inside." He said in an interview he still has nightmares about the case.

The Watsons' neighbors remember when the Watsons' house was full of life, then the place was overrun with grandchildren.

Though the Watsons had a fancy home, they weren't possessive about it. They opened it to friends, family, visiting church youth groups, the Christmas banquet of the church choir and other gatherings.

Friends and neighbors said Hubert and Freida Watson were known as some of the most generous people around Galax, helping often when they heard of people in trouble. They gave their money anonymously and rarely talked about it.

Said Robert Hudson, their former minister. "They did it in such a way that no one was aware."

majority of the remaining cases only had resulted in warning letters.

Another Sunday morning commenced with my routine of drinking coffee while browsing the paper. Articles concerning pesticides had become as common as the comics. I continued following the reports in anticipation of a resolution. Would the uproar catalyzed by the *Roanoke Times & World News* be calmed? What exactly would have to be done to alleviate the skepticism encompassing exterminators?

Pest control companies were beginning to defend their tumbling reputations. Companies like Terminix argued in defense of the competency of its operators via a letter to the readers of the *Roanoke Times*.

Orkin attempted to redeem itself with a full-page letter in the *Roanoke Times & World News*. Orkin expressed its condolences for the deaths of the Watsons, while emphasizing that the Galax fumigation was not representative of its business activities. Orkin also stressed that it is dedicated to high standards of safety in providing effective pest control services.

I sipped my coffee, while digesting what I had just read. Homeowners were skeptical and some even hysterical. The media had fostered panic in exterminators, customers, and state officials at the Office of Pesticide Regulations (also referred to as the Office of Pesticide Management) in the U.S. Department of Agriculture. How could pesticide regulators make amends?

A few days later, talk of stiffer regulations and punishments was circulating. Some people opposed tighter regulations, while others saw stricter regulations as a means of sprucing up the image of legitimate operators. Ron Chaney, President of the Virginia Pesticide Control Association,

acknowledged the need for more government control, as long as the controls are laws "that we can live with."

Governor Baliles reacted to public concerns by establishing an eight-person pesticide enforcement team, The Council on the Environment, costing \$535,000. The panel was requested to conduct a 90-d investigation of pesticide regulations in Virginia (Exhibit 3).

The Council aroused the concerns of agriculturalists. Farmers vocalized their opinions at a public forum in Harrisonburg. One farmer announced that chemicals have made great contributions to fruit production. He also warned that in the past "near panic" was created because of new federal regulations. Farmers suggested that the panel should only increase regulations where problems could be documented.

Billy Walls, Virginia's Chief Pesticide Regulator, expressed his concerns about the banning of agricultural pesticides, "If you eliminate too many pesticides, you are



Exhibit 2. Complaints in Virginia.

## Council on the Environment Findings:

### INTRODUCTION

Pesticides are widely recognized for their contributions to modern society. The productivity of modern American agriculture owes much to the use of chemical pesticides. Some estimates indicate that world-wide food production could drop by as much as forty percent without agricultural chemicals. Public health throughout the world would be in a far more precarious state were it not for the use of pesticides in the eradication of insect, rodent and other disease vectors.

However, pesticides are a concern because they are so effective and because they are widely available and common toxic chemicals. For most other chemicals, toxicity is merely incidental to their main purpose in manufacture or other chemical processes. Except in rare cases, their release into the environment occurs only by accident. Pesticides are different. They are meant to be poisonous and cannot reach their intended targets unless released into the environment.

It is essential that pesticides—both their chemical make-up and their use—be strictly controlled to minimize the risk to public health, safety and the environment while allowing their continued use to benefit society.

Any program which seeks to manage or control the risks associated with pesticides must concentrate in two areas. First, it must ensure that the pesticides work the way they are intended, are not toxic to non-target organisms, or are not excessively persistent in the environment, or are not excessively persistent in the environment beyond the time of their intended use. Secondly, the management of pesticides must concentrate on the proper application and use of the chemicals, including developing less toxic alternatives. This report examines all aspects of pesticide use and management in Virginia.

...Overall, the subcommittee finds that Virginia's citizens do not have adequate assurance that pesticides used here are safe for use under Virginia conditions and that they are applied in a way that guarantees public health, safety and the protection of the environment. This is in part due to insufficient training and verification of competence for those who apply large quantities of pesticides, and in part due to inadequate monitoring, enforcement and penalty provisions. It is compounded by the lack of basic data on the chemicals themselves and how and where they are used, by the lack of public understanding regarding the appropriate use of pesticides, and by the lack of applied research to guide management actions. Virginia's pesticide management program as a whole suffers from a lack of direction, oversight and coordination and insufficient staffing and funding support. In addition, the subcommittee finds gaps in program elements dealing with disposal of pesticide wastes and worker and public safety.

Exhibit 3. Council on the Environmental Findings: Introduction.

going to affect the cost of food and fiber.” When Furadan, an agricultural pesticide that environmentalists claimed to have killed bald eagles, was under siege in 1987, a Virginia Tech Extension Entomologist wrote Billy Walls, adamantly opposing the regulation of Furadan: a “good insecticide.”

The news featured additional coverage concerning pesticides in agriculture. Lt. Governor, Doug Wilder, was quoted at an annual Farm Bureau meeting, “It is obvious to all of you as it is to me that, without pesticides, the American farmer could not feed the people of this country...but it is also obvious that the use of pesticides has created problems.”

Editorials and commentaries featured in the *Roanoke Times & World News* depicted readers’ viewpoints. One reader wrote an editorial suggesting that in the process of settling the disagreement that persisted over additional regulations, people must be protected. He stated, “Protecting people, let’s recall, is what this whole controversy is about.” Another reader suggested that the government and exterminating businesses should not bear total responsibility for claims of pesticide misuse. She stated that we live in a period of “information overload”. Information indicating the dangers of chemicals is readily available. She asked, “In this age of information overload, how much protection should willful ignorance purchase?”

Occasionally readers still write letters to the editor in response to the pesticide series. One reader wrote the editor alleging that the pesticide reports had been one-sided. “She (referring to Mary Bishop) heard one side of the issues, thus her article had a very negative tone.”

As I see it, the media has captured the concerns of both the private and public sector. Exterminators are defending their reputations, pesticide regulators are investigating existing laws, farmers are voicing their concerns, and residents are expressing their fear and anger. All citizens have an opinion, whether positive or negative, about pesticide application and regulation. Most Virginians recognize the contributions chemicals have made to our society, however negative publicity has clouded our perception.

I am a farmer and consumer of agricultural commodities and a resident and homeowner in southwest Virginia. I want to see agriculture continue to meet the needs of our population, yet I want to see my family protected against environmental hazards. To ensure that my concerns are addressed I plan to testify at one of the forums held by the Pesticide Enforcement Board (Council on the Environment). What should I recommend to the Council concerning pesticide regulations?

#### Case Exhibits<sup>2</sup>

1. The Roanoke Times & World News. August 1988. Fumigation “loaded gun,” expert says. Included with this abridged version.
2. The Roanoke Times & World News. August 1988 Visual of complaints in Virginia. Included with this abridged version.

<sup>2</sup> This list shows all exhibits included in the complete case. In this abridged case, only Exhibits 1 and 2 are shown in their entirety. Exhibit 3 is displayed as a condensed version of the original exhibit.

3. The Council on the Environment. 1989 excerpts from the published review on findings concerning pesticide regulation in Virginia. Condensed version included in this abridged case.
4. The Roanoke Times & World News. 21 Aug. 1988 article “Pests, poisons, and risks.”
5. The Roanoke Times & World News. 25 Aug. 1988 letter to the readers from Terminix, stating the competency of Terminix as a pest control service.
6. Orkin. 20 Nov. 1988 letter to the Roanoke Valley Community, expressing condolences to the Watson family, while emphasizing that the incident was not representative of its work.
7. The Roanoke Times & World News. August 1988 article “Exterminators want some government regulation.”
8. The Roanoke Times & World News. 28 Sept. 1988 article “Pesticide study worries farmers, orchardists.”
9. The Roanoke Times & World News. 20 Feb. 1987. Letter to Bill Walls at the Office of Pesticide from James Roberts, extension entomologist at Virginia Tech, indicating his belief that no chemicals should be banned.
10. The Roanoke Times & World News. 12 Oct. 1988 letters to the editors “Pesticide stories confuse the elderly.” and “Pesticide hearings: One-sided report.”
11. The Roanoke Times & World News. 23 Oct. 1988 editorial “Exterminators not selling cookies.”
12. The Roanoke Times & World News. 28 Oct. 1988 commentary “Restrict exterminator’s role.”

#### TEACHING NOTE

##### Case Goals and Objectives

The aim of this case is to familiarize students with the sensitive issue of chemical application for home exterminations and commercial food and fiber production. Students should be aware of how even a single instance of chemical misuse can result in chaos for the pesticide industry. Participants will ultimately be challenged to resolve the pesticide dilemma through a synergistic approach that will benefit both the pesticide industry, and consumers.

After completion of the case, students should be able to:

1. Recall specific problems associated with chemical application.
2. Explain the circumstances leading to the death of the Watsons.
3. Explain the role of the state, exterminators, agriculturalists, and consumers in ensuring public safety in regards to chemical usage.
4. Explain how the media’s portrayal of an incident can cause disruption within an entire industry.
5. Decide if Virginia’s pesticide laws are adequately monitoring the handling of chemicals
6. Determine if additional government regulation of pesticides is necessary
7. State who to target if new laws are implemented

##### Use of the Case

This case is applicable to a wide-ranging audience. Any individual interested in promoting synergy between the pub-

lic and private sector, regarding the use of chemicals, may benefit from Exterminators.

### **Study Questions**

In-class discussion of the following questions will guide participants to the main issues within the case.

1. Who is responsible for the death of the Watsons?
2. Is the media coverage of the pesticide industry in the best interest of the public?

3. Who, if anyone, should be taking a defensive stance: consumers, state officials, or exterminators?
4. Should the agricultural industry be dragged into an exterminator's problem?
5. What action should the reader recommend the Council take?

The author's insights to the study questions are provided in the complete teaching note.◆



# ARTICLES

## The Perkins Farm: A Video-Enhanced Decision Case for Extension Education

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### ABSTRACT

Decision case education is becoming increasingly important in agriculture. However, use of decision cases within extension education has lagged behind that in resident education. One serious constraint to the use of cases in extension education is the lack of a sufficient number of cases suited to the particular needs and demands of extension. The Perkins Farm case was developed specifically for extension audiences. The case concerns the Perkins' farm management decision whether to purchase a larger row-crop planter and associated equipment to improve efficiency and save time in the field. Complications in the decision include uncertainties about the Perkins' future in farming and the implications of the larger equipment for their son, should he assume operation of the farm in the future. The case is formatted in two easily assimilated segments to make it possible for learners to discuss the case even with little opportunity to prepare prior to the session. The case also includes a two-part video that enhances the capability of learners to identify with the decision makers and their situation. The Perkins Farm case was developed to increase understanding of farming and sustainable agriculture issues with particular emphasis on profitability, quality of life, and the environment. The case also helps learners to become better informed about sustainable agriculture techniques and approaches, and improves their decision-making skills. A lesson plan for using the case with extension audiences is described.

DECISION CASES have become an important new approach to enhance learning in higher education of students in agriculture, life sciences, and natural resources (Simmons et al., 1992). Although decision cases are new to agriculture, they have a longer tradition in fields such as business, medicine, and education. Interest in decision case education has resulted in recent publication of several cases (e.g., Crookston et al., 1993; Grabau and Kane, 1992; Taack et al., 1994; Vietor et al., 1995). No cases have been published specifically for use in extension education situations.

One constraint to using conventional decision cases in extension has been the unique circumstances faced by extension educators. Extension clientele are often addressed in other than a course context. The extension educator may encounter learners with very little opportunity for them to

prepare before the learning session. It is often not possible for the educator to make an advanced assignment to the learners, and even if assignments were made, it is unlikely that all will have prepared beforehand. Furthermore, extension audiences are often "bottom line" and may not commit time to developing background understanding that seems superfluous. They usually bring with them a definite set of expectations and needs.

Decision cases, as conventionally used in higher education, usually involve at least five phases spread over two or more class periods—assignment, engagement, analysis, discussion, and response. This approach to case instruction is not well suited to many extension education situations. A need exists to develop decision cases explicitly for extension applications. This paper presents and discusses a video-enhanced decision case developed for use in a single learning session with little or no preparation beforehand. The content of the case is well suited to introducing and analyzing issues affecting the sustainability of farming operations.

### THE CASE

#### Part One: Background on the Perkins and Their Farm (Exhibit 3—Video segment one shown)

Jerry and Terry Perkins, a husband-wife team, operate a farm near Worthington, MN that was started on 65 ha (160 acres) in the early 1900s by Jerry's grandfather. Jerry's father farmed 194 ha (480 acres), growing corn (*Zea mays* L.) and soybean [*Glycine max* (L.) Merr.] and raising beef cattle (*Bos taurus*) and hogs (*Sus scrofa*). In his later years of farming, Jerry's father eliminated livestock from the operation and in 1974 Jerry and Terry assumed management of the farm. Jerry stated, "Our attitude at the outset was to closely follow what had been done here before—to keep up the momentum—because my father had an operation that was successful, and then make changes from that. And what we started to move into rather quickly was to manage more residue for soil protection."

The Perkins management of soil surface residues began in 1976, starting with no-till corn on limited acreage. By 1986 most of their corn was planted using no-till. Renting a no-till drill, they began drilling no-till soybean on a small scale in 1990. In 1994 they purchased one-half interest in a used no-till drill with a neighbor and expanded the no-till practice to approximately one-third to one-half of their soybean acreage. However, their farming system has not followed the strict definition of no-till (Exhibit 1). They continue to cultivate and rotary hoe their corn and conventionally planted soybean for weed control to reduce the use of herbicides.

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### Exhibit 1. What is no-till?

In no-till, the soil is left undisturbed from harvest to seeding and from seeding to harvest. The only "tillage" is the soil disturbance in a narrow slot created by coulters, disk, or runner seed furrow openers, or hoe openers attached to the planter or drill. No-till planters and drills must be able to cut residue and penetrate undisturbed soil. Weed control relies on herbicides applied preplant, pre-emergence, or postemergence. The type and time of herbicide application depends on the weed pressures and climatic conditions.

Strictly speaking, a no-till system does not allow operations that disturb the soil other than the planting operation. In some cases the basic no-till system is modified by the use of a drag harrow, rotary hoe, row-crop cultivator, or knife fertilizer applicator (Dickey et al., 1992).

Eliminating primary tillage from fields increases the amount of crop residue left on the soil surface. Benefits of increased crop residue include reduced wind and water erosion. The reduced amount of tillage can result in reduced fuel and time savings to the farmer. However, reduction in mechanical weed control is often replaced by an increase in the need for chemical weed control. Cultivation in no-till allows a significant decrease in herbicide inputs. Farmers like the Perkins who practice no-till, strive to find a balance between soil conservation and chemical use on their fields.

No-till planting provides higher yields on highly erodible land (>6% slope) than other methods. Yield potential on well-drained, more level land is equal to that of other systems for corn, soybean, and wheat [*Triticum aestivum* (L.) em Thell ] in the North Central region of the USA. Rotation of crops is important in maintaining yields in no-till (Griffith et al., 1992).

Machinery and labor costs for a no-till system are low compared to other tillage systems. Herbicides increase costs, but total machinery, labor, and herbicide costs for no-till are typically less than those in a conventional system of chisel and moldboard plowing (Siemens and Doster, 1992).

During their years farming, the Perkins have tended to purchase land rather than machinery, judging land to be a better investment. Their farm acreage grew from an initial 194 ha (480 acres) in 1974 to 486 ha (1200 acres) by 1984. Although approximately one-half of the land they farm is rented on a year-to-year basis, all of it has been rented for at least 10 yr and some of it for 35 yr. The expansion in acreage occurred without increases in machinery size or hired labor due in part to the time the Perkins saved using reduced tillage on their farm.

Jerry and Terry's financial approach has been to avoid taking major risks such as heavy investment in new, large equipment. For the past 20 yr they have continued farming using an eight-row system. In addition to their hesitation to increase expenses, a narrow bridge leading from the county road to their house and machine sheds limits expansion in equipment size. Folding equipment with more than 12-rows would likely be too expensive for the amount of acreage they farmed.

Two goals for the Perkins' farm include maintaining yields and minimizing costs. They have been successful in achieving these goals. Average yields and below average costs rank their returns in the top 20% for the Southwest Farm Management Association to which they belong.

Before returning to farming, Jerry and Terry had been Peace Corps volunteers in South America as well as involved in adult education overseas and in the USA. They remain interested and involved in international development issues. Both have been active members of the sustainable agriculture community, and Jerry has served on the Minnesota Institute for Sustainable Agriculture board. Terry has played an active role in the farming operation. Jerry describes her as "the computer literate person in the family and very much involved in the operation, both physically and managerially."

### Exhibit 2. Estimated costs of purchasing 12-row equipment.

Current equipment	Proposed equipment	Approx. price*
1975 JD 4230 - 105 Hp, dual hydraulics uses: power elevator, cultivate, rotary hoe, spray, hauling		
1976 JD 4430 - 145 Hp, dual hydraulics uses: planting, hauling		
1977 JD 4630 - 170 Hp, triple hydraulics uses: primary and secondary tillage		
1976 JD 7000 Planter (8-row, 0.9 m [36 in.] rows, with dry fertilizer, dry herbicide)	Planter (12 row, 0.8 m [30 in.] rows)	\$15 000
1978 133 IH row-crop cultivator (8-row, vibrashank)	Cultivator (new)	\$12 000
1978 Noble Danish tine (8-row skip-row folding cultivator)		
1980 'Blumhard' pickup sprayer (13.7 m [45 ft] booms)		
1980 JD rotary hoe (7.3 m [24 ft] folding)	Rotary hoe (9.1 m [30 ft] new)	\$ 5 000
1985 JD 6620 Combine (4-row corn head)	Combine (6-row corn head)	\$ 6 000
1990 'Demco' Sprayer (14.6 m [48 ft] booms)	Sprayer (18.2 m [60 ft] booms)	modify existing
1991 JD 750 no-till drill (4.6 m [15 ft] spacings)		
TOTAL		\$38 000

\* All purchase prices are for used equipment with trade in 1994 unless otherwise noted. Source: Jerry and Terry Perkins.

The Perkins prefer a proactive approach to decision making. Jerry remarks he would rather, "be moving in a direction instead of having to be forced in a direction." Decisions are based on profitability, environmental impact, and quality of life for their family and the community. They define quality of life in part by the discretionary time they have—time for their family, their community, and the international projects with which they have been involved. They tend to place a higher value on life experiences than on material possessions.

### The Decision

Jerry and Terry Perkins place a high value on their time and they are always looking for ways to reduce the amount of time spent on farm work. For a few years, they have been thinking about buying a larger corn planter for their no-till farming operation. Planting more rows per pass would save the Perkins time in the field. Replacing their eight-row planter with a 12-row planter has been a consideration off and on in the past, but they have put off making such a move for several years.

### Part Two: Beyond the Decision (Exhibit 3—Video segment two shown)

One advantage of owning larger equipment would be more timely planting operations. It is 13 km (8 miles) from the two farthest points in the Perkins operation. Since their current eight-row equipment needs to be put up onto transports, it takes more time to move from field to field than upgraded 12-row machinery would. Increased crop quality, yields, and reduced labor costs might all be advantages to having equipment more suitable to the size of the Perkins' farm.

However, the Perkins know there are more issues involved with the decision than just purchasing a corn

planter. There are considerations about other equipment that would need to be purchased or modified to be compatible with a 12-row planter, such as the row-crop cultivator, sprayer, rotary hoe, and combine head (Exhibit 2). Changes in sprayer and rotary hoe width were necessary to control wheel traffic. Costs of these items need to be considered along with the cost of the planter. Jerry and Terry could secure a 3- to 5-yr loan for the larger equipment if they decided to purchase it. But would the larger equipment require further expansion of acreage to justify its cost and use? Jerry and Terry would increase their field capacity about 20%, equal to saving approximately 19 h of their time spent in corn planting by making a move to 12-row equipment. They knew they would also save additional time cultivating and harvesting. Although the Perkins have expanded their acreage over the years, they now think that they are close to the maximum manageable size. They have no desire to spend more time on additional acreage since that conflicts with one of the most compelling reasons for changing to the 12-row equipment—to have more “free” time.

The timing for purchasing the equipment is also an issue. To gain a higher equipment depreciation for tax purposes in 1994, it would be necessary to trade their old equipment before 1 October. Only 25% of the first year's depreciation could be taken after that date, whereas 100% could be taken prior to 1 October. Already it was the beginning of summer. Thus, if they wanted to start farming using 12-row equipment in 1995, they needed to make a decision soon.

While they were weighing the equipment size decision, Jerry and Terry were also considering narrowing the row widths in their corn from 0.9 m (36 in.) to 0.6 m (22 in.). They wanted to have equipment that could be readily adapted to narrower rows. Tires and wheel spacing would need to be changed on tractors and combines. The combine head would need to be reworked to suit the row spacing, and Jerry did not think an air delivery system for dry fertilizer in 22-in. rows was even on the market.

Although data on the practice were sparse, 22-in. rows were expected to give increased yields and earlier canopy cover for better weed control. However, while faster canopy closure should reduce the need for postemergence weed control, the larger number of rows in the field would result in an increase in herbicide use. The Perkins would have to switch from their current practice of banding grass herbicide in their corn to broadcasting herbicide.

While they were not yet sure about 22-in. rows, if they did buy 12-row equipment the Perkins would at least narrow their row widths to 30 in.

In addition to these considerations, Jerry is interested in redefining his role in farming as he approaches age 55. Jerry thinks that farming is not an “old man's game.” “I think that at age 55 you should be looking at a transition out of active farming and moving a new generation in.” He is interested in gradually passing the farm on, perhaps staying involved in management, investment, and helping at times of peak labor. He is considering working more in consulting, both on a local and international scale.

Terry is less enthused about phasing out of farming. Jerry states, “Obviously, anytime you have a family, you have a number of opinions depending on the number of family members. ...My wife likes being involved with the farm

because she can feel that she's making a contribution. If we do move into ag consulting, then her role isn't as active or fulfilling for her.”

The Perkins are concerned about who might begin to work with them in preparation for taking over the farm. One strong possibility is their 25-year old son, Mike, who rented land and farmed with them from 1990 through 1993. Mike experienced three difficult farming years and stated, “the first one was a wet year, the second was disastrous with hail, and [the third] with flooding—that can't go on forever.” In 1994 Mike was taking a break from farming to determine his interest in taking over the family operation. It was possible he could be gone for several years as he considered his options.

Another prospect to take over the farming operation is a young neighbor. This person was renting 145 acres of tillable land from the Perkins in 1994, but also had a full-time, nonfarm job. Although there is potential for him to phase into the operation, no concrete plans would be made until Mike decided his plans for the future. An important factor was that the Perkins wanted to find a new operator who had a management philosophy similar to theirs, including support for sustainable approaches to farming.

### Exhibits

1. Description of no-till.
2. Estimated costs of purchasing 12-row equipment.
3. Video segments one and two. The video segments together are 13 min long and depict the decision makers and their dilemma using a documentary format interspersed with actual interviews with the Perkins. There are several scenes of the Perkins' farm and equipment.

## INTERPRETIVE NOTE

### Case Objectives

Through deliberation of this case, participants will:

1. Gain a better understanding of farming and sustainable agriculture related issues with particular emphasis on profitability, quality of life, and the environment.
2. Become better informed about sustainable agriculture techniques and approaches.
3. Improve their decision making skills.
4. Engage in discussion that leads to information exchange.

### Use of the Case

This case was developed for use by extension educators, professionals, and others concerned with introducing and discussing sustainable approaches to agriculture. To date, the case has been used successfully in extension educator in-service workshops and with farmers interested in sustainable agriculture issues within Minnesota and the North Central region of the USA. This case is designed to be discussed in a 30 to 90 min time period and is organized in two parts to help discussants easily assimilate the case. It has been used successfully with group sizes ranging from 10 to 40 people.

It is assumed that many extension audiences for which the case is suited will have had no prior introduction to the case before attending the learning session. Since the case

contains the two-part video, the capability is enhanced to quickly acquaint the learners with the decision makers and their situation. If time is limited, an educator might use only the video and base discussion on the information contained therein. The amount of information available through the video alone is somewhat limited, but many aspects of this case can still be addressed using only the video.

A primary goal in using this case with extension education audiences is to help the learners step into the role of the decision makers, the Perkins. The case is intended to be used with a discussion-based, active-learning process centered around defining and resolving the dilemma. This can be done by analyzing the situation and soliciting a variety of decision options. The extension educator, when acting as case facilitator, guides the discussion, asks probing questions, redirects questions among the discussants, and helps provide transition from point to point within the case discussion. The facilitator also recognizes and validates discussants' contributions, and records information and contributions on a blackboard, overhead projector, or flip chart.

Cases such as The Perkins Farm can precipitate disagreements, particularly when values and opinions differ among the discussants. The discussion of The Perkins Farm can take any number of possible directions depending on the purposes and emphases of the facilitator and the discussants. Similarly, several decision options are possible with no single option being favored. The case discussants may determine that more information would be helpful or essential before reaching a decision. If so, the case facilitator may have the discussants identify and list the additional information that they think would be needed to make the best decision and how that information might be obtained. Nevertheless, few decisions in real life are made with all possible information in hand and the facilitator may choose to press the discussants to make a decision even though information is incomplete. It will become clear to most groups that the overt dilemma—whether to expand equipment size—is only part of the dilemma facing the Perkins. Thus, decision options proposed by the group may range from equipment choices to more fundamental considerations of long-range planning and restructuring of the farm operation.

Arrangement of the facilities can play an important part in leading a case discussion. Many extension education rooms are arranged in rows suited to a lecture or specialist presentation, but such physical settings can stifle effective case education. A better situation may be to arrange the discussants in a horseshoe or "U" shape so discussants can easily see one another. The case teacher can readily move among them while being able to record items on the blackboard, overhead, or flip chart.

In opening a discussion of The Perkins Farm case, it is usually advantageous to first show the initial segment of the video. Then the group can be subdivided into groups of two to four people, told to review part one of the written case, and asked to discuss questions 1, 2, and 3 (below) within their subgroups. The facilitator can then initiate discussion of the case by the entire group after it has become apparent that the subgroups have generated ideas to sustain a lively dialogue. Question 4 could be used during this discussion time.

When the facilitator is satisfied that the discussion by the entire group has progressed sufficiently in defining the dilemma, consistent with the information presented in the first part of the case, the second segment of the video can be shown. Discussants may then be given part two of the written case to review. The discussion facilitator could ask the members of each subgroup to discuss question 5 among themselves before initiating discussion of the case with the entire group. Once the facilitator is satisfied that her or his purposes for using the case have been satisfied—often after discussants have proposed several options for the Perkins based on their definition of the dilemma—the facilitator should conclude and summarize the discussion. The facilitator may choose to have the group make a decision individually or collectively. This often helps to leave discussants with a sense of "closure" for the case discussion experience. However, consensus may not be achieved. The case facilitator can note that it is often not feasible to reach a single, universally accepted decision when dealing with a complex dilemma such as that faced by the Perkins.

### Discussion Questions and Issues in the Case

Below are examples of the kinds of questions that might be used to stimulate discussion of the issues in the case.

**1. What is the dilemma faced by the Perkins?** The Perkins' basic dilemma is whether to replace their current eight-row planter with a 12-row planter to begin planting corn in 12 rows. However, discussants will likely list many other dilemmas such as obtaining more discretionary time, reducing agricultural chemical use, and developing/reconciling longer range goals of the Perkins family.

**2. What approaches do the Perkins have toward farming? How do these approaches differ from those of other farmers (or yours)?** The Perkins consider profitability, the environment, and the community when making decisions on their farm. Soil conservation is important to them. They are not as concerned about the cosmetics of weed control as other farmers may be and make efforts to limit the need for chemical weed control on their farm. The Perkins are distinctive for their activity in international aspects of agriculture. Also, they tend to adopt new methods in a gradual, deliberate way, as shown in the way they adopted no-till.

**3. What effects do these approaches have on the equipment size decision that they face?** This question will prompt discussion of the priority the Perkins and other farmers assign to quality of life vs. profitability or environmental issues. The Perkins will only make a change to their farming system that they judge to be environmentally sound and profitable. Also, they prefer to adopt new practices gradually, which may cause hesitation in purchasing equipment. However, at the current time, the high priority they place on the amount of time they have available away from farm work may be enough to justify purchasing machinery.

**4. What issues do you think are important in affecting this decision?** This question may bring up issues that aren't raised until the second segment of the video and written case. The facilitator may want to note these issues on the board, but postpone discussing them until later. Issues that

have been introduced at this point in the case include the Perkins' desire to have more discretionary time, their hesitation to invest in new equipment, and their ability to afford larger equipment.

**5. What additional issues have been introduced in the second video and written case segments that might influence the decision whether to purchase 12-row equipment?** Many additional issues are introduced in the second portion of the case. Among these are the need to purchase additional equipment to match a 12-row planter, the urgency of making the purchase soon, the associated decision to use narrower row-widths in corn, Jerry's desire to change his role in farming, the concern about passing equipment loan debt to the next operator of the farm, uncertainty about who will take over the farm, and maintaining the farm's sustainability through these transitions.

**6. In the video, Jerry discusses his feelings about the issue of farm size. How does farm size affect the Perkins' decision?** This question, like numbers 7, 8, and 9 below, could be used to stimulate more in-depth discussion of sustainable agriculture techniques and approaches and related issues.

**7. What agronomic and environmental "tradeoffs" might the Perkins face in making this decision?** Some considerations may include environmental tradeoffs such as pesticide use vs. soil conservation, and quality of life tradeoffs such as time vs. income.

**8. How do economic considerations impact the Perkins' decision?** Exhibit 2 shows the current equipment and expected costs of newer equipment as estimated by the Perkins. The Perkins rank in the top 20% for returns in their farm management association. They could expect to qualify for a 3- to 5-year loan for the equipment if they decided to purchase it. Maintaining the optimum machinery size on the farm will maximize the Perkins profits. The time savings with larger equipment estimated in the case were calculated using an effective field capacity equation (Boehlje and Eidman, 1984). Effective field capacity considers typical delays caused by turning, handling materials, cleaning, adjustments, waiting, and efficient use of the full width of the equipment.

**9. Why is Jerry interested in changing his role in farming? Why is Terry hesitant to do so?** The Perkins' commitment to international involvement has led them to be active in agricultural projects in different areas of the globe. Jerry wants to be able to commit more time to such efforts, as well as endeavors such as participation in the Minnesota Institute for Sustainable Agriculture. Jerry does not think he wants to continue farming until retirement age. Both he and Terry are interested in finding someone else to assume more responsibility for the day-to-day farm operation. However, both realize that Terry's role on the farm is more fulfilling than her role might be in agricultural consulting, particularly internationally. Terry also suggests that she is less comfortable with this sort of change than is Jerry.

**10. What decision options do the Perkins have?** Following are several decision options, some of which the Perkins themselves felt that they had. Not all of these options will necessarily be mentioned each time the case is taught and other options may also be possible.

*Buy a 12-row planter.* This option would actually involve purchasing additional equipment such as a cultivator and a combine head.

*Hire a custom operator.* This option could save the Perkins time in the field if they could find reliable help. There are also additional costs associated with this option.

*Reduce acreage.* This would reduce the amount of time spent in the field and remove the need for larger equipment. The Perkins yearly income would be reduced. Also, the Perkins have increased their land over the years as an investment. Selling land now would be contrary to that approach. Renting their land is possible, but they may be concerned about renting to a farmer whose approach is not compatible to theirs.

**11. What decision should the Perkins make?** As noted above, case discussion facilitators may not wish to try to reach consensus regarding a decision. Discussants could be asked how their opinion of the decision faced by the Perkins may have changed from their initial impression of the case. Another option is to have the discussants write a brief statement of how they would resolve the dilemma if they were making the decision. If this is done, it is usually good to have them also state the most compelling reason for making the decision that they did.

## ACKNOWLEDGMENTS

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# Plow or Play: A Land Use Decision

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## ABSTRACT

In 1991 in Indianapolis, IN, an appropriations bill was brought to the floor of the Indiana General Assembly for debate. The bill included a \$900 000 appropriation for the purchase of land to build a new state park in northwest Indiana. The park would be located in the district of Senator Mike Gery of West Lafayette, a legislator who had followed this issue very closely over several years. It was an issue that was volatile in his home district. When Senator Gery had his chance to publicly debate and vote on this issue on the senate floor, he knew his constituents would be watching closely. This case presents Senator Gery's decision-making dilemma on an issue that was extremely important to his constituents. Senator Gery knew there was a large core of park supporters among his constituents. However, there was also a significant group who actively opposed the park, including one family who would lose a substantial portion of their farming operation if the park was established. Senator Gery was concerned for his constituents and wanted to do what was best for them. He wanted to take an action that would minimize hostile reactions, but he also wanted to make the best land use decision for the future of his district. Each side put forth convincing arguments that Senator Gery had to consider. Through this case, students will gain an understanding of the technical factors and ethical issues involved in land use decisions.

AS POPULATION INCREASES and residents focus on environmental concerns, land use has become an important issue in the USA. Land available for agriculture has decreased every year since 1954, and decreased 4.5% during the 1980s (USDA, 1991). Each interest group has their own idea on the best use for a tract of land. When the land in question is privately owned, the rights of the landowner also become an important consideration. Land use decisions usually affect several people directly, especially landowners. As a result, land issues can lead to emotional confrontations, and sorting out information in an unbiased way can be difficult. This case provides insight into the myriad of complex issues typical of land use decisions at the rural/urban interface.

## THE CASE

The Indiana General Assembly convened in Indianapolis in 1991 for a Second Special Session. Scheduled to be debated was PL240, an extensive appropriations bill that would determine how the state would spend its tax revenues for the next year (Acts of Indiana, 1991). Section 34 was of particular interest to Mike Gery, state senator from the 17th congressional district. That section appropriated \$900 000

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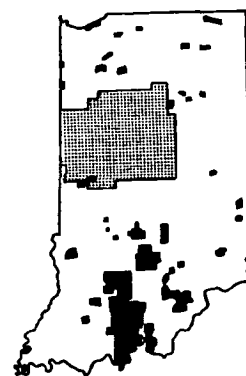
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for land acquisition in his district. The land would be purchased from private citizens for the construction of a new state park. Completion of the park would require much more than \$900 000, but this appropriation would be a vital first step.

At first, Senator Gery believed the majority of his constituents supported the park. He could envision little objection to a beautiful new state park within easy access. However, after numerous town meetings and personal contacts with constituents, he found the issue was more contentious than he originally thought.

## The Decision to Establish a Park

The Indiana Department of Natural Resources (IDNR) oversees the state park system in Indiana. The mission of the IDNR is "to protect, enhance, preserve, and wisely use natural, cultural, and recreational resources for the benefit of Indiana's citizens through professional leadership, management, and education" (Indiana Department of Natural Resources, 1995). One way the IDNR fulfills its mission is by constructing new state parks. The IDNR realized that some residents of Indiana had to drive considerable distances to reach public outdoor recreation sites. As a result, in 1983 the Indiana State Senate passed Concurrent Resolution no. 77, which authorized the IDNR to analyze the recreational needs of an area in northwest Indiana. This agricultural region seemed to be particularly short on outdoor recreation opportunities (Exhibit 1). The methods used in the assessment were: 1. Comparisons with national standards, 2. Drive time from regional facilities, and 3. Distribution of recreational opportunities based on population



 AREA DEFINED BY  
CONCURRENT  
RESOLUTION #77

 PUBLIC OUTDOOR  
RECREATION AREAS

Exhibit 1. Distribution of public outdoor recreation areas in Indiana and the area defined by Concurrent Resolution #77.

Abbreviations: IDNR, Indiana Department of Natural Resources.

(National Park and Recreation Association, 1983). Each method verified a shortage of outdoor recreation facilities in the region (Indiana Department of Natural Resources, 1983).

The IDNR concluded the study area was deficient in lands available to the public for recreation use. They also concluded, based on surveys conducted during the study, that the people of the area wanted more outdoor recreation areas. This prompted the General Assembly to authorize a state park site selection study.

### The Site Selection Process

The legislature, in granting the IDNR the authority to conduct a site selection study, listed three conditions for the site. They were:

1. The site should contain between 809 and 1618 ha (2000 and 4000 acres) of land.
2. The site should contain a 40 to 120 ha (100–300 acre) lake.
3. The site should be located in an area bounded by Interstate Highway no. 65, U.S. Highway No. 24, and US Highway no. 31 (Exhibit 2).

Twenty-six sites were located within the study area. Fifteen of these were eliminated due to obvious suitability problems relating to lake potential, feasibility of physical development, or present land use. The remaining 11 sites were inspected in the field and ranked. The site selected as the best was located in Tippecanoe County (Indiana Department of Natural Resources, 1991). However, this site was abandoned in 1987 due to local opposition and potential construction problems.

By 1989, 7 yr had passed since the authorization to select a park site. With the loss of the Tippecanoe County site, the IDNR still had no place to build a park, despite spending a considerable amount of taxpayers' money during the site selection process. They decided to reevaluate sites previously overlooked because they failed to meet the lake criteria outlined by the General Assembly. However, it seemed as though every potential site had either serious physical limitations, local opposition, or was opposed by influential spe-



Exhibit 2. The location of the site selection study area for a new state park in Indiana.

cial interest groups. There did not seem to be even one site that was free of these problems. Finally, the IDNR settled on another Tippecanoe County site located near Battle Ground, Indiana. The potential for a large lake did not exist, but the IDNR believed there were other considerations that made this site ideal. In 1989, even though local opposition was anticipated, the IDNR recommended to the General Assembly that 1121 ha (2770 acres) just southeast of Battle Ground become Prophetstown State Park.

### Physical Characteristics of the Site

To decide the best use for a tract of land, Senator Gery knew it was important to assess the physical characteristics of that land. Although he was already somewhat familiar with the area, he studied the proposed Prophetstown site carefully. The site was located just southeast of the town of Battle Ground in Tippecanoe County. Interstate Highway 65 would serve as the west boundary, while the Wabash and Tippecanoe Rivers would form the south and east boundaries. Battle Ground, which contained about 700 residents, would form part of the north boundary. Most of the county's 130 598 residents lived about 5 miles southwest of the park site in the twin cities of Lafayette and West Lafayette (U.S. Census Bureau, 1995).

Most of the site (89%) was devoted to corn (*Zea mays* L.) and soybean [*Glycine max* (L.)] production (Exhibit 3). However, this land was not considered to be prime farmland because of droughtiness, slope, or flooding problems. Much of this land was located in a floodplain that was highly productive but frequently flooded. Most of the upland farm-ground was sloping, but soil erosion was generally not a problem because of the soil conservation practices being followed. According to George Parker, Professor of Forestry at nearby Purdue University, the most serious erosion problem at the site was the streambank erosion that occurred on the Wabash and Tippecanoe Rivers. Senator Gery knew Dr. Parker well, and often relied upon him for information about the Prophetstown site.

Nonagricultural land at the proposed park site was primarily timber, wetlands, and residential tracts (Exhibit 3). There were two large housing developments within the proposed park boundaries. The IDNR proposed to exclude these from the park and allow the residents to stay there to

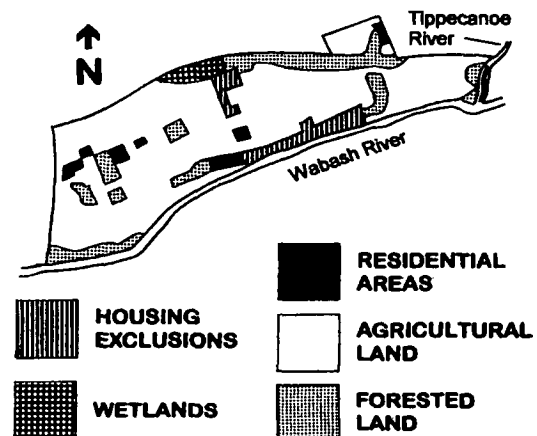


Exhibit 3. Land uses at the proposed site of Prophetstown State Park.

reduce the number of buyouts, thereby saving money and avoiding adverse reactions from unwilling sellers. When these housing developments were excluded, only 17 homes comprising 17 ha (42 acres) remained to be bought out.

There were approximately 30 ha (74 acres) of wetlands within the site. If the park was built, the underground drainage systems would be dismantled to expand the wetlands to their original areas. They would cover 140 ha (345 acres), becoming one of the largest wetland areas in the region (Weber, 1992).

Before the area was inhabited by non-native settlers, the proposed park site was primarily forested. Seventy-six hectare (189 acres) of timber remained at the site. The soils in the area were well suited to growing trees. If the park was established, extensive tree plantings would be undertaken to restore the native woodland habitat, which should encourage an extensive array of wildlife.

The Wabash and Tippecanoe Rivers were the two major rivers at the site. Through correspondence with researchers from Purdue University, Senator Gery was informed the Wabash was a relatively unpolluted river at the site and it sustained diverse populations of fish and mussels. The stretch of the Tippecanoe River just upstream from its confluence with the Wabash was one of the most biologically diverse river sections in Indiana, sustaining several species of endangered mussels and many rare fish species. However, it was an ecosystem that appeared to be deteriorating. The macrophytes (large plants) in the Tippecanoe were decreasing every year for some unknown reason. This was alarming to researchers because the macrophytes were an important component of the ecosystem.

### **History of the Prophetstown Site**

Senator Gery was well aware of the history of the Prophetstown site. The proposed park site had great historical significance from the standpoint of Indian culture and religion. Indians had congregated in the proposed park site for at least 10 000 yr. In 1808 it became the site of the Indian village of Prophetstown. Prophetstown was built by the Shawnee religious leader Tenskwatawa, also known as The Prophet. He was the brother of the Shawnee leader Tecumseh, who strived to unite various Indian tribes of America to retain their homeland against expansion by the USA. Tecumseh was often traveling and visiting with other tribal leaders to convince them to form a confederation. He was on one of these trips when U.S. troops, led by William Henry Harrison, destroyed Prophetstown in the fall of 1811 in a conflict which became known as the Battle of Tippecanoe. Harrison's military victory at Prophetstown catapulted him into the Presidency of the USA. The Indians regrouped and rebuilt Prophetstown the following spring, but were forced to flee advancing Kentucky militia in the fall. The militia burned the village to the ground, never to be rebuilt by the Indians. The battle is commemorated by the Tippecanoe Battlefield Memorial at the edge of Battle Ground, which includes a small park and museum. Prophetstown State Park would greatly expand on this with the construction of an Indian Cultural Center and Indian Village within the park (Weber, 1992).

Because of the long Indian presence in the area, it was thought the proposed park area contained rich archaeological sites. A local anthropologist informed Senator Gery there were no active digs in the area because the land was being used for agricultural and residential purposes and was not available for archaeological exploration. If the park was built, the area within the park would be preserved for future archaeological activities.

### **Acquiring the Land for Prophetstown State Park**

Senator Gery realized that one of the drawbacks to building a park was that some people would be forced to leave their homes or sell their property. Eminent domain laws allow the state to acquire private property if they purchase it at a fair market value and if the acquisition is required for the benefit of the general population. Senator Gery knew that the use of eminent domain for public park acquisitions had been recognized in the USA since the middle of the 19th century. John Davis, Director of Land Acquisition for the IDNR and Prophetstown State Park, said the process works like this: The state would have the properties appraised by an independent, reputable appraiser. The state would make an offer to buy the property based on its fair market value. If the property owner was willing, the sale would then be completed. If the property owner did not want to sell, the state could start condemnation proceedings. Davis said he wasn't sure how many of the property owners at the Prophetstown site might refuse to sell. A group of businessmen who owned a large portion of the site did not object to the park proposal. However, there was at least one unwilling seller—the Okos family.

The Okoses' views were often expressed on the editorial page of the local newspaper (Exhibit 4). Linda Okos explained in one such column, "It was 1 yr ago, on November 19, when an engineer from the IDNR came out, and he said to us, 'I want you to know, we have the right all the way up to the Supreme Court to take your land'. And that's the way it's been ever since. This has been government coming at us" (Norberg, 1992). The Okoses—Martin, Linda, and their four children—reside and farm near Battle Ground. Although their home is not within the proposed park boundaries, they would lose 32.4 ha (80 acres) of their own farmland and 48.6 ha (120 acres) of farmland they rent. "That's a third of our farming operation," says Linda. "This is definitely going to cut us back. We're really not happy about this. But we're also not sold on the fact that this is the best thing for Battle Ground. If you're talking 500 000 visitors per year, that will put a tremendous traffic crunch on Battle Ground. There's not too much that can be done with Main Street, and we have two schools on that street." Indeed, Senator Gery had been to Battle Ground on numerous occasions. He was aware of its friendly, safe, quiet small town atmosphere. He often wondered how a town of 700 would adapt to half a million visitors a year.

### **Effects on Area Residents Who Would Live Near the Park**

Senator Gery knew there was significant local opposition to the park. When he drove near the park site, he saw homemade signs landowners had put up (Exhibit 5). Senator Gery



## Guest Column

### New, improved park plan – isn't

By LINDA OKOS

Guest Columnist

The newly proposed state park plan has been hailed as a grand improvement.

Before we get caught up in the greatness of this new plan, we need to look with eyes wide open at what has actually been proposed:

- The 70 acre lake will be long and narrow. Its shoreline will be barely over 3 miles - half of which will not be accessible to the public. If you like to fish, you'll have the opportunity. But if you are a powerboat lover or water skier, forget it. A major length of the lake will never be deep enough for boating.

- The boundaries of this park wind around some 60 homes on Houston Road and Indiana 225, offering little in the way of beauty to the park-goer or the homeowner.

- I urge you to take a look at this total park plan before deciding that it is the best thing that could happen to the Battle Ground area. We are literally being asked to give up our privacy and invite the entire state to our backyards for their picnicking and fishing pleasure. Traffic will increase. Lakes are not always clean, beautiful, or safe - especially after the public takes over.

- And now a word to the many park supporters - we are all friends of the Wabash River. The beauty of this area with its historical significance is something which we are all very proud. We need to guard and protect it. We can do that much better in a quiet manner without a large public park. The character of this area will be better preserved if we hold on to what we have. Once we open our doors to the public, we will sacrifice the very features which make Battle Ground so unique. Why not use the grounds of the amphitheater for an Indian Cultural Center and village? Money is already invested in that site.

- Lastly, a word for our state legislators. Census Bureau data indicate that state spending has risen an average of 7.5 percent annually or 1.5 times the rate of inflation. And you plan to keep spending for pleasure? How can you guarantee the landowner a fair price for his property when state funds are so tight? There isn't even money for education. University salaries were frozen this year for the first time in 18 years. Schools are in need of additional funding. It is your elected responsibility to spend wisely - yet you continue to get us deeper in debt. This type of activity does not make for good re-election support. The legislator who holds the line on spending is the one who stays in office.

- The bottom line is: We don't need and can't afford a state park. What presently looks like a future gain to Battle Ground will really be future loss to the uniqueness of this community. The DNR is nothing short of a large industry knocking at our door. Will we let them in? I urge you to think again about this issue and make your feelings known.

*The writer, her husband Martin, and their four children operate a farm on the newly proposed park site. Guest columns, published when timely and in the public interest, do not necessarily reflect the views of the Journal and Courier.*

**Exhibit 4. Excerpts from Linda Okos's editorial in the *Lafayette Journal and Courier*.**



**Exhibit 5. Signs placed by citizens who owned land at the proposed park site.**

had spoken to many of the local residents at monthly meetings he convened to talk about the park. The people who lived in the excluded housing developments had been particularly vocal in their opposition to the park. They were glad their homes would be spared, but objected to being surrounded by a park.

Others who lived next to the proposed park site had other concerns. Some residents were worried that the state park would cause property values to go down. Many were concerned that the quality of life would decrease because of the estimated 500 000 visitors the park would receive each year. But the most stressful thing of all, according to Martin Okos, was the uncertainty in their future as a result of this long, drawn-out process. They did not know how to plan for the future until they knew if and when the park would actually be built.

### The Referendum

A nonbinding State Park Referendum was placed on the 1990 November ballot (Acts of Indiana, 1990). Senator Gery hoped the referendum would help him understand how local citizens felt about Prophetstown. Only Tippecanoe County ballots had the referendum. The referendum had four choices, of which the voters were instructed to select one. Sixty percent of Tippecanoe County's eligible voters turned out, which amounted to 33 709 voters. The choices and the official results were:

1. Favor the Prophetstown site near Battle Ground—43%
2. Favor a state park, search for another site—30%
3. Favor a state park and have no preference for location—7%
4. Oppose any state park in Tippecanoe County—20%

This four-option referendum resulted in both sides claiming victory (Gerrety, 1990). The anti-Prophetstown camp said it was significant that the majority of voters in the county did not want Prophetstown, because if choices 2, 3, and 4 are combined, it could be said that 57% of the voters passed up a chance to vote for Prophetstown. "If the people had wanted Prophetstown, they would have voted for it", said Dave Linder, who lived at the proposed park site. However, the pro-Prophetstown people claimed the referendum numbers were in their favor. "Our goal was to see that no. 1 was the choice of preference, whether it's 2% or whatever," said Scott Frankenberger, president of the local environmental

group called Friends of the Wabash. "The opponents will say anything to put the park in a bad light."

Many predicted the fight would remain bitter in the General Assembly. Senator Gery was the voice for the people of Tippecanoe and surrounding counties. His immediate choices were clear. He must either support the \$900 000 start-up appropriation as it was stated, or show even stronger support by trying to get even more money approved, or show a lack of support by trying to kill the appropriation. Theoretically, he could also try to kill the park funding with the hope of changing the park plan or the site, but with all the time and expense that went into the selection of the Prophetstown site, he knew this alternative would receive little support from anyone. Whatever path Senator Gery chose, one of his priorities was to please as many of his constituents as possible. He also had a sincere desire to do what would most benefit them in the future. He realized that land use decisions affect many people far into the future. What action should Senator Gery have taken?

### CASE EXHIBITS

1. Distribution of public outdoor recreation areas in Indiana and the area defined by Concurrent Resolution no. 77.
2. The location of the site selection study area for a new state park in Indiana.
3. Land uses at the proposed site of Prophetstown State Park.
4. Excerpts from Linda Okos's editorial in the Lafayette Journal and Courier.
5. Signs placed by citizens who owned land at the proposed park site.

### TEACHING NOTE

#### Case Objectives

Upon completion of this case, learners will be able to:

1. Describe how the physical characteristics of land can affect its suitability for different uses.
2. Recognize that, in addition to land physical characteristics, a wide array of special interests and personal philosophies affect land use decisions.
3. Recognize that land use can have a significant impact on local environments, economies, and social factors.
4. Defend a recommendation for building, stopping, or modifying Prophetstown State Park.
5. Argue a viewpoint on the ethical question of using eminent domain to acquire land for a public park.
6. Describe why an elected official may formulate a decision differently than a private citizen.

#### Use of the Case

The case is well suited for use by college students in agriculture, natural resources, recreation, or related disciplines. The case may also work well in political science courses covering political ethics or ideology. This case does not require the learner to have a specialized background in any area, thus increasing its utility for use with groups whose members have varied backgrounds and expertise.

After learners read the case outside of class, they may be required to prepare a written response to some or all of the questions listed below in advance of a general class discussion. Another option would be to break the class into small groups to deliberate the issues prior to a general class discussion or debate.

Students at Oregon State University and Purdue University have discussed the case. In a Contemporary Issues in Natural Resources course at Oregon State, approximately one-half of the class felt Prophetstown should be built after reading the case. However, after in-class discussion, approximately three-fourths felt it should be built, with two students changing their minds to not having it built. Many said they changed their minds because the discussion brought out social and environmental points they had not previously considered.

At Purdue University, the case was used in a Contemporary Issues in Agriculture course for two semesters. Approximately three-fourths of both classes initially felt the park should not be built, and class discussion failed to change the overall viewpoint in either class. The predominance of agriculture majors who were from the farm may explain this response.

Students at both universities positively evaluated the case. All felt the case helped them realize the importance of determining best use of land resources, and gave them different perspectives on the issues surrounding how land should best be used.

#### Discussion Questions and Issues in the Case

**1. Do the benefits of Prophetstown State Park outweigh the drawbacks?** This is a question which should be answered from the learner's personal viewpoint and also from Senator Gery's viewpoint. It is a seemingly important question if the Senator is to evaluate what is best for his constituency, but one that is also dependent on subjective judgments of individuals, and therefore difficult for which to find a "right" answer.

The way this question is analyzed is to some extent based on an individual's personal value system. For example, someone who enjoys the outdoors and places importance on preserving nature would probably favor the park. To this individual, these benefits may override any potential drawbacks. However, there may be many local residents who enjoy the rural, quiet setting of the Battle Ground area. To these people, the hustle and bustle of having a busy state park in their backyards may be a serious drawback. It will become clear that everyone has a unique point of view, and that personal viewpoints must be set aside somewhat when making a decision for many, as the senator must do.

**2. If you could choose a land use for the Prophetstown site, what would it be, and why?** This question will cause learners to assess the physical characteristics of the site while also bringing out learners' different values. The wide array of reasoning may take into account physical, social, and economic factors. This question lends itself well to classroom debate. Some foreseeable responses could be:

- a. Leave the area as is, to be used for agricultural production. The amount of farmland is decreasing in the

USA, and we should preserve it. Parks are not as important as agriculture.

b. Try to find a better place for the park, or build the park in a way that would be less objectionable to the local citizens. Parks are needed, but this location is too controversial. Too many people will be uprooted from their homes, and there is too much local opposition. It is not fair to the Okoses.

c. Build Prophetstown at the proposed site, as planned. We must take care of our environment. If we ruin that, we will have nothing. The park will preserve important habitats. The history that occurred at this site is a part of our national heritage. Although agricultural land is decreasing nationwide, we do not have food shortages in the USA. Besides, this is a small area and it is not prime farmland.

**3. Is it right to use eminent domain to acquire the Okos's land?** This is a complicated question that will probably elicit mixed reactions and lively debate from the class. Some may believe using eminent domain is proper in some instances, but not for a park. Learners should be encouraged to justify their response. The pathways the discussion could follow are numerous.

**4. What was Senator Gery's dilemma?** Senator Gery had to decide how to act on a land use issue that was extremely important to his constituents. It will become clear to the learners he was required to take a different approach in forming his decision in comparison with the approach of his constituents because his purpose was to represent the wishes of many. Legislators generally want to please their constituents. However, they also often have more information at their disposal and thus should be able to develop a more informed view on what would be best. What should he have done if his constituency did not agree with his idea of what was best? A prerequisite to making the decision is to understand the wishes of his constituents, but in this case it appeared that figuring out what the majority wanted was difficult. The referendum was so poorly designed the results were inconclusive, with all sides claiming victory. There was a lot of mixed signals from local citizens and special interest groups, with sizable numbers both for and against the park.

**5. What were Senator Gery's options?** Regardless of personal preferences, the reality is that Senator Gery needed to make a decision. The choices were clear. The senator could vote for the appropriation, thereby showing his support for Prophetstown. Likewise, he could make a motion to amend the bill to cut the Prophetstown funds, thereby showing his disapproval of the park. If the lack of support is widespread and the Prophetstown appropriation is taken out of the bill, the park may essentially die.

**6. If you were Senator Gery, what would you have done, and how would you have responded to the criticism of your decision?** This question forces the learner to be placed in the shoes of perhaps the ultimate decision maker, a legislator who is accountable to many and makes decisions that affect many. The learner will realize there are many concerns a legislator needs to consider in addition to his or her personal feelings on an issue. The learner will understand how complex and difficult it can be to try to take into account the views of many and to accurately reflect a constituency while doing what you think is best.

**7. What did Senator Gery do?** Senator Gery decided to support the park. He was a key figure in moving ahead with its establishment, and worked to "sell" the park to his constituents. He remained popular and was reelected in 1994.

At time of publication, approximately 200 ha (500 acres) at the park site had been purchased by the state. In 1996 there was a federal effort to pinpoint the exact location of the historic Indian settlement, highlighting the national importance of the Prophetstown park site.

The authors would prefer learners not have access to this information until after discussing the case. If learners knew the results of the case beforehand, it would taint their approach to the case. This case is designed to address issues of wider context and applicability; thus, knowing what Senator Gery decided is not of the utmost importance. However, the case is real, and we would encourage instructors to provide this information near the end of discussion.

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# Will the Toad Croak? An Endangered Species Decision Case

William C. Akey,\* Todd Russell, Craig Alford, Tracy Morrison, and Matt Denning

## ABSTRACT

In 1992, the USEPA proposed a ban on the use of 43 pesticides in a large portion of Albany County, Wyoming. The ban was intended to protect the habitat of an endangered species, the Wyoming toad (*Bufo hemiophrys baxteri*), as required by the Endangered Species Act of 1973. For many years, portions of Albany County that included Wyoming toad habitat had been routinely sprayed with insecticides to control mosquitoes. Residents were concerned that without adequate mosquito control, recreation, tourism, agriculture, public health, and property values could be impacted. A task force comprised of local residents of diverse backgrounds and viewpoints was appointed in 1992 by the governor of Wyoming and Albany County commissioners to consider how best to (i) protect the Wyoming toad and aid its recovery, and (ii) maintain effective mosquito control. The goal of the group was to submit an alternative proposal to the U.S. Fish and Wildlife Service and to the USEPA that would meet both objectives and be more acceptable to the residents of Albany County than the USEPA's proposed ban. This case provides a focus for considering the value of endangered species, possible impacts of the Endangered Species Act on agricultural producers, local businesses, visiting tourists, and local residents. It also permits students to consider the involvement of local communities in decision-making.

THE ENDANGERED SPECIES ACT has frequently been a subject of controversy. Public opinion varies greatly regarding the extent to which human activities should be altered to protect a single species. The Wyoming toad (*Bufo hemiophrys baxteri*) is an inconspicuous, 5-cm (2 in.) long

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amphibian whose decline in numbers had been alleged to be linked to human activities. Moreover, many people felt entitled to use chemical pesticides on their own land, free from governmental control. This case explores the issues that confronted the Wyoming Toad Task Force as it attempted to formulate a proposal to submit to the USEPA.

## THE CASE (ABRIDGED)<sup>1</sup>

### Overview

In late 1992, a draft bulletin was issued by the USEPA to ban the use of 43 pesticides in a large section of Albany County in southeastern Wyoming (Exhibit 1). The proposed ban encompassed an area of 2513 km<sup>2</sup> (970 mi<sup>2</sup>), which included the town of Laramie (Exhibit 2). The bulletin was implemented to fulfill the USEPA's obligations under the Endangered Species Act to protect the habitat of an endangered species—the Wyoming toad (Wyoming Toad Task Force, 1993, personal communication). The community was given 120 d to comment on the proposed ban.

Albany County residents had mixed reactions to the USEPA proposal. Some residents expressed general support for the recovery efforts. Rancher Mark Swanson, on whose land a small population of Wyoming toads had been found, said that aside from having to rotate his cattle a little differently, his family's operation hadn't been affected (Tollefson, 1995b). "We would have done it differently if the land was still ours, but it's worked out well so far," he said. "They trust my count on the cows and how long I've had them in there. I think it's been a great deal, and if they can save their

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<sup>1</sup> This is an abridgment of the complete case. The complete case consists of 21 pages of text and 19 pages of exhibits, and a 6-page teaching note. For a copy of the complete case, contact the corresponding author.

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**Abbreviations:** USEPA, U.S. Environmental Protection Agency; FWS, U.S. Fish and Wildlife Service; WTTF, Wyoming Toad Task Force; BTI, *Bacillus thuringiensis* subsp. *israelensis*.

little toad too, that's great," he said (Tollefson, 1995b). Neighboring rancher Pam White said that she felt a real sense of pride in having the toads and other wildlife on her land. "There's just something about their look, a kind of intelligence and pride," she said about a personal encounter with a toad in her yard (Tollefson, 1995b).

Others had concerns about the impact of restricting the use of pesticides, and especially the insecticide malathion [diethyl (dimethoxythiophosphorylthio) succinate], which was used to control the extensive mosquito populations in the county. They were mainly concerned about the effects that changes in mosquito control would have on recreation and the local economy. The business district in Laramie reacted very negatively to the USEPA's proposed pesticide ban. The Wyoming Territorial Park's Board of Directors, the Laramie Area Chamber of Commerce (Exhibit 3), and the Albany County Tourism Board all expressed concerns in their letters to the Albany County Commissioners. The agricultural community also complained of potential economic loss due to the negative impact of large numbers of mosquitoes on livestock. Larry Bourett of the Wyoming Farm Bureau suggested that cattle grazing in areas of high mosquito infestation have lower body weights, grow at slower rates than do other cattle, and are more prone to disease

(Pelkey, 1993b). One species of mosquito in the Laramie Basin was a potential vector of encephalitis, a disease affecting both horses and humans. On the other hand, the local chapter of the Sierra Club recommended that the use of broad spectrum insecticides in the Laramie area be eliminated—not just for its impact on the Wyoming toad and local recreation and economy, but on humans and wildlife as well (Exhibit 4).

Under the Endangered Species Act, the Wyoming toad was guaranteed protection. The control of mosquitoes was viewed as essential by many local residents. Were there other safe, effective, and economically feasible ways to control mosquitoes? A Wyoming Toad Task Force, made up of local citizens of diverse backgrounds and viewpoints, was created to consider the issues involved and to develop an alternative to the USEPA proposal that would be more acceptable to all parties.

### Background on the Wyoming Toad

**History.** The Wyoming toad was discovered in 1946 by a University of Wyoming zoology professor, George T. Baxter. Baxter spent 30 yr studying the toad's breeding sites and monitoring its population. The Wyoming toad is a sub-

Pesticide	Chemical Name	Use Restriction Code†
Aldicarb	2-methyl-2-(methylthio)propionaldehyde O-(methylcarbamoyl)oxime	60B
Aluminum Phosphide	Aluminum phosphide (AIP)	60B
Atrazine	6-chloro-N <sup>2</sup> -ethyl-N <sup>4</sup> -isopropyl-1,3,5-triazine-2,4-diamine	60B
Azinphos-methyl	O,O-dimethyl S-[(4-oxo-1,2,3-benzotriazin-3(4H)-yl)methyl] phosphorodithioate	60B
Benomyl	Methyl 1-(butylcarbamoyl)benzimidazol-2-ylcarbamate	60B
Captan	N-trichloromethylthio-4-cyclohexene-1,2-dicarboximide	60B
Carbaryl	1-naphthyl methylcarbamate	60B
Carbofuran	2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate	60B
Chlorpyrifos	O,O-diethyl O-(3,5,6-trichloro-2-pyridinyl) phosphorothioate	60B
Copper sulfate, Basic	Copper sulfate (CuSO <sub>4</sub> )	60B
Diazinon	O,O-dimethyl O-[6-methyl-2-(1-methylethyl)-4-pyrimidinyl] phosphorothioate	60B
Dimethoate	O,O-dimethyl S-methylcarbamoylmethyl phosphorodithioate	60B
Disulfoton	O,O-diethyl S-[(ethylthio)ethyl] phosphorodithioate	60B
Diuron	N'-(3,4-dichlorophenyl)-N,N-dimethylurea	60B
Endosulfan	6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,3,4-benzo-dioxathiepin 3-oxide	60B
Enquik	1-aminomethanamide dihydrogen tetraoxosulfate	60B
Esfenvalerate	(S)-α-cyano-3-phenoxybenzyl (S)-2-(4-chlorophenyl)-3-methylbutyrate	60B
Ethion	O,O,O',O'-tetraethyl S,S'-methylene bis(phosphorodithioate)	60B
Fenthion	O,O-Dimethyl O-[3-methyl-4(methylthio)phenyl]phosphorothioate	60B
Fluridone	1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-4 (1H)-pyridinone	20C
Fenamiphos	Ethyl 3-methyl-4-(methylthio)phenyl (1-methylethyl)phosphoramidate	60B
Fonofos	O-ethyl S-phenyl ethylphosphonodithioate	60B
Malathion	Diethyl (dimethoxythiophosphorylthio)succinate	60B
Mancozeb	Zinc-manganese ethylene bisdithiocarbamate	60B
Methodathion	S-2,3-dihydro-5-methoxy-2-oxo-1,3,4-thiadiazol-3-ylmethyl O,O-dimethyl phosphorodithioate	60B
Methomyl	S-methyl N-[(methylcarbamoyl)oxy]thioacetimidate	60B
Methyl Parathion	O,O-dimethyl O-(4-nitrophenyl)phosphorothioate	60B
Mevinphos	2-carbomethoxy-1 methylvinyl dimethyl phosphate	60B
Naled	1,2-dibromo-2,2-dichloroethyl dimethyl phosphate	60B
Nitrapyrin	2-chloro-6-(trichloromethyl)pyridine	60B
Oxamyl	S-methyl N',N'-dimethyl-N-(methylcarbamoyloxy)-1-thio-oxaminidate	60B
Oxydemeton-Methyl	S-[2-(ethylsulfanyl)ethyl]O,O-dimethyl phosphorothioate	60B
Parathion-ethyl	O,O-diethyl O-(4-nitrophenyl) phosphorothioate	60B
Pendimethalin	N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzeneamine	60B
Permethrin	3-phenoxybenzyl (1RS)-cis, trans-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane-carboxylate	60B
Phorate	O,O-diethyl S-[(ethylthio)methyl] phosphorodithioate	60B
Propachlor	2-chloro-N-isopropylacetanilide	60B
Propargite	2-[4-(1,1-dimethylethyl)phenoxy]cyclohexyl 2-propynyl sulfite	60B
Pyrethrins	Botanical compounds of pyrethrins I and II, cinerins I and II and jasmolins I and II	60B
Terbufos	S-[[[(1,1-dimethylethyl)thio]methyl] O,O-diethyl phosphorodithioate	60B
Thiophanate-Methyl	Dimethyl [(1,2-phenylene)bis-(iminocarbonothioyl)]bis[carbamate]; dimethyl 4,4'-O-phenylenebis[3-thioallophanate]	60B
Trichlorfon	Dimethyl (2,2,2-trichloro-1-hydroxyethyl)phosphonate	60B
Trifluralin	α,α,α-Trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine	60B

† Limitations on pesticide use: 20C Do not apply to water within the species habitat; 60B Do not apply this pesticide within the species habitat.

Exhibit 1. List of USEPA proposed pesticide restrictions for the protection of the Wyoming toad. Excerpted from Review Draft of USEPA Bulletin.

species of the Manitoba toad (*Bufo hemiophrys*), which is found in Saskatchewan, Manitoba, Minnesota, Montana, and North Dakota. The Wyoming toad is a relict; it was isolated from the rest of its species at the end of the last Ice Age and has since lived on the floodplains of the Big and Little Laramie Rivers and lake and pond margins in the Laramie Basin (Baxter et al., 1982).

The Wyoming toad was widespread in the Laramie Basin from the 1950s through the early 1970s, but the population began declining in the mid-1970s and the toads were rarely found by the early 1980s (Baxter et al., 1982). In January of 1984, the Wyoming toad was officially listed as an endangered species. In 1987, a small population of toads (100–150) was found about 19 km (12 mi) southwest of the city of Laramie on the shores of Mortenson Lake. Shortly thereafter, the U.S. Fish and Wildlife Service (FWS) began drafting a recovery plan. Subsequently, the known habitat of the Wyoming toad decreased to a 5 km<sup>2</sup> (2 mi<sup>2</sup>) radius encompassing Mortenson Lake; this habitat area was created by mapping sightings of the Wyoming toad since their discovery in 1987 (U.S. FWS, 1993).

No one is certain of the reasons for the decline in Wyoming toad numbers. Hypotheses included pesticide poisoning, disease, habitat disruption, severe winters, predation, and biological and genetic risks associated with a small, isolated population. No single hypothesis had gained consensus support. Many people expressed concern that the chemical ban was proposed to protect the toad without conclusive evidence that chemicals were, in fact, responsible for the decline in its numbers.

The reduced toad numbers that became evident in the late 1970s coincided with the commencement of aerial spraying of insecticide. However, Baxter, the Wyoming toad expert, felt that the decline could have been due to a “natural phenomenon” (B. Mears, 1993, personal communication). Danny Walker, assistant state archaeologist and author of a monograph about the late-geological history of vertebrate animals in Wyoming, proposed that the decline of the Wyoming toad was due to climatic warming that had occurred in the 10 000 yr since the end of the Pleistocene glaciation (B. Mears, 1993, personal communication).

U.S. ENVIRONMENTAL PROTECTION AGENCY  
 ENDANGERED SPECIES PROTECTION PROGRAM  
 Map of Areas Where Pesticide Use Limitations  
 May Apply To Protect Endangered Species  
 Review Draft  
 December 1992

ALBANY COUNTY, WYOMING

 Shading Key

Wyoming toad, *Bufo hemiophrys baxteri*.

The shaded area shown on the map is:

T20N	R73-74W	
T19N	R73-75W	
T17-18N	R73-76W	
T16N	R78W	Sec. 22-27, 34-36
	R73-77W	
T15N	R78W	Sec. 4-9, 16-21, 28-33
	R73-77W	
T14N	R77W	Sec. 22-27, 34-36
	R74-76W	
T13N	R77W	Sec. 1-3, 10-15
	R76W	Sec. 1-18
	R75W	Sec. 1-18.

The species habitat is within one mile of lakes, ponds, streams, wetlands and riparian habitats, irrigated meadows, and associated water supply systems found within this area.

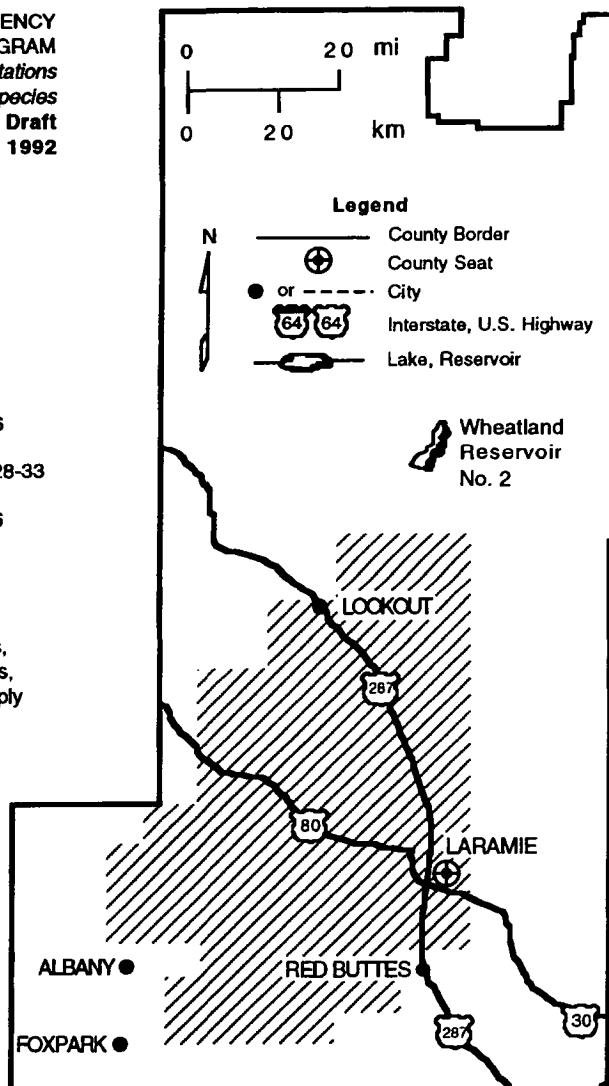


Exhibit 2. Original 1992 USEPA map of areas where pesticides use limitations may apply to protect the Wyoming toad. Excerpted from Review Draft of USEPA Bulletin.

Reduction in numbers of amphibians is a poorly understood global trend. Other amphibian populations in Albany County had also undergone changes in their populations. Leopard frogs (*Rana pipiens*) declined in the Laramie Basin at the same time the Wyoming toad declined. A species closely related to the Wyoming toad, numbers of the boreal toad (*Bufo boreas boreas*) were also reduced during the same time period, even though its habitat was in forested areas that were not sprayed with pesticides. Conversely, numbers of the boreal chorus frog (*Pseudoeacris triseriata maculata*) and tiger salamanders (*Ambystoma tigrinum*) remained abundant throughout the area (Lewis et al., 1985). But it may have been significant that the Wyoming toad and the northern leopard frog spawned at times when they were likely to be exposed to insecticide spraying, whereas the boreal chorus frog and the tiger salamander bred 3 to 4 wk earlier (Withers, 1992).

**The Wyoming Toad Recovery Group.** The Wyoming toad Recovery Group (Recovery Group) was formed in 1987 to coordinate efforts to research, protect, and assist recovery of the Wyoming toad. This group consisted of representatives from the Wyoming Game and Fish Department, the FWS, The Nature Conservancy, and the University of Wyoming. The Recovery Group monitored and took measures to protect the toad population living around Mortenson Lake. They contacted the mosquito control districts to create a coordinated plan so that known populations of the toad would not be adversely affected by chemicals until research

**LARAMIE AREA CHAMBER OF COMMERCE**  
P.O. Box 1166  
800 S. Third Street  
Laramie, Wyoming 82070  
(307) 745-7339

Albany County Commissioners  
Albany County Court House  
Laramie, WY 82070

Dear County Commissioners:

The Board of Directors of the Laramie Area Chamber of Commerce would like to voice their support of your effort to provide Laramie and Albany County with an affordable and effective mosquito spraying process. We believe the effects of limited or no mosquito control would be disastrous for business in Albany County and the City of Laramie.

Many of our business people barely survived the years when the mosquitos were uncomfortably and even dangerously thick in Albany County. The members of our agribusiness community have very realistic concerns about reverting to similar times of little or no mosquito control and the devastating effects on livestock and the difficult work environment created in our agricultural areas.

The outlying recreational areas have brought business to this community and county for numbers of years and we are currently able to track the increase of visitors to this area. The loss of business from the tourist industry will have an impact on all areas of Albany County. Many of the businesses which rely on a healthy summer economy will feel the effects of the uncomfortable visitor or the dissatisfied visitor. The only potential increase will be the sale of insect repellent as the visitor is leaving town, never to return.

The Laramie Area Chamber of Commerce is sympathetic to the plight of the Wyoming Toad and supportive of the search to identify the exact habitats of the toad. We do feel the 900 square miles currently designated as possible toad habitat are not substantiated habitat sites and should not limit the use of effective insect control programs.

We understand the limited budget the Albany County Commissioners currently works with and support your efforts to maintain an insect control program which is safe for the public, workable for agricultural and realistic to conserve necessary habitats for the toad.

Sincerely,

Board of Directors Laramie Area Chamber of Commerce

President - Joseph G. Sestak  
President Elect - Rod Fisher

Exhibit 3. Text of letter received by Albany County commissioners from the board of directors, Laramie Area Chamber of Commerce on 26 July 1993.

**WYOMING CHAPTER SIERRA CLUB**  
**SNOWY RANGE GROUP**  
811 South 7th Street  
Laramie, WY 82070

1209 "W" Hill Rd.  
Laramie, WY. 82070  
April 7, 1993

To: Albany County Commissioners Mayor of Laramie  
EPA  
Wyoming Dept. of Agriculture

There has been a great deal of discussion lately concerning the EPA's proposed ban on a number of pesticides used to kill mosquitoes. This issues has raised several questions, not all of which pertain to the Wyoming Toad. For instance:

- What criteria did the EPA consider in defining the pesticide restriction area?
- How is the former range of the Wyoming Toad defined?
- Will the elimination of certain pesticides benefit humans and other wildlife?
- What is the cost of employing growth regulators and biologicals instead of Baytex and malathion? How effective are these alternatives?
- Do certain practices, such as flood irrigation along the Laramie River, exacerbate the mosquito problem? If so, what can the residents of Albany County do to resolve this situation?

While the Snowy Range Group (SRG) supports the preservation and recovery of the Wyoming Toad, it appears that the presence of this endangered species plays only a minor part in this issue. Indeed, there may be many reasons not to use broad spectrum insecticides in Laramie and the surrounding area. Before anyone can offer solutions, several questions, such as the ones noted above, need to be addressed.

As a result, the SRG suggests that a committee be formed that would examine the many facets of this issue. This committee should have a representative from each of the following groups: EPA, City Council and/or County Commission, an expert in this area from the UW Agricultural Department (for Instance, Mike Brewer, Ast. Professor of Plant, Soil, and Insect Sciences), the ranching community, and the environmental community. This committee would hopefully arrive at a mutually agreeable solution to present to the residents of Albany County for public consideration.

We do not believe that the EPA's proposed ban is a "spray-don't spray" situation. The formation of this committee and the further examination of this problem will, at the very least, better define the issues and may, at the very most, devise a solution acceptable to most of the area's residents.

Thanks for your time and consideration. If you wish to discuss this issue further, please do not hesitate to call me (742-5383).

Sincerely,

Mike Massie  
Chairman

Exhibit 4. Text of letter received by Albany County commissioners from Snowy Range Group, Wyoming Chapter Sierra Club on 7 Apr. 1993.

could be conducted concerning the causes of their decline. The Recovery Group also hoped to establish reproducing populations of approximately 100 adults each at four other locations. Captive rearing programs were initiated to this end. Their official target was to "remove the Wyoming toad from the Endangered Species list by 2005" (U.S. FWS, 1993).

A major function of the Recovery Group was to establish protocol for searching possible toad habitats and to organize these searches. Most of the Wyoming toad's former habitat was on private lands; therefore, the establishment of good relations with the landowners was critical. The landowners were not legally obligated to let people onto their land to conduct searches or for other recovery activities. Under the Endangered Species Act, the only obligation of a landowner was to avoid the "taking (harass, harm, kill, capture, or collect) of a listed species." Ranchers were assured by the governmental agencies that if they cooperated, their privacy would be maintained and the extent of management activities on their property would be at their discretion.

Other efforts were made by members of the group. For instance, the FWS purchased most of the land around Mortenson Lake where the toad was found. The Nature Conservancy contacted a landowner whose property was adjacent to the lake to establish an easement on the land. Two captive-rearing programs were established—one at the Wyoming Game and Fish Department's Sybille Wildlife Research Unit and the other at the Cheyenne Mountain Zoo in Colorado Springs. Unfortunately, even with these efforts, the population of toads continued to decline. In the early 1990s the toad population at Mortenson Lake was threatened by poor breeding, predation, and a stress related bacterial disease known as *redleg* (Withers, 1992).

### Background on Chemicals

**Spraying History.** Aerial spraying for mosquito control began in the Laramie Basin in 1976. The first chemical used for mosquito control was Baytex (fenthion), an organophosphate insecticide. Fenthion is a member of a group of pesticides that act as cholinesterase inhibitors within the nervous system. It is moderately toxic to mammals and highly toxic to birds. The decline in toad numbers coincided with the application of this insecticide, so it was believed that fenthion may have been responsible for the marked decline in toad numbers. The toad population found in 1980 was immediately adjacent to a ranch that had not permitted spraying for mosquitoes. Two juveniles, the only toads found in 1983, were found outside the mosquito control area. However, research conducted at the University of Wyoming did not show immediate effects on the health of two closely related amphibians (*Rana pipiens* and *Bufo boreas*) at the levels of expected field concentrations. Mortality and reproduction were affected at higher dosages (Lewis et al., 1985). The researcher did suggest that further work was needed before dismissing fenthion as a factor in the toad decline, since other studies had shown that sublethal doses of fenthion could lower thermal tolerance in related amphibian species (Lewis et al., 1985).

Baytex was removed from the market in the mid-1980s by its manufacturer. After depleting its supplies of Baytex,

the City of Laramie Department of Public Health began to spray with malathion, another organophosphate insecticide. Malathion is also a cholinesterase inhibitor, but is much less toxic to mammals than fenthion. Some insects possess an enzyme that converts malathion to another cholinesterase inhibitor, malaxonon, which is 40 times more powerful. Malathion is known to be highly toxic to amphibian populations (Rosenbaum et al., 1988). It is a fairly inexpensive insecticide that provides control of adult mosquitoes. It is used in many states for insect control and is frequently sprayed on food crops. Although it is considered to be one of the safest organophosphate insecticides, its use is controversial, and the possibility exists that use of malathion could be restricted or banned in the future.

Biological larvicides provide an alternative to organophosphate insecticides for mosquito control. These agents were more expensive than malathion. The bacterium *Bacillus thuringiensis* subsp. *israelensis* (BTI) is the basis for a biological insecticide that attacks mosquito larvae. The larvicide was available from several manufacturers in various formulations, for instance, VectoBac from Abbott Laboratories and Altosid from American Cyanamid. Formulations applied as sprays, such as VectoBac, required repeated applications for good mosquito control. Altosid was available in a 30-d (wet days) briquette. The mosquito season in the Laramie Basin is relatively short and dry, so one application of Altosid per year would usually be sufficient. *Bacillus thuringiensis* subsp. *israelensis* was viewed as a more ecologically sound alternative for mosquito control, and therefore was favored by those interested in protecting the Wyoming toad. According to Laramie's director of environmental health, BTI was the city's "first line of defense" against mosquitoes (Pelkey, 1993a). However, BTI was not always entirely effective, because late-season rains provided unexpected breeding opportunities for mosquitoes. If mosquitoes were not controlled in their larval stage, the city would spray malathion to kill the insects after they hatched (Pelkey, 1993a).

**Cost of Control.** The cost of controlling the mosquitoes varied with the agent used. In the early 1990s the cost of malathion varied from \$2.86 to \$5.59 ha<sup>-1</sup> (\$1.16–\$1.86 acre<sup>-1</sup>) depending on the density of mosquitoes. The city of Laramie was given a bulk discount on liquid VectoBac, reducing its cost to between \$1.56 and \$6.18 ha<sup>-1</sup> (\$0.63 and \$2.50 acre<sup>-1</sup>) (S. Whitman, 1996, personal communication). It was recommended that the VectoBac application be repeated 7 to 14 d after the first application (D. Watson, 1996, personal communication). The cost of aerial application of either malathion or VectoBac was approximately \$1.73 ha<sup>-1</sup> (\$0.70 acre<sup>-1</sup>). Application could also be made from the ground using boom sprayers. The cost of Altosid briquettes was \$860 ha<sup>-1</sup> (\$348 acre<sup>-1</sup>), excluding cost of application (each briquette covered 9.29 m<sup>2</sup> [100 ft<sup>2</sup>]). Application costs for Altosid were variable, depending on price of hand labor. This form of control was good for the entire season (D. Watson, 1996, personal communication).

The City of Laramie sprayed approximately 6900 ha (17 000 acres) each year for mosquito control. This included 4900 ha (12 000 acres) of ranch land. Two other mosquito control districts in Albany county also sprayed large areas.



## The Wyoming Toad Task Force

**The Players.** The widespread controversy surrounding the 1992 USEPA proposed pesticide ban prompted the Albany County Commissioners and Wyoming's governor, Mike Sullivan, to officially appoint the Wyoming Toad Task Force (Task Force). General consensus was that a local-level committee could define a more balanced and manageable plan than that proposed by the USEPA (Wyoming Toad Task Force, 1993, personal communication). The Task Force was composed of ranchers; state, local, and federal officials; conservationists; and biologists. The USEPA had requested comments on its proposal by 15 May 1993, but subsequently granted extensions to November 1993, to allow time for the Task Force to research an alternative proposal.

When asked about his experience on the Task Force, State Representative Mike Massie responded, "The group hewed strictly to the middle of the debate, drawing fire from both extremes." Rancher Margaret Page, when asked about her involvement, said, "I think we mainly went to protect our interests, and I think the rest of them were fair about that and saw our point of view" (Tollefson, 1995a). However, not everyone on the task force was happy with it. Harrison Talbott, a rancher whose property adjoined a ranch where toads were found, thought the money and effort just weren't worth the results. Talbott said that if he had it to do over again, "I think before we set up a task force, we'd set up a lawsuit" (Tollefson, 1995a), referring to the fact that lawyers had pledged their help, some even freely, in fighting implementation of any spraying restrictions.

### The Decision

In November 1993, the Task Force had to submit a plan to Governor Sullivan (USEPA, 1993, personal communication). Upon receipt, the governor was to review the plan and forward it to the FWS where it would be approved or denied. The USEPA would then act on the FWS recommendation. The newly formed Task Force had two goals: (i) protect the endangered Wyoming toad, and (ii) maintain mosquito control. "We want to increase the areas of existence of the toad and still allow the city and the county to have effective mosquito control," said Lou Shilt, Albany County commissioner and chair of the Task Force (Williams, 1993).

Public opposition to restricting use of malathion, beyond the normal restrictions listed on the label, was evident. Rancher and Task Force member Margaret Page believed a number of landowners in the county were afraid of what would happen if toads were actually found on their land. "Ranchers are afraid they are going to be hurt if toads are discovered on their land," said Page (Williams, 1993). Task Force member Bill Gentle, deputy commissioner for the Wyoming Agriculture Department, thought the USEPA would agree with any consensus from the Task Force. "I really believe that if this group comes to a consensus, the EPA will accept our recommendations," said Gentle (Williams, 1993). However, there was never any question that the USEPA would restrict pesticide use in toad habitat areas. To be effective, the Task Force's plan needed to meet the criteria of the USEPA and at the same time be accepted as a reasonable solution by the Albany County citizens.

What recommendations should the Task Force make in their plan?

### CASE EXHIBITS<sup>2</sup>

Exhibit 1. List of pesticides proposed to be banned by USEPA; excerpted from Review Draft of USEPA Bulletin. *Included with this abridged case as Exhibit 1.*

Exhibit 2. 1992 USEPA map of areas where pesticides use limitations may apply to protect the Wyoming toad; excerpted from Review Draft of USEPA Bulletin. *Included with this abridged case as Exhibit 2.*

Exhibit 3. 21 July 1993 letter to Toad/Mosquito Study Group (WTTF), Albany County Courthouse, from Kay Willis, chair, board of directors, Wyoming Territorial Park, urging maintenance of the present mosquito abatement program.

Exhibit 4. 26 July 1993 letter to Albany County commissioners from board of directors, Laramie Area Chamber of Commerce, expressing concern over possible elimination of the Albany County mosquito spraying program. *Included with this abridged case as Exhibit 3.*

Exhibit 5. 27 July 1993 letter to Albany County Commissioners from Carol Waller, Chairman, Albany County Tourism Board, supporting continuation of the current mosquito spraying policy.

Exhibit 6. 10 May 1993 letter to Don Rolston, director, Wyoming Department of Agriculture from Richard Anderson, chair, board of directors, Albany County Weed and Pest Control District, objecting to the USEPA's map and list of pesticides proposed to be banned.

Exhibit 7. 7 April 1993 letter to Albany County Commissioners from Mike Massie, chair, Snowy Range Group, Wyoming Chapter Sierra Club, suggesting formation of a committee to examine the possible broader impact of the current pesticide use and possible alternative solutions. *Included with this abridged case as Exhibit 4.*

Exhibit 8. Draft protocol for searching for Wyoming toads and for declaring an area clear. Prepared by the Wyoming Toad Recovery Group, Laramie, WY.

Exhibit 9. Wyoming Toad Landowner's Fact Sheet. Prepared by Ecological Services of the FWS, Cheyenne, WY.

Exhibit 10. Specimen pesticide label for Malathion 57EC. Platte Chemical Company, Fremont, NE.

Exhibit 11. Specimen pesticide label for Vectobac 12AS, a biological larvicide manufactured by Abbot Laboratories, Chicago, IL.

### TEACHING NOTE

#### Case Objectives

Upon completing this case, students should have:

1. A better understanding of the complexities of saving an endangered species.
2. A better understanding of how people of opposing viewpoints can work together for a common good.

<sup>2</sup> This list shows all exhibits included in the complete case. In this abridged case, only Exhibits 1, 2, 4, and 7 are provided in their entirety.

3. A better understanding of pest management issues and how they affect agriculture and the larger society.
4. A better understanding of how governmental regulation is involved in saving an endangered species.

### Use of the Case

This case was developed by undergraduate students at the University of Wyoming in conjunction with a term project for a capstone course in agroecology. The case may be suited to introductory courses in agroecology, biology, ecology, insect pest management, range management, or agricultural economics. Students also gain an appreciation for the need for communication and cooperation between agricultural and nonagricultural sectors of society.

The following is an approach that could be used for teaching this case:

- Students are assigned the case before it is to be discussed in class and asked to review the case.
- Study questions, additional research topics, or outside readings may also be assigned to help prepare students for in-class discussion of the case. Specific roles could be assigned to individual class members or small groups if the instructor prefers to explore the case in a role-playing manner.
- Students may benefit from meeting together in small groups (three to five students per group) before the in-class discussion of the case, work out their roles, or answer any assigned questions.
- During the class period when the case is discussed, the instructor can begin by assigning an introductory question for small group discussion. Alternatively, assigned roles can be played out in a mock town meeting during the class and students could be assigned follow-up questions.
- If a discussion format is being used, large group discussion can be initiated once the small group discussions have gained momentum. Discussion of the case might focus on question such as no. 1 through 4 below.
- Discussion could be concluded by constructing, with the help of the students, a list of decision options and possibly seeking a consensus decision from the class.

### Discussion Questions and Issues in the Case

**1. Why were the chemical ban and attempts to save the Wyoming toad so controversial?** This question brings to the forefront the main issues involved in the case and aids in defining the problem. Discussion of this question could profitably go in any of several directions. The students could consider economic aspects of the decision: If malathion could not be used in populated areas and the spray district could not use BTI for some reason, tourists might not be happy with the increased numbers of mosquitoes and local businesses would suffer. Was replacing malathion with BTI economically feasible for the spraying districts and the state? Ranchers felt they needed to control mosquitoes to protect their investment in livestock and to prevent the possible spread of disease.

Students could also focus on the question of why the Wyoming toad should be saved. Putting themselves in the governor's or a Task Force member's shoes, would they suggest continuing or terminating the recovery effort? The

students could be encouraged to come up with a list of questions concerning the validity of the recovery, such as: Was the Wyoming Toad really vital to the ecosystem? What would we potentially lose if this subspecies becomes extinct? The health of amphibian populations is increasingly used by scientists as a measure of the overall health of an ecosystem because of their sensitivity to the presence of toxins in watersheds. The toad might bring ecosystem problems to light before the human environment is directly affected. Could what is affecting them be affecting us?

Some antagonists of the recovery efforts appeared to be angered because they were told they could not spray because of a "little toad." Others probably felt threatened either by governmental restrictions or their fear of the mosquitoes becoming a bigger problem in and around Albany County. Ranchers had to voluntarily allow searches for the toad to occur on their land. They could opt not to allow the searches, but that would have consequences for all the neighboring ranches.

**2. What is the most effective way to control mosquitoes and preserve toad habitat in the Laramie Basin?** From a purely economic viewpoint, malathion provides the most economical means of control. However, malathion may have had some effect on the Wyoming toad. From a safety perspective, it may have been better to use BTI to control the mosquitoes, since it is not toxic to amphibians. The 30-d BTI briquettes were quite suitable for mosquito control in Laramie, with its short, relatively dry mosquito season, but they are considerably more expensive than malathion. Using BTI spray products also provides good mosquito control, but they require repeated applications to be effective. In terms of public relations, using BTI would be a much better solution than applying malathion.

**3. Even if pesticide applications were not proven to be toxic to the Wyoming toad, could they still have contributed to the toad's demise?** This question should lead students to consider possible indirect effects of pesticide application on the Wyoming toad. In this case, the applied pesticides were known to be toxic to aquatic and/or terrestrial stages of various insects, thus destroying or diminishing the food supply of the toad. This, in turn, may have contributed to the observed decline in population of the Wyoming toad.

**4. What recommendations should the Task Force make in their plan?** The instructor may decide not to address this question directly during the class discussion or, alternately, might ask the group to reach consensus and detail their recommendations. The question could also be assigned as a written exercise to be handed in at a later date.

Students should recognize that the USEPA and FWS needed to approve all parts of any plan the Task Force proposed, and that to be effective the plan must be accepted by the public.

The USEPA's proposal involved banning 43 pesticides in a 2513 km<sup>2</sup> (970 mi<sup>2</sup>) area. Students could be encouraged to carefully examine the USEPA map and consider whether or not it accurately depicted the toad's potential habitat. If not, what might be done to devise a more representative map?

The Wyoming Toad Recovery Group was involved in establishing protocol for searching possible toad habitats

and to organize these searches. Should such searches be incorporated in the Task Force's plan? How might they be used? Including details such as the search protocols in the Task Force's plan might help them gain the support of the local residents and reduce potential mosquito control costs by allowing them to spray cheaper—but potentially more dangerous insecticides—in areas that could be shown not to be inhabited by the Wyoming toad.

The reasons behind the USEPA's ban should also be explored. The USEPA approached this endangered species issue from a pesticide safety perspective because they had the responsibility and the authority to do so. Obviously, the proposed ban was issued to protect the Wyoming toad. However, it may be worth considering whether the decline of the Wyoming toad resulted in part from the USEPA's delay in initiating a ban? The USEPA held significant power over the local residents by having the final say in regulating pesticide applications. On the other hand, to adequately ensure the safety of the Wyoming toad, the government agencies needed access to private lands. The Task Force's plan must somehow provide a compromise in this very complex case.

**Epilog: What happened to the recovery projects and the Wyoming Toad Task Force?** The instructor may choose not to reveal this information to the students. However, some students may be curious about the outcome of the case and this information could be shared with the students after they have completed the case.

The first major component of the Task Force plan involved developing a more suitable principal habitat map than was provided by the USEPA. The USEPA map had delimited 2513 km<sup>2</sup> (970 mi<sup>2</sup>) of area (Exhibit 2), but much of this area was arid rangeland unsuitable for toad habitat. The new map was expected to more clearly identify wetlands or areas containing open water that would be suitable habitat for the toad. This map was constructed at the University of Wyoming using geographic information system (GIS) technology. The map was based on aerial photos taken in 1984, a record wet year. As a result, the map displays the maximum potential habitat area for the Wyoming toad. The newly created map reduced potential toad habitat to approximately 648 km<sup>2</sup> (250 mi<sup>2</sup>). Before the map could be used as a basis for field searches, both the FWS and the USEPA had to approve it (Wyoming Toad Task Force, 1993, personal communication). The Task Force recommended that use of the 43 pesticides on the USEPA's list not be restricted in areas too arid for toad habitat.

The second part of the committee's plan involved coordinating controlled searches of potential toad habitat as identified on the Task Force's new map. The Task Force anticipated that searching the entire potential toad habitat would require two summers (1994 and 1995). They planned to contract with a biological consultant to conduct the searches. The consultant as well as the methodology of the searching techniques would be approved by the FWS. The searching techniques proposed were those already in use by the Recovery Group.

The searches would be coordinated with the Task Force, FWS, city and county governments, and private landowners. The Recovery Group had already searched and *cleared* some areas of potential toad habitat before the formation of

the Task Force. The Recovery Group had not found any toads outside the Mortenson Lake area (Wyoming Toad Task Force, 1993, personal communication). The committee recommended that when a potential habitat area was searched two times and found to be free of toads, according to FWS protocol, then the area should be designated as cleared. Once an area was cleared, pesticide use could resume. The only applicable restrictions would be those on the pesticide's label. If a Wyoming toad were discovered during a search, its presence would be immediately reported to the FWS, and pesticide restrictions would remain in effect.

The third part of the plan involved detailing specific protected buffer zones for each of the 43 pesticides in potential habitat areas (Exhibit 13). The USEPA had originally recommended buffer zones of 1.6 km (1 mi) for all 43 banned pesticides. Some of these pesticides were not used in Albany County. Those that were used were considered individually with regard to the method and location of application and their potential impact on the Wyoming toad. On the basis of expert opinion from a subcommittee of the Task Force, modified buffer zones were recommended for some of these pesticides.

The Task Force felt their proposal would protect the Wyoming toad, would involve intensive searching in potential habitat area, would aid in recovery efforts, would allow reasonable and safe pesticide applications, and would be an acceptable solution to Albany County residents.

Following is a timeline detailing what happened to the recovery projects as of May 1996:

- April 1994—The USEPA accepted the Task Force's Plan.
- May 1994—Wyoming toad eggs were laid in captivity for the first time. Most died, confirming the difficulty of breeding the toad in captivity.
- July 1994—A dispute nearly scuttled the program. Three days before spraying was due to begin, the two federal agencies informed the task force that spraying could not take place, contrary to prior agreements, because the searches had not been completed.
- September 1994—Searches found no toads and a large portion of area in question was cleared for pesticide use.
- November 1994—The Cincinnati Zoo joined with other zoos in Oklahoma, Colorado, and Texas to begin breeding efforts to save the Wyoming Toad.
- May 1995—Searches resumed and eventually all areas were cleared for pesticide use. No toads were ever found outside of Mortenson Lake and Lake George, Wyoming.
- September 1995—The Wyoming Toad Task Force was disbanded, although several members continued to work with the toad recovery program.

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# The Falke Farm: A Decision Case in Rural Land Use Management<sup>1</sup>

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## ABSTRACT

Rural land use decisions have become increasingly scrutinized as policy makers at federal, state, and local levels seek to diminish pollution of air and water. This case describes the dilemma of one farm family within the Minnesota River Basin as it encountered local resistance to a planned expansion of its confinement swine production capacity in 1995. It considers various arguments against the expansion, as well as the family's rationale for continuing to pursue it. The case provides a vehicle for discussion of a wide array of contemporary agricultural issues related to rural land use and environmental decision making. It also highlights changing perceptions of acceptable land use in rural areas as well as the continuing debate over the structure and size that agricultural enterprises should have. The case was developed primarily for adult extension audiences, but it can be adapted to the university or secondary education classroom.

IN 1989, several federal, state, and local agencies in Minnesota began a comprehensive appraisal of the Minnesota River Basin to evaluate its water chemistry, biological communities, and land uses (MPCA, 1994). The study concluded that the Minnesota River, which drains a watershed within which 92% of the area is dedicated to agricultural activity, was "one of the state's most highly polluted waters." Common sources of pollution included storm sewer discharge, septic tank discharge, and runoff from agricultural fields and feedlots. The principal pollutants of concern in the river were bacteria, sediments, nutrients, and "oxygen demanding substances" (MPCA, 1994). Raw manure and feedlot runoff contribute each of these types of pollutants.

Feedlots have caused additional concerns and debate within the Minnesota Basin as residents argued against the establishment of "factory farms" producing objectionable odors and lowering landscape aesthetic qualities near their homes. These people are often concerned that the value of their homes and properties would be reduced as a consequence.

Research in Michigan found that characterization of livestock odor as a problem was positively associated with high frequency and duration of exposure as well as low public perception of a facility's appearance (Lohr, 1996). Also endemic to the debate about feedlots was disagreement

about what size livestock production systems should be. Proponents of large confinement livestock production facilities argued that such operations were inherently more efficient than smaller operations. They also contended that non-point source pollution could be better monitored and controlled when production systems were concentrated geographically across a watershed. This question of feedlot size fostered further debate over who, if anyone, should regulate the size and location of livestock facilities—local, state, or federal governments.

There is a lot at stake in the debate over the structure and control of livestock production systems in the USA. This case provides a basis for discussing this issue within the context of current consideration of the need for landscape and ecosystem-based management to reduce pollution of water and air.

## THE CASE

### Emotions Run High

The Falke's are predators when it comes to livestock!  
The flag of the Falkes should be the dollar bill, not the American flag!

Kari Falke and her husband Kurt were both exhausted after the County Commissioners Board Meeting. Angry comments made against them, such as those above, had been emotionally draining. The Falkes were planning to build a hog finishing facility on land they owned about 13 km (8 mi) east of the small southern Minnesota town where they lived and farmed. The conditional use permit they needed to begin work on the site had been approved at the commissioner's meeting, but only after a highly charged hearing where some neighbors voiced strong opposition. Still, fall was approaching and the Falkes were eager to begin construction before winter.

In the larger scheme of things, Kari knew that the neighbors and others opposed to their expansion could not stop the project indefinitely, although they would continue to try. As long as the Falkes followed the permitting process to the letter, the project could go forward. But Kurt and Kari did have to shop at the store, attend church, and work with some of these same people who opposed the finishing operation. Even if their comments were not effective at halting the project, the words still hurt. At the hearing, a neighbor who lived near the proposed site had jumped to his feet and shouted:

These five buildings Falke is asking for now will become 10 and then 20. He is only 100 ft (30 m) away from a drainage ditch. Why isn't he building on his own home farm? He says it is because he doesn't want to have to haul manure, but he is going to have to haul feed to the feedlot. What's the difference?

<sup>1</sup> Persons who intend to use this case for classroom or extension purposes should request a copy of the case (EP-6679) and full Teaching Note from the Educational Development System of the Minnesota Extension Service, Univ. of Minnesota, 405 Coffey Hall, St. Paul, MN 55108-6068 (Phone: 612-625-8173). Names in this case have been disguised.

Department of Agronomy and Plant Genetics, 411 Borlaug Hall, 1991 Upper Buford Circle, Univ. of Minnesota, St. Paul, MN 55108-6026 and Minnesota Extension Service, Minnesota Agric. Exp. Stn. Journal Series no. 961130004. Received 9 Dec. 1996. \*Corresponding author (ssimmons@maroon.tc.umn.edu).

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**Abbreviations:** MPCA, Minnesota Pollution Control Agency; EAW, Environmental Assessment Worksheet; EIS, Environmental Impact Statement.

The Falke's proposal included five finishing buildings with a capacity for 960 head in each. The population of the buildings was expected to turn over 2.5 times per year totaling 12 000 animals. The hogs were to be brought in young and grown to market weight. The Falkes planned to use the services of an integrator who would actually own the animals. Integrators typically provided the animals to the finisher and sold them when grown, giving the finisher a guaranteed fee for raising the hogs. One of the Falke's goals was to own their own animals someday.

### How Big is Too Big?

Several people were upset by the size of the operation. Kari remembered the statements made at the hearing:

Do we really need more pork? It just lowers the price so exporters can export more. It is a low paying, hazardous industry. I have lung problems just from working in my own barn. We also have to ask ourselves if we really want more large, corporate farms vs. small, independent farms.

Another resident of the township also spoke up:

There are more important issues here than economic development. These mammoth facilities are putting small farmers out of business. Plus, small farmers buy locally. I don't know that Falke would do this.

Yet another resident said:

It's not where we raise the food that's the problem, it's how we raise the food.

Even some fellow hog farmers had opposed the expansion, implying that the Falke's operation would drive them out of business:

There are 18 hog farmers in [our] township. They average about 1000 hogs per site per year. The Falke's site can produce 14 000 to 18 000 hogs per year. It will double the hog production of the township.

Kari thought back to their rationale when they decided to expand their hog operation. She and Kurt had four children and wanted to use the income from the facility to help put them through college in a few years. This operation was also intended to provide Kurt and Kari's retirement income. It was difficult in today's economy to be successful, full-time farmers, and Kari was proud of their success. She wanted to be able to work full time on the farm and the expansion would permit her to do that since she was to be the principal manager for the new facility. Kurt's main job would remain with their 1500 head beef cattle and 1215 ha (3000 acre) corn-soybean [*Zea mays* L.–*Glycine max* (L.) Merr.] operations, which he operated in partnership with other family members.

### Too Much Manure?

At the hearing, some people expressed concern about the amount of manure projected to be produced by the Falke's operation and whether it could be handled effectively. One person addressed the issue at length:

Eleven parcels have committed to accepting manure from the proposed site. Only two of the owners actually

live on the land. Falke's agreement with these owners states, 'this agreement is good until canceled.' He could get canceled at any time. Then what does he do with that manure?

He pointed out that people might cancel due to a number of reasons including pressure from their neighbors, a realization that they didn't know what they were doing when they signed, and concern about increased compaction on their fields that might result from manure-spreading operations. He went on to propose what would happen if the Falkes lost some of their manure contracts:

Falke is paying \$5 per load and bidding wars will occur when people cancel. Their options will be to buy or rent more land to spread manure. He can buy mine for \$10 000/acre (\$4050/ha), just what any other corporation, like a shopping mall, would pay to come in there. The agreement should be for the life of the feedlot and should attach a 30-yr easement to the abstract of the properties in question.

Later in the hearing, Kurt addressed this issue:

The spreading agreements I have with the 11 parcels are worded according to what is required by the county and the MPCA (Minnesota Pollution Control Agency). Land in [this] county doesn't turn over rapidly. I think these owners will be around for a while.

Kurt continued:

Also, crop farmers want the manure as a way to lower their [fertilizer] cost and increase profits. The fertilizer value of the manure is worth twice what the spreading cost of the manure is.

Kari felt that they were well prepared for the amount of manure the proposed site would generate. Each of the five proposed finishing barns would have a concrete manure pit that had the capacity to hold 13 mo worth of manure. The contracts with nearby farmers allowed them to spread manure on 429 ha (1060 acres) (A plot map of the proposed facility site and contracted manure spreading sites is not shown but is available from the Minnesota Extension Service), twice the 214 ha (529 acres) needed for the amount of manure they were projected to produce. The soils of the area were mostly clay loam with good infiltration properties. More than 90% of the farmland in the area of the Falke's proposed site was drained by subsurface tiles.

### Not in My Backyard!

The site under consideration hadn't even been the Falke's first choice, a fact that Kari thought showed they had gone out of their way to accommodate their neighbors' concerns. The first site chosen was not prime farmland, not near running water, and had paved roads on two sides. Also, it was located on a hill with vegetation that could serve as a visual buffer.

After they filed for their permit with the MPCA, Kurt and Kari met with the neighbors. The neighbors strongly objected to the use of this original site because it was too close to other houses and odor would be a problem. Also, they expressed concern over the effects of the feedlot on the water quality of a nearby marsh. Because of these concerns,

Kari and Kurt pulled the application and selected a second site 1 mi (1.6 km) farther east. The Falke's neighbors said they would not object to the alternative site. However, some of the neighbors subsequently filed for an Environmental Assessment Worksheet (EAW) (Exhibit 1) on the second site. An EAW would investigate the potential impact the site could have on the environment, including water quality.

Located within the Minnesota River Basin, the site and the contracted land on which manure would be spread were within the watersheds of two different rivers and a small lake. Kari felt there was nothing negative about the second site with respect to its effect on water quality. Water from the marsh near the first site didn't flow near the new location. Furthermore, the MPCA, the Department of Natural Resources (DNR), naturalists, and others all looked at the second site and found it wasn't necessary to conduct an EAW.

Although the second site was still accessible to good manure spreading land, it had been their second choice for several reasons. It was classed as prime farmland and would have to be taken out of production, and it didn't have the paved road access. Only gravel roads served the second location and they would require maintenance and construction to accommodate extensive truck traffic. One township board member at the county hearing said:

We shouldn't expect taxpayers to foot the bill on the road to this site. It costs \$600 to \$700 per mile (\$373-\$435/km) for gravel and blading to maintain and improve that road. Just building this site is going to destroy that road.

An Environmental Assessment Worksheet (EAW) is a questionnaire used to help a local government or state agency decide if a proposed project has the "potential for significant environmental effects." The EAW is used to determine if an Environmental Impact Statement (EIS) must be prepared.

The EIS is part of the formal process established by the Minnesota Environmental Policy Act of 1973 for reviewing environmental impacts of major development projects such as airports, animal feedlots, commercial or residential developments, hazardous waste facilities, highway projects, marinas, sewage systems, and solid waste facilities. Examples of environmental impacts are water quality, air quality, effects on wildlife or wildlife habitat, ecologically sensitive areas, park lands, historic sites, increased noise levels, and odors.

Some projects, based on their size and location, are automatically required to have an EAW and EIS completed. Others may have an EAW requested by citizen petition. The petition requires the signatures and mailing addresses of at least 25 people and "material evidence" showing that the nature or location of the proposed project has potential for significant environmental effects. The petition process is not a means for resolving a disagreement about whether a project should be built but can delay construction on a project for several months.

The governmental unit that has responsibility for the approval or disapproval of the project is responsible for making case-by-case decisions on the need for an EIS or EAW. The request for environmental review is approved only when the governmental unit determines that there may be the potential for significant environmental effects.

Exhibit 1. Description of the Environmental Assessment Worksheet.

Kurt had several ideas for handling manure that could help reduce the amount of wear and tear on the road. Also, he had offered to pay a \$2500 bond to the township for current and future road improvements. The township felt this wouldn't be enough and asked that he pay an additional amount to cover road maintenance. Kurt reminded the board at the hearing that the road is public and used by others. A County Commissioner said:

How would the township's rules apply to other farmers? You can't treat one road user different from another. Is it a public road or not? If I have to pay to maintain it, do I have special privileges on it?

In the long-run, Kurt and Kari felt the township and the county would benefit financially from their operation. They would hire a full-time employee to help with the operation and would also provide business for the local veterinarian and feed companies. They also felt they were producing a local value-added product (pork) and a market for the corn and soybean farmers in their area. At the hearing another hog farmer had come to the Falke's defense stating:

The Falke's buildings will bring in \$1504 to the county, \$364 to the township, and \$2230 to the school district in taxes each year.

### Who Regulates the Air?

The most emotional comments at the hearing came from people who talked about the odor that they feared would be generated from the proposed site.

One man said:

The people who live next to this site need to breathe! This feedlot will take away their lifestyle. They will have to move because of the odor.

Another woman jumped to her feet and declared:

I live 600 feet (182 m) from a feedlot and the odor is there! Big operations don't smell like small ones. I've lived next to a small hog farmer and never smelled anything. The residents of the township were here first and have the right to determine use of the land!

A local activist pitched in:

Who regulates the air? MPCA does not look at air quality issues. It is the county's responsibility to ensure air quality for its citizens.

In reality, the Falke's operation would be located almost six times farther from the nearest neighbor than the 500 feet (152 m) required by the county feedlot ordinance. "How far is far enough?" Kurt had asked at the hearing.

Kari thought:

We're building in A-1 Prime Ag Land. Where else would you put a feedlot like this? Our current operation gets phone calls whenever it smells in town, whether it's blowing from our direction or not. When Kurt was growing up this was unheard of. Fewer and fewer farms are out there.... The airport is in Richfield. If you move to Richfield, you can't ask them to move the airport because you don't like it. The airport is there. It's the same with prime ag land. This is the place where food is raised.

Total livestock numbers in the township had been in a steady decline for decades. A member of the Township Board had commented at the hearing:

A 500-foot (152 m) setback from the next residence is not enough. Ninety percent of the people in the township are against feedlots in general. There are currently no confinement feedlots in the township. The density of the hog population is what concerns people now.

Kari and Kurt were frustrated with the leadership in their township. The Township Board appeared to be giving in to pressure from the neighbors. When Kurt met with the township board in August, they said they needed some time to consider doing their own zoning because the residents wanted it. The township board then passed a moratorium on all new livestock operations with more than 300 animal units. Kari felt that although the township board had tried to disguise the moratorium by adding other restrictions on things like junkyards, it did appear to be aimed at stopping expansion of their operation. Kurt and Kari had filed for a temporary restraining order against the moratorium. Based on the Illegal Access law, which prevented zoning regulations being made against a single individual or operation, they felt the township could be stopped from halting their operation. Now neither the Falkes nor the township could do anything until the situation had been resolved through mediation.

Kurt felt that the trends in raising livestock were moving toward operations of the type and size that they planned. He said:

It seems that livestock operations in the area are struggling to maintain a steady industry, while feedstuff production steadily increases. Does the public want a livestock and diversified family farm industry in the Minnesota River Basin where we can monitor environmental concerns? Or will we 'wash our hands' and have the industry move to areas that are less regulated?

### Is It Worth It?

Kari reflected on what an ordeal it had been trying to get this expansion project approved. She wondered how much more public opposition she and Kurt would face. In making their decision, a County Commissioner had said:

If you remove emotion from this issue, the Falkes meet or exceed all the requirements of the feedlot ordinance.

It was an emotional issue for many people. While she had little doubt that they could go ahead with their plans, Kari wondered if it was really worth the emotional and social costs she and her family were paying in the process.

## TEACHING NOTE

### Case Objectives

Through deliberation of this case, participants will:

- Gain understanding of rural sociological issues surrounding the increasing concentration of livestock production.
- Gain understanding of changing perceptions of acceptable land use in rural areas.
- Gain awareness of the impact that agricultural systems can have on water and air quality.

- Gain understanding of how to reconcile differences among viewpoints and seek constructive solutions to complex problems.

### Uses of the Case

This case was developed for use by extension educators, university, and secondary agriculture and social studies teachers, state agency personnel, policy makers, and others interested in enhancing understanding of rural land use and development issues and watershed management. It can also be used to help students relate to strong sociological forces that influence decision making in agriculture. Discussion of this case can last from 30 to 90 min, depending on the degree of preparation by the participants and the desired extent and depth of the discussion. If desired, the facilitator can include additional information on water quality as well as the Minnesota River to enhance discussion and to create a broader understanding of those topics. Such information is available in the Minnesota River Assessment Report (MCPA, 1994). Also, instructors who wish to use the case as a specific basis for discussion of human values and ethics within agricultural situations may choose to include additional readings that will enable students to prepare. Some examples of readings that might be used include Thompson (1995, 1996).

The case contains no data or information regarding the Falke's economic status that might be needed to specifically evaluate the feasibility or impact of increasing hog production capacity. Nevertheless, an instructor may want to ask students to identify what kinds of information they would need to evaluate the expansion plan from an economic perspective. Similarly, the case does not explicitly indicate the impact of the expanded hog operation on water quality except to suggest that the potential exists for adverse effects. Once again, an instructor may choose to have students describe various situations or scenarios whereby negative impacts of the expansion on water quality could occur.

This case has been used in several train-the-trainer and classroom sessions involving extension, state agency personnel, and undergraduate students. The response to the case by participants in these sessions has been favorable.

### Discussion Questions and Issues in the Case

Below are examples of the kinds of questions the case facilitator might use to stimulate discussion of issues in this case. Participants could choose to discuss some of these questions in groups of two or three and others as a large group. The questions can vary depending on the time limit and the issues intended to be discussed. Other questions, of course, may be added.

**What was the Falke's dilemma?** Kari is especially struggling with peer and public resistance to their plans to build an expanded hog finishing facility. She is uncertain whether she is willing to pay the emotional and social costs necessary to gain the approval to build. She and Kurt feel as though they have gone above and beyond the letter of the law in planning their facility and accommodating their neighbors' concerns—yet they still face opposition. The Falkes would have needed to fight a long and potentially costly battle with the Township Board. Even if the facility



were completed, they would likely still face opposition or resentment in their community. Would it be worth the costs?

**Why were the neighbors opposed to the Falke's proposed operation?** The following are some of the issues that participants might discuss in response to this question:

- Negative public perception of large farming operations—large vs. small farms
- Potential odors
- Increased wear on public roads
- Concern about the large amount of manure to be spread and the longevity of the manure-spreading contracts
- Their opinion that the Falkes did not practice good land or environmental stewardship
- Environmental water and air quality concerns
- A negative opinion of the business arrangement the Falkes would have with an integrator
- Some believed that expanded hog production would put added pressure on other, particularly smaller, hog producers in the area

**What were the Falke's reasons for wanting to build the livestock facility?** The following are several reasons stated in the case for them to build the facility. Discussants may propose other reasons based on their perceptions of the case and its issues.

- Kari's desire to work full-time on the farm
- Kari and Kurt's perceived need to generate income for retirement and a college tuition fund for their children
- A desire to expand and improve on an already successful business

**What would have been the economic effects of increasing the hog production capacity of the Falke farm?** This question might be assigned to small groups with instructions that each group consider it from a different perspective (e.g., the Falkes, other hog producers, the township, local communities, etc.).

**Why was there concern about the manure that the site would produce?**

**Should the Falkes, the neighbors, the county, or the state have been concerned about the effect of the proposed hog operation on the water quality of the nearby streams, lakes, and the Minnesota River?** These questions address the specific link of feedlots to issues of water quality. Although specific data on potential feedlot or manure runoff are not presented in the case, discussants can be asked to list the questions and safeguards that should be in place to ensure a nominal impact of a new feedlot on surface waters.

The MPCA and DNR both examined the site and deemed that an EAW (Exhibit 1) was not necessary. The instructor may want to have students discuss whether the land area under contract to receive manure should have also been examined. Also, this question can lead to discussion about producers' and the general public's attitudes and understanding of watershed systems and issues.

**What is your reaction to Kari's comment that rural landscapes such as the one in which the proposed feedlot was situated are the "place where food is raised"?** This question permits consideration of widely differing percep-

tions of the purpose and use for rural lands. Participants may be prompted to discuss whether feedlots belong in rural areas such as that portrayed in this case.

**How would you have responded to the neighbor's comment that the township residents "have the right to determine the use of the land"?**

**What do you think of the township board's decision to place a moratorium on expansion of large hog feedlots in the township?** These questions prompt consideration of who should have authority to regulate agricultural land use, an especially sensitive issue in contemporary agriculture and land use management.

**What were the Falke's options in this situation?** This question allows participants to discuss the need for communication and information exchange between farmers, non-farmers, and policy makers. It also allows for discussion of how participants view the Falke's options. Some of their options included, but were not limited to:

- Respond to public opinion by discontinuing their plans to expand on the site. This option might compromise Kurt's and Kari's personal sense of fairness.
- Find another location. They might seek a third site, perhaps in another township. This option might have pleased the current neighbors, but the Falkes could have faced new opposition elsewhere. Also, they would lose the time and the money they had spent planning and litigating for the second site.
- Implement a strategy to swing public opinion in the township to favor their cause. The Falkes could have worked to influence public opinion through the local media and personal contact with key people in their community. This option would have required a lot of effort on their part. Also, they might not see this as necessary because they had already complied with all the requirements needed for approval.
- Ignore public opinion and press ahead. This might not have been possible if the township moratorium were upheld.

**What should the Falkes do?** It may or may not be a goal of the case discussion to try to reach consensus regarding a preferred decision. At the time of their decision, Kurt's and Kari's options were limited pending resolution of the court case deciding the legitimacy of the township moratorium. The instructor may wish to consider the Falkes' options if the court did or did not rule in their favor. If the court lifted the moratorium, would the Falkes have been wise to press their advantage? The discussants could consider the costs of such a course of action, including the impacts on the Falkes' standing within the local community.

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# Building Consensus on Timber Harvesting in Minnesota: A Decision Case Study

D. G. MacKay,\* M. A. Kilgore, and P. V. Ellefson

## ABSTRACT

Forest and natural resources policy development is often a contentious process. This decision case presents a dilemma, faced by a natural resources planner in Minnesota, regarding implementation of the recommendations of an environmental impact statement that had broad implications for forestry in the state. A study had been conducted in response to environmental and conservation group concerns about the effects of increased timber harvesting on a variety of resources, such as wildlife and water quality. The study, which cost nearly \$1 million, found that current and increased levels of harvesting would be sustainable, when accompanied by appropriate mitigation strategies. However, the study made few program recommendations on how to implement the mitigation strategies. Therefore, the state needed a process to develop a range of policies and programs to implement the report's findings and recommendations. Through this case, students will gain an understanding of the difficulties that natural resource managers face in balancing technical recommendations with the conflicting preferences of stakeholder groups. The case study also provides an opportunity for students to examine alternate processes to gain stakeholder support for potentially contentious environmental policies and programs.

THE development of forest resource policies and programs is an increasingly complicated and contentious process. Demands for a variety of forest outputs such as recreational opportunities, wood fiber, and environmental services have grown. The finite ability of forests to provide these resources has resulted in conflicts over which resources should be produced, and how they should be produced. At the same time, the public is increasingly demanding a voice in how forested lands, both public and private, are managed. Finally, scientific research has suggested complex relationships between the various forest resources; however, many of the relationships are not yet fully understood nor are they universally accepted. This case illustrates some of the issues and difficulties created by these factors. It does so in the context of a dilemma about how to implement the recommendations of a study of the effects of increased timber harvesting in Minnesota.

## THE CASE

In March 1994, the state of Minnesota was faced with a politically charged issue—how should the findings and recommendations of a 4-yr study on timber harvesting and for-

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<http://www.agronomy.org/journals/jnr/1998.html>

est management in Minnesota be implemented? The development of the study had been driven largely by state law. However, now that the study was complete, its findings and recommendations had no force of law and little political support. Given the high level of contention associated with the formulation of forestry policy, should the wide-ranging recommendations be converted into implemented laws, policies, or incentive programs, and if so, how? The 4-yr process of completing the study had already strained relations among the various groups concerned about Minnesota's forests. Memories of the spotted owl controversy in the Pacific Northwest were fresh—and many were concerned that a similar political gridlock over forestry issues might occur in Minnesota.

Finding a solution to this dilemma was the primary responsibility of one person, Dr. Wanda Carter, who was a planner with Minnesota's environmental policy board, the Minnesota Environmental Quality Board (EQB). However, Dr. Carter was unsure how to proceed. In Minnesota, recently proposed forestry legislation had failed because the various interests, including forest industry and environmental groups, had not been able to garner enough broad-based support to have their bills passed. Wanda Carter knew that it was a critical time for forestry in Minnesota, and a critical time for her career. The Generic Environmental Impact Statement (GEIS) Study on Timber Harvesting and Forest Management in Minnesota was commissioned by the EQB in response to growing concern over environmental impacts associated with expanded timber harvesting activity. The study, which she had administered, had cost nearly \$1 million and was developed from the contributions of 60 researchers—one of the largest environmental efforts in the state in the previous 20 yr. Given the attention the study had received in the media and with many interest groups, expectations for progress were high. She knew that many people would link the outcomes of the study with her managerial and political skills. Further, to implement the study results, she would be moving to a new position in the Minnesota Department of Natural Resources (DNR). Positive study outcomes would likely secure a good start for this phase of her career.

## Context

Forests and timber harvesting were becoming increasingly important issues in Minnesota. Minnesota had nearly 6.7 million ha (16.7 million acres) of forest, approximately 44% of which was privately owned. These private owners included more than 100 000 small private woodlot owners, as well as several large forest industry companies. However, most debate about timber harvesting had occurred over harvesting on public lands, including federal, state, and county lands.

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**Abbreviations:** DNR, Department of Natural Resources; EQB, Environmental Quality Board; GEIS, generic environmental impact statement.

**SIERRA CLUB**  
North Star Chapter

February 1, 1989

Commissioner  
Joseph Alexander  
Department of Natural Resources  
500 Lafayette Rd.  
St. Paul, MN 55155

Dear Commissioner Alexander:

The growing list of wood products firms which have announced plans to locate or expand operations in Minnesota has caught our attention and has generated a number of environmental concerns.

A recent Minnesota-Department of Natural Resources document, entitled "Mitigation of the Environmental Impacts of Expanded Timber Harvest in Minnesota" projects an annual clearcut of 6,000,000 cords by 1995. This would double the harvests in Minnesota from 1975 and require clearcuts of 300,000-350,000 acres of timberland. Much of the increased harvest will be centered on aspen trees for use in both paper pulp and waferboard products.

We recognize that there may be serious environmental problems under such an aggressive harvesting program. To date, no Environmental Impact Statement (EIS) exists which would examine the environmental effects of large scale aspen harvests in Minnesota. We feel the following questions need to be addressed, they include:

- 1) What level of new road construction and reconstruction is necessary to access the additional cords of aspen?
- 2) In light of the lack of any comprehensive biological surveys, how will the increased roading program effect wildlife species sensitive to further habitat fragmentation? i.e. wolves, warblers or endangered plant species.
- 3) What measures will the DNR take to control off-road vehicle use on these forest access roads?
- 4) What are the long-term impacts on forest sails and understory vegetation associated with mechanized harvesting?
- 5) Will forest soils be depleted of nutrients by repeated aspen clearcuts?
- 6) How will increased road building and clearcuts impact the water quality of our lakes and rivers?
- 7) What are the long-term effects of regenerating major portions of the forest to an aspen monoculture?
- 8) How will the increased timber cutting effect the long-term biological diversity of the forests?
- 9) Does the DNR support the planting of non-native hybrid aspen on public lands? If so, what are the potential drawbacks of establishing fast growing hybrid aspen on the aesthetic or visual quality of the forests, forest soils and water resources?
- 10) How will the increased harvest levels affect the tourist economy?
- 11) How will DNR staffing levels be adjusted to monitor timber sales, reforestation protection of wildlife, soil, water and recreational resources?

To reiterate our concerns. The growing tendency to provide year-round timber access roads for harvesting negatively impacts forest soils leading to increased erosion and compaction problems. In addition, the intensity of aspen cutting necessary to satisfy the timber industry will likely lead to decreases in species and community diversity. The harvesting scheme of short rotational clearcutting and subsequent regeneration to aspen may jeopardize attempts to provide a diverse and biologically sound forest.

Multiple-use and sustained-yield forestry must account for all the needs of the people of Minnesota, both tangible commodities, as well as their needs for recreation, a healthy, viable set of wildlife populations, habitats and plant communities. The time has come for the DNR to provide data on these questions, before any large scale road building and aspen clearcutting begins.

We look forward to hearing from you on this at your earliest convenience.

Sincerely,  
Gene Christenson  
Chair-North Star Chapter  
Sierra Club

The volume of timber harvested in Minnesota had increased from 5.1 million m<sup>3</sup> in 1980 to an estimated 8.9 million m<sup>3</sup> in 1990. Future expansions totaling approximately 2.2 million additional m<sup>3</sup> per year were possible by the year 2000.

The forest products industry was expanding, and had become the second largest manufacturing industry in the state. In 1988, Minnesota's forestry and forest products sectors provided 54 000 jobs (2% of the state total) and \$2.2 billion of personal income (4% of the state total). In addition, the forest industry was projected to make \$2.2 billion in capital investments in Minnesota between 1991 and 1995. Forests resources were also important to the health of the state's growing tourism and recreation industries—more than 25% of the state's travel and tourism industry employment was in the forested regions of the state.

### The Study

In Minnesota, a generic environmental impact statement is different from other environmental impact statements in several respects. A typical environmental impact statement for a wood products mill expansion focuses on the expansion of a single mill. Minnesota is unusual in that the Minnesota Environmental Policy Act also recognizes the use of a *generic* environmental impact statement. A generic environmental impact statement is different in that: (i) there is a focus on cumulative impacts of many separate, but related, activities (such as the construction or expansion of several woods products mills in different parts of the state), (ii) the policy recommendations that are developed have no force of law, and (iii) it is a long-range environmental planning document.

While the DNR was aware of the projected increase in timber harvesting, it was hampered in analyzing the effects of the increased harvest by outdated forest inventory data and a lack of information assessing the impact of harvesting on nontimber forest resources. The issue of increased timber harvesting had simmered within the state for several years. One of the first signs that the issue had reached a critical point was a letter from the North Star Chapter of the Sierra Club to the DNR dated 1 Feb. 1989 (Exhibit 1). This letter questioned the anticipated expansion of forest industry within the state. Eventually, a citizen petition, signed by 400 individuals, was presented to the EQB in July of 1989. This petition was developed through the efforts of environmental activists from northern Minnesota. The petition, entitled "A citizen petition for a comprehensive study of forestry impacts on the environment of central and northern Minnesota," specifically requested that "the Environmental Quality Board conduct a generic environmental impact statement on the resultant environmental effects of unprecedented timber harvesting in central and northern Minnesota."

Initially, several organizations argued against conducting a GEIS. The forest products industry opposed the GEIS study, claiming that it was unnecessary. However, in November 1989, representatives of the industry reversed their position and called for a GEIS. "Our previous position was that a generic environmental impact was not necessary," stated Wayne Brandt, executive vice president of Minnesota Forest Industries, an organization that represents many forest products firms in the state. "But we don't have any fear

**Exhibit 1. North Star Chapter of the Sierra Club letter to the Minnesota Department of Natural Resources.**

(of the study) because we don't feel there are any significant environmental impacts from forest management in Minnesota" (Rebuffoni, 1989).

The only other major interest that opposed the study was the DNR, which had hoped to resolve the issue through negotiations. The commissioner of the DNR, Joseph Alexander stated, "I don't disagree with the questions they [the petitioners] ask, but they seem to be asked with the assumption that we don't have the answers. We do. I think [the negotiations] can be done through the committee we are setting up" (Laszewski, 1989).

After approximately 8 h of deliberation over three meetings, the EQB concluded that the nine criteria for conducting a GEIS identified in Minnesota Rules, part 4410.3800, subpart 5, were substantially satisfied, and that there was broad support for conducting the study. On 21 Dec. 1989, the EQB ordered preparation of the Timber Harvesting GEIS.

Editorials from around the state applauded the decision to conduct the study. The Rochester, MN, Post-Bulletin said, "A full-scale, objective, and credible study is needed" (Rochester Post-Bulletin, 1989). In a headline of an editorial, the Duluth News-Tribune stated "Timber study must be made" (Duluth News-Tribune, 1990).

The EQB hired Jaakko Pöyry Consulting, an international forestry consulting firm, to prepare the GEIS. Many of the processes and procedures necessary to conduct the study were described in state law and administrative rules. Complying with the various mandates and the direction of the EQB required a substantial amount of analysis (approximately 8000 pages). To gain access to expertise within Minnesota, Jaakko Pöyry Consulting subcontracted much of the analysis to the faculty of the College of Natural Resources, University of Minnesota. In total, some 60 scientists representing a variety of disciplines worked on preparing the GEIS.

The GEIS found that timber harvesting has both beneficial and adverse impacts. Some of the beneficial effects were:

- The economic contribution of the forest products and associated industry to the state
- The creation of wildlife habitat for certain species and of recreational opportunities
- The minimization of risk of insect and disease outbreaks
- The use of forest management is a tool to achieve a desired future condition of the forest

Adverse impacts of timber harvesting on the state's forests were also found. Among these were:

- Depletion of nutrients in forest soils
- Reduction of habitat for certain wildlife species
- Reduction of aesthetic values
- Reduction of biological diversity
- Creation of potential threats to rare and endangered plant species
- Creation of a potential negative impact on tourism

Ultimately, Jaakko Pöyry Consulting concluded that the current level of timber harvesting was creating impacts, but that harvesting could be sustained at current or higher levels if two conditions were met: (i) the adverse impacts were

effectively mitigated, and (ii) Minnesota did not experience appreciable changes in forest-land availability. Some examples of specific practices and activities to mitigate or eliminate the impacts considered in the study included:

- Reduce the area of forest that is converted to nonforest land uses
- Maintain patches of intact forest in areas of mixed land use
- Monitor the age class and covertype structure of the state's forests and forest patterns across the landscape
- Manage a proportion of the state's forest stands under extended rotation forestry guidelines
- Develop landscape-based road and trail plans
- Retain or redistribute slash within the harvest site (decreases soil nutrient loss)
- Modify the time of equipment operation to minimize soil compaction (e.g., harvest in winter)
- Modify silvicultural systems to maintain key habitat components (e.g., retain mast trees, cavity trees, and conifer inclusions, and use uneven-aged management where appropriate)
- Have an organization maintain a list of known cultural and historical resources that exist in forested areas

Before its public release, an independent peer review was conducted on the draft Timber Harvesting GEIS. After this peer review, the EQB established a 90-d public comment period on the draft. Six public information meetings were held during this period. In total, more than 800 people attended the six meetings, and 119 individuals commented at the meetings. More than 1300 letters with comments were received during the public comment period. The EQB identified all substantive comments that had been received and forwarded them to Jaakko Pöyry Consulting for its response.

The draft text of the proposed final GEIS was substantially revised by the consultant in response to specific comments. As with the draft GEIS, copies of the proposed final GEIS were made available for public review in libraries around the state, the regional offices of the DNR, and the EQB office.

The EQB unanimously approved the final GEIS on 21 Apr. 1994 (Exhibit 2). Prominent individuals spoke in positive ways of the study, but most were looking ahead to the future. Wayne Brandt of Minnesota Forest Industries stated, "What the [study] shows is that there's not a need for a revolution in logging and forest management, but rather a continued evolution." Don Arnosti, Minnesota director of the National Audubon Society, stated that the study was a "reasonably good start." However, he also stated that "this is just a report." The Minnesota Commissioner of Natural Resources, head of the DNR, called the report, "a very positive conclusion for the future of Minnesota's forest management" but he too acknowledged that "admittedly, there are many issues to be resolved to everyone's satisfaction" (Meersman, 1994).

In the Laws of Minnesota, 1992, Chapter 513, Article 4, Section 11, it is stated: "...upon completion of the study (GEIS), responsibility for analyzing and implementing study recommendations is transferred to the Department of Natural Resources under Minnesota Statutes, Section

15.039..." This law transferred both the authority for and personnel (including Dr. Carter) required to implement the GEIS recommendations from the EQB to the DNR, at the time the EQB approved the final GEIS. Given this legislative directive, the DNR was the agency with primary responsibility for administering the GEIS implementation process and the recipient of its outcomes. The EQB would continue to monitor the GEIS implementation process through periodic briefings as well as through direct participation in the process.

### The Problem

To many observers, completion of the study provided a window of opportunity to forestall the type of conflict seen in the Pacific Northwest over the spotted owl; to others, completion of the study created uncertainty about the promulgation of new forest practice regulations. Quite possibly, the results of the study could lead to major changes in the way forestry was practiced in Minnesota. However, whereas the study had produced solid technical work, there were unfulfilled expectations about the implementation of the recommendations and findings. For instance, segments of the state's forestry community were becoming increasingly aware that, as a technical document, the GEIS was not going to solve the many contentious value and political differences that existed over the use and management of Minnesota's forests. Providing technical information was one thing; incorporating differing sets of values into agreed to and effective policies was another. There was also uncertainty about the benefits of continuing searches for certainty about the consequences of using and managing the state's forests. Dr. Carter felt that the benefits produced by greater and greater investments in information gathering and analysis were beginning to wane.

There were other concerns, too. Failure to effectively implement the GEIS could spoil an otherwise successful effort in preparing the report. Also, there were substantial negative political implications; failure to implement the GEIS after

investing nearly \$1 million in technical analysis could pose major problems among those who had supported the investment. Conflicts among long-time adversaries might again surface, legal entanglements were a very real possibility, and a series of legislative proposals and actions developed and fostered by opposing interest groups might result in poorly designed and potentially ineffective forest resource policies and programs.

Despite the statutory direction giving DNR implementation responsibility, Dr. Carter was faced with a series of difficult decisions. Even if the implementation responsibility was transferred to the DNR, how should the many recommendations in the GEIS be converted into the laws, guidelines, regulations, and perhaps incentive programs necessary to implement the recommendations? Up until this point, state law had largely directed the process of preparing the GEIS. However, state law was silent on how to implement the results of the study. Also, this was the first GEIS in Minnesota, and there was a lack of a clearly prescribed process for converting the GEIS recommendations into public policy. Further, support for implementation was uncertain because the recommendations did not have the explicit backing of any constituent groups, having been primarily developed by Jaakko Pöyry Consulting. There was concern that the consultant was not universally accepted by all segments of Minnesota's forest resource community, particular some vocal environmental activists. Finally, whereas Dr. Carter and many experts felt that the final GEIS contained a wealth of technical data, Dr. Carter also believed the policy and program recommendations contained in the GEIS were incomplete and often sketchy (Exhibit 3). For instance, only 28 of an estimated 8000 pages were devoted to potential policies and programs. How could more attention be given to the policy recommendations, while at the same time crafting a politically acceptable solution?

Dr. Carter saw several alternatives. One option was for the DNR to develop bills, based on the GEIS recommendations, that would hopefully be enacted into law. Another option was to work with specific groups who would likely

## Timber study gives good report and a warning

By Tom Meersman  
Staff Writer

State officials Thursday approved the results of Minnesota's most comprehensive environmental study, an 800-page document on forests and timber harvesting in the state. The study, which cost nearly \$1 million and took three years to complete, involved more than 60 researchers.

It was originally requested almost five years ago by a group of northern Minnesota environmentalists who feared that expansion of the pulp and paper industries would result in too many trees being cut. The report estimated that there will be more than enough fiber from

trees during the next few decades, but it also warned that the amount of timber already being cut may be affecting ecosystems, including wildlife habitat, bird populations and the diversity of forests.

Wayne Brandt, executive vice president of Minnesota Forest Industries, a trade group, said the study provides a "tremendous amount of information" and highlights areas in which further research is needed, such as interrelationships between wildlife species, the health of songbird populations and the quality of forest soil. "What the (study) shows is that there's not a need for a revolution in logging and forest management, but rather

a continued evolution," Brandt said. The system doesn't need additional governmental regulations, he said, and is constantly improving its environmental practices.

Don Arnosti, Minnesota director of the National Audubon Society, called the study "a reasonably good start." He said some sections of the report provide such valuable information about environmental concerns as the effect of timber harvesting on soil nutrients and water quality. But Arnosti was disappointed with other elements of the study, including its unsuccessful attempt to quantify the impact of increased logging on tourism and resort businesses. "This is just a

report," he said, and added that it won't mean a great deal unless it leads to specific changes in logging and forest practices.

The Environmental Quality Board approved the document unanimously yesterday, and Chairman Bob Dunn said the result "exceeded my hopes" on what proved to be "an extremely complicated and controversial matter."

Natural Resources Commissioner Rod Sando called it "a very positive conclusion for the future of Minnesota's forest management," but said, "admittedly, there are many issues yet to be resolved to everyone's satisfaction."

Exhibit 2. Minneapolis Star Tribune article on GEIS study approval. (Reprinted with permission of the Star Tribune, Minneapolis-St. Paul.)

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- Certification or licensing programs for loggers, forest operators, and foresters.
  - Statistically sound monitoring of landowner compliance with voluntary forest practice guidelines (these guidelines protected water quality during timber harvesting). If compliance falls below a specified threshold, mandatory compliance rules should then be considered.
  - Wood purchasing industries will be encouraged to adopt a forest operators/loggers Code of Practices that is congruent with voluntary forest practice guidelines. The Code of Practices would then be introduced into all forest operators/loggers contracts to ensure statewide compliance.
  - The state should work with its own agencies and department, the counties and the USDA- Forest Service to develop financial and technical assistance and incentives programs for private landowners, operators, and loggers to encourage adherence to the voluntary forest practice guidelines.
  - Monitor the age class and covertype structure of the state's forests.
  - Complete an inventory of the state's biodiversity features, and conduct an inventory of old growth forests across all ownerships.
  - Upgrade and maintain a listing of known archaeological, historical, and traditional use sites in the state.
  - Develop and fund a research program to investigate the effects of timber harvesting and forest management activities on the tourism and travel industry in Minnesota.
- 

**Exhibit 3. Selected programmatic recommendations from the GEIS.**

develop their own bills to address the recommendations most important to them. A coalition of environmental groups had already proposed some specific recommendations (Exhibit 4). These groups felt strongly that there be no delay in changing the way forestry was practiced. Forest industry perspectives and suggestions were more modest (Exhibit 5). Industry was concerned about the costs of the GEIS recommendations, and their effect on the timber supply. A third option was to work to create a consensus among a broad-base group of stakeholders and have this group negotiate and formulate bills that propose enacting a package of policies and programs. No matter which path was chosen, any of the proposed policies and programs would

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Selected from the *Citizen's Guide to the G.E.I.S.*, prepared by the National Audubon Society, the Minnesota Center for Environmental Advocacy, the Minnesota Public Interest Research Group, and the Sierra Club-North Star Chapter.

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- To maintain some interior forest species and their habitat, such as old growth forest and the red-shouldered hawk, preserve blocks of undisturbed forest. Interior forest characteristics can be maintained if 300-foot buffer strips surround the entire stand.
  - Vastly reduce cutting techniques that remove all trees at once (clearcutting).
  - Prohibit clearcutting in riparian zones.
  - Voluntary use of [forest practice guidelines] may not be enough to safeguard fish and water quality if logging increases.
  - Reduce new forest road construction so that it is balanced by permanent forest road closures. "No net gain of forest roads."
  - Elevate importance of recreation in forest planning.
  - Management changes can only help to the extent that they are implemented across all forest land managers; private, county, state, and federal.
  - No future expansions of Minnesota pulp and paper mills should be permitted unless they utilize recycled pulp.
  - Investments must be made in forest management to encourage more pine in our forests. Younger stands of white and red pine should not be clearcut. Any logging of these stands should be of selected trees only, leaving others to reach greater ages of maturity.
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**Exhibit 4. Selected excerpts of environmental group coalition recommendations.**

have to be enacted into law by the state legislature and governor. Minnesota does not have the initiative process, in which citizens can vote to enact laws without any involvement of the legislature or governor.

If the alternative of having a group of stakeholders negotiate a package of policies and programs was selected, then two issues that Wanda Carter would have to address were: (i) which stakeholders to include, and (ii) the short time frame available to craft new policies and programs.

**Stakeholders.** To Dr. Carter and the DNR leadership, a critical element in implementing the recommendations would be generating input from a broad-based group of stakeholders. Broad stakeholder involvement and consensus had not led to the GEIS recommendations; however, these stakeholders would have strong opinions regarding appropriate programs to implement the recommendations. Furthermore, forming an effective coalition of stakeholders might provide an opportunity to take another look at the recommendations suggested by the GEIS. Various stakeholders might have alternative recommendations for policies, programs, and procedures to reduce the adverse impacts identified in the GEIS. Ideally, these stakeholders might review various means by which the GEIS recommendations could be implemented and recommend to the DNR a package of policy and program options to submit as bills to the legislature. Therefore, Dr. Carter drew up a list of organizations that could be represented in such as coalition (Exhibit 6) and she prepared a tentative budget for convening the stakeholders (Exhibit 7).

**Projected Timelines.** One of Dr. Carter's greatest concerns was the amount of time available to negotiate and formulate the bills proposing the new policies and programs. Although background research had begun, the process of formulating these bills could not start in earnest until the final GEIS had been approved by the EQB. The development of bills had to be complete by the end of 1994, to be considered in the 1995 legislative session. Therefore, time constraints dictated a maximum 6-mo negotiation and bill formulation process—a short time frame to develop a viable package of comprehensive policy and program recommendations. Failure to act quickly could delay action for 2 yr because of Minnesota's biennial legislative process, in which funding for new programs is usually only addressed every 2 yr. The next opportunity to initiate a major new pro-

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Excerpted from *Understanding the Generic Environmental Impact Statement on Timber Harvesting: A resource guide to Minnesota's comprehensive forest analysis*, prepared by Minnesota Forest Industries.

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- Establishment of [extended rotation guidelines] is appropriate, but only if the substantial continued aging of forests projected in the GEIS does not occur.
  - Protection for plant species should be undertaken, but specifically for those in the threatened or endangered categories.
  - Establishment of [a landscape-based road and trail plan] would be best suited to the County Road Committees, which are currently functioning.
  - [GEIS recommendations] related to slash (limbing and topping) and retention must take into consideration resulting issues related to logger safety. Also, in some cases, slash should be removed for fire and disease prevention purposes.
  - A specific description of sensitive sites [such as nest sites, habitats, and rookeries] and the values they represent should be developed.
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**Exhibit 5. Excerpts of forest industry's perspective on the GEIS.**

gram would be in 1997, too late from the perspective of the environmental groups. Dr. Carter knew that now was the time to develop new policies and programs, but how should she proceed?

### CASE EXHIBITS

1. Sierra Club letter to the Minnesota Department of Natural Resources.
2. Minneapolis Star Tribune article on GEIS study approval.
3. Selected programmatic recommendations made in the GEIS.
4. Environmental group coalition recommendations.
5. Excerpts of forest industry's perspective on the GEIS.
6. Potential stakeholder organizations.
7. Staffing and budget projections.

### TEACHING NOTE

#### Case Objectives

Upon completing this case, students should have:

1. An understanding of the need to involve stakeholders in the formulation and implementation of natural resources policies and programs.
2. An understanding of the complexity and uncertainties of natural resources policy decision making.
3. An understanding of various processes for involving stakeholders in the development of natural resources policy, as well as barriers to involving stakeholders.

#### Uses of the Case

This decision case study was written primarily for use in natural resources and environmental policy courses. It has been used in its current form twice in a course entitled Management of Natural Resources Conflict. All the students were either seniors or graduate students. The case was used

Interests	Organizations
State land management	DNR
County land management	Minnesota Association of County Land Commissioners
Federal land management	Chippewa and Superior National Forests
Nonindustrial landowners	Minnesota Forestry Association
Forest industry	Minnesota Forest Industries
Primary manufacturing	Champion Paper
Loggers	Associated Contract Loggers
Loggers	Timber Producers Association
Environmental organizations	Center For Environmental Advocacy
Environmental organizations	Audubon Society
Environmental organizations	The Nature Conservancy
Sporting interests	Minnesota Deer Hunters Association
Secondary manufacturing	Minnesota Wood Promotion Council
Resort/tourism	Minnesota Resort Association
Labor	Wood Fiber Council
State interests	EQB
K-12 education	Minnesota Environmental Education Advisory Board
Higher education/research	University of Minnesota
Higher education/research	Natural Resources Research Institute
Forestry professionals	Society of American Foresters
Wildlife professionals	The Wildlife Society

Exhibit 6. Potential stakeholder organizations.

in a section of the course on public policy dialogues and negotiation. The students were asked to read the case before class and to think about how Dr. Carter might proceed to implement the study recommendations. The case was then debriefed in class. It is used as a complement to lecture and readings on public policy development.

The primary use of the case is to allow students to apply theoretical concepts from the lecture notes and other readings, and to stimulate discussion about how natural resources policy and programs are developed. The case focuses the student's attention on the need to involve stakeholders in the development of public policy, and generates a discussion of how such stakeholder involvement could occur. The case also has been used to discuss the use of alternative dispute resolution processes, particularly negotiation and facilitation, in natural resources policy formulation and implementation. Specific issues that have been addressed in class include: determining the number of individuals participating in the negotiation or facilitated meeting, suggesting processes for participant selection, and developing process groundrules.

#### Discussion Questions and Issues

There are a variety of questions that can be used in preparing for and debriefing this case. Some introductory questions that are typically used in cases such as this one are:

- What precisely is the dilemma faced by Wanda Carter? Who are the major stakeholders and what are their interests in this case?
- What characteristics of stakeholders are considered by public agencies when they select or ask them to participate in public planning and policy formulation processes?
- What are Wanda Carter's options?

More probing questions are presented below, along with brief comments and potential answers for each question.

Workplan staffing estimates. Project staffing needs (to be provided or funded by the DNR):

- **Project director/administrator (full-time).** Direct and oversee the GEIS implementation process.
- **Professional facilitator.** Work to help generate consensus on selecting options for implementing the GEIS recommendations.
- **One professional staff (full-time).** Provide technical and project support in assisting the project director in administering the GEIS implementation process.
- **One clerical staff (one-quarter to one-half time).** Provide project support in areas such as making meeting arrangements, as well as preparing mailings and correspondence associated with this project.

Workplan estimated budget. These costs did not include the staffing costs for DNR employees.

Policy and program option development:

- Conduct background research and surveys. (Cost: \$12 000)
- On-site visits to selected states to review existing programs, administrative structures, etc. (Cost: \$13 000).
- Convene policy/administrator expert workshop. (Cost: \$10 000)

Subtotal: \$35 000

Administration costs: \$15 000

**Total: \$50 000**

Exhibit 7. Staffing and budget projections.

**1. What organizations and institutions could be invited to participate in the development of new policies and programs?** Wanda Carter faces an important dilemma in deciding which organizations could be invited to participate in a consensus-building process. On one hand she wants to seek a broad, representative stakeholder involvement in the process. On the other hand, she may want to limit the number of parties at the table—too many groups might slow down or halt the process.

**2. How should individual participants be selected?** An important question that Wanda Carter will need to determine is how to select individual participants to represent themselves or to represent selected interest groups. For instance, participants might be selected by the EQB or the DNR from a pool of nominations submitted by the various stakeholder organizations. Wanda Carter might also want to consider specific criteria for selecting among potential participants, such as their knowledge of forestry issues and whether they will be able to commit a substantial amount of time to meetings.

**3. How could participants not familiar with forestry issues or the GEIS become informed about these matters? What types (and how much) of policy and scientific background information could be provided to the participants?** Some participants may not be familiar with forestry issues, or they may have a limited knowledge of the Timber Harvesting GEIS. Wanda Carter must decide if she wants to educate these individuals, and she must also decide how to inform them. She has a variety of alternatives, including distributing background papers to them, making oral presentations to them herself, or bringing in outside experts to focus on specific forestry issues.

**4. How could conflicts among participants be resolved?** If a formal group of stakeholders is convened, some mechanism (e.g., voting or consensus) must be developed to move the group beyond impasse when conflicts arise. Wanda Carter might consider institutionalizing this mechanism in groundrules. Given that a broad consensus appears to be the most desirable, she might lean toward consensus rather than voting to decide issues. However, it is likely that at some point a final decision will have to be made by individual participants whether or not to support the products of their efforts.

**5. Should the participants limit their activities to discussing the policies and programs suggested by the GEIS, or should the members develop their own program ideas?** It is unlikely that the participants would desire to stay within the confines of the previous recommendations. Further, a major purpose of bringing the stakeholders together would be to gather input from each of the stakeholder groups. This would have two main benefits: (i) more information would be gathered about how to structure rec-

ommended policies and programs, and (ii) more input from the stakeholder groups might increase their perceived ownership of the report, thus increasing the likelihood that broadly supported policies and programs would result.

**6. If a group is convened, how could the discussion be managed? Should an independent facilitator be used to manage the discussions?** Given that the work will be contentious, and many important stakeholders will participate, it might be advisable for Dr. Carter to employ a professional facilitator. Further, many of the issues will be complicated and interrelated, requiring the management skills of a professional who is experienced in group processes and dynamics. Finally, there are good reasons to choose an independent facilitator. If the DNR is a participant, a facilitator from that organization might be seen as biased.

**7. What types of recommendations could the participants make? Should the recommendations be specific or broad? What should be the final product of their deliberations, if any?** The participants will be expected to develop some sort of product, most likely a report of some kind. The participants might also become involved in developing and recommending bills. However, given the short time frame and the diversity of viewpoints that will likely be represented, chances are the report will be rather strategic in scope. The depth and breadth of the deliberations will be an important issue for Wanda Carter to resolve. Some of the participants will want the recommendations to be at the strategic level, while others will want to develop a detailed recommendation. If she tries to deal with too much detail, however, the group might never reach agreement. On the other hand, if she tries to keep the group focused on the strategic level, some will say the group accomplished little of substance.

## ACKNOWLEDGMENTS

Sincere appreciation is expressed to T. Dunrud and S.R. Simmons of the Program for Decision Cases at the University of Minnesota for reviewing a draft of the case study, and to T. Dunrud for assisting in the development of the teaching note.

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# The Dairy Dilemma: A Decision Case for Water Quality

B. E. Miller,\* K. L. Farrell-Poe, and J. Egelund

## ABSTRACT

This decision case study involves a dairy (*Bos taurus*) operation that contributed bacterial pollution to a nearby waterway in northern Utah. Students must use whole-farm management and waste management design criteria in the decision process. A solution requires balancing the current crop and livestock management philosophies of the owners with water quality standards mandated by the state. The method has been used successfully in three courses. Chet and Todd Benson are currently operating a dairy in Wellsville, UT, which has been found to be a major contributor of water pollution in the Little Bear River. The state of Utah and the USEPA have hoped that an educational effort will allow for voluntary measures to mitigate the pollutants leaving the dairy. To date, the Utah Department of Environmental Quality (DEQ) has issued few citations in the state and are hoping to continue on a *voluntary compliance* basis. The primary operator of the dairy, Todd, must decide what course of action to take related to their family dairy operation. It is a delicate issue because his father, Chet, feels that the state is meddling into their business. Todd must also take into account the future of the dairy because the voluntary compliance program has some attractive incentives to encourage participation, namely, cost-sharing for improvements. If they choose not to participate, it is likely that they will be ineligible for future USDA cost-sharing arrangements. The key issues in the case involve voluntary vs. involuntary participation in government programs, water quality, and implications to agricultural operations, dairy waste management, and Western water rights.

WASTE MANAGEMENT on livestock farms is increasingly under public scrutiny. Traditionally, livestock operations were often sited near surface water sources that provided drinking water for the family and livestock, as well as drainage for runoff. This farm runoff contributes to non-point-source pollution of public waters. The pollutants may include excess nutrients, bacteria, and sediments. Today, such siting requires a high level of management because of increased farm densities along waterways, multiple uses of the surface waters, as well as environmental regulations.

## THE CASE

In 1990–1991, the USDA designated 5-yr demonstration projects in 90 locations, most of them in portions of watersheds called hydrologic units, to help states improve water quality in identified agricultural watershed areas. Cost-sharing was provided for conservation practices such as animal waste control facilities, grassed waterways, water manage-

ment systems, and integrated crop management for water quality improvement (USDA, 1990).

The hydrologic unit areas were under joint leadership of the extension service (ES) and the Natural Resource Conservation Service (NRCS). The ES provided information including specific recommendations on the use of nutrients and pesticides. The NRCS assisted farmers and ranchers in developing appropriate conservation systems. Planners sought to involve the client in all phases of the planning and implementation process.

The Little Bear River watershed was one of the projects funded under the USDA plan. The watershed contributed excessive amounts of nutrients and sediment to the Little Bear River. The Little Bear River Hydrologic Unit Area (LBR HUA) was established and problem areas were identified (USDA-SCS, 1992).

Although the original focus was nutrient and sediment levels, it soon became evident that bacterial loading was also of concern. One hundred dairies within the LBR HUA were identified as definitely contributing excessive bacteria, and another 100 dairies had the potential to contribute excessive bacteria. This case study concerns one of the dairies that contributed excessive bacterial loading.

## Decision Case Information

The dairy farm has been in existence for over 100 yr, handed down from generation to generation. Tradition keeps the family owner/operators on familiar ground and allows them to remain within their comfort zone. Change would take them outside of their comfort zone.

Willard Benson, an early pioneer, settled land just north of Wellsville, UT, in the early 1860s. He was the first in his family to break ground in Cache Valley—on land that his grandson, Chet Benson, 80 yr old, and his great grandson, Todd Benson, 38 yr old, continue to farm to this day. Neither of the families live at the dairy operation.

Chet and Todd operate the dairy farm. Chet manages the cropland, and Todd manages the dairy and provides the overall management. The dairy consists of 120 Holstein milking cows. They grow the majority of the alfalfa (*Medicago sativa* L.), barley (*Hordeum vulgare* L.), and corn (*Zea mays* L.) required to feed their herd each year on approximately 111 ha (275 acres) spread over 26 km<sup>2</sup> (10 mi<sup>2</sup>).

Chet's wife does not work outside the home, and although she contributed heavily to the farm when the children were young, she no longer assists with farm chores. With the exception of Todd, the rest of Chet's children are married and live off the farm. Todd's wife is employed off the farm and devotes very little time to the farm. Todd hopes that his only son will eventually take over the family farm. His children (including two daughters) are less than 8 yr of

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**Abbreviations:** DEQ, Department of Environmental Quality; ES, extension service; NRCS, Natural Resource Conservation Service; LBR, Little Bear River; HUA, Hydrologic Unit Area.

**Exhibit 1. Field sizes, proximity to animal facility, and predominant soil type.**

Field no.	Field size		Distance to animal facility		Predominant soil type
	ha	(acres)	km	(miles)	
1	2.8	(7)	Adjacent		Hendricks (HdC)
2	19.4	(48)	0.8	(0.5)	Hendricks (HdC)
3	14.9	(37)	1.2	(0.8)	Nibley (NcA)
4	1.6	(4)	1.6	(1.0)	Greenon (GSA)
5	10.1	(25)	5.6	(3.5)	Greenon (GSA)
6	8.5	(21)	6.4	(4.0)	Greenon (GSA)
7	16.6	(41)	3.5	(2.2)	Crowshaw (CrD)
8	35.1	(87)	1.6	(1.0)	Timanogos (TmB)
Building site	2.0	(5)			
Total	111.0	(275)			

age; thus, Chet and Todd do all of the work and hire no extra help.

Chet feels that there is nothing wrong with his farm nor his water—after all, he has been drinking the water throughout his 80-some years of living and dairying on the same land, even though he currently lives in town. Although Todd acknowledges the problems, he is concerned that the NRCS-developed management plan will be too inflexible. Together, the Bensons only provide enough information about their farming operation to appease the NRCS.

### Cropland Operation

There is 111 ha (275 acres) available for raising crops; however, the land is spread over approximately 26 km<sup>2</sup> (10

mi<sup>2</sup>). Approximately 3 ha (7 acres) immediately adjacent to the dairy operation receives all the animal waste from the dairy operation. Exhibit 1 specifies fields, as well as their sizes and predominant soil type. Exhibit 2 lists the soil characteristics found on the Benson farm.

### Dairy Operation

A spring surfaced at the farm during the 1970s when a hydrological change relocated a nearby spring. The water rights for the spring were already filed by the owner of the property where the spring was located originally. Therefore, according to Western water law, Chet and Todd did not have the rights to the water from the spring that was now on their property. The average flow rate for the spring was about 38 L/min (10 gallons/min).

The dairy operation consists of 190 cows: 120 milking cows, 20 calves, 20 heifers, and 30 dry cows. The milking cows and dry cows are fed and kept in a confined holding area year-round. They are milked twice a day. The 40 heifers and calves are kept in a pasture area adjacent to the flowing spring, just east of the dairy unit. Exhibit 3 presents a schematic diagram of the dairy operation.

The manure in the holding areas is scraped daily into concrete bunkers until it is spread on the crop ground. The liquid runoff from the confined holding area flows onto the field located on the northeast side of the dairy unit. Exhibit 3 provides the NRCS-derived job sheet of the animal waste management system nutrient analysis.

**Exhibit 2. Soil map legend table (USDA, 1974).**

Soil series and map symbols	Soil features affecting—								Degree and dominant limitations for—	
	Suitability as a source of—		Farm ponds						Foundations for low buildings	Sewage lagoons
	Topsoil	Road fill	Reservoir area	Embankment	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways		
Crowshaw: CrD	Fair: gravelly loam	Fair: A-4 material	Slopes of 3–20%	Low to medium shear strength; susceptible to piping; semi-pervious	Not applicable	Moderate intake rate; slopes of 3–20%	Slopes of 3–20%	Slopes of 3–20%	Slight to severe: slopes of 3–20%	Moderate to severe: slopes of 3–20%; moderate permeability
Greenon: GsA	Good	Fair: A-4 material	High water table; slopes of 0–10%	Low to medium shear strength; susceptible to piping; semipervious; medium compressibility	Moderate permeability; high water table	Moderate intake rate; slopes of 0–10%	High water table in some areas	Slopes of 0–10%	Moderate: water table at a depth of 30–40 inches; moderate shrink-swell potential	Moderate: moderate permeability; water table at a depth of 30–40 inches
Hendricks: HdC	Good to depth of 15 inches; fair below 15 inches depth	Fair to poor: A-4 and A-6 material	Slopes of 1–20%	Impervious to semipervious; low to medium shear strength; medium compressibility	Not applicable	Moderate intake rate; slopes of 1–20%	Slopes of 1–20%	Slopes of 1–20%	Moderate to severe: slopes of 1–20%; moderate shrink-swell potential	Moderate to severe: slopes of 1–20%; moderate permeability
Nibley: NcA	Poor: silty heavy clay loam	Poor: A-7 material	High water table in some areas; slopes of 0–6%	Impervious; medium to high compressibility; low to medium shear strength	Slow permeability; high water table in some areas; fine texture	Slow intake rate; high water table; fine texture	Not applicable	Not applicable	Severe: water table at a depth of 30–60 inches; high shrink-swell potential; poorly drained	Moderate: water table at a depth of 30–60 inches
impanagos: TmB	Good	Fair: A-4 material	Occasional high water table; slopes of 0–20%	Susceptible to piping; semipervious to impervious; low to medium shear strength; medium compressibility	Generally not applicable; water table at a depth of 36–54 inches; moderate permeability	Moderate intake rate; high water table; needs drainage in some areas; slopes of 6–20% are best suited to sprinkler irrigation	Moderately permeable; water table at a depth of 36–54 inches in some areas; slopes of 0–20%	High water table at a depth of 36–54 inches in some areas; 0–20% slopes	Moderate to severe: water table in some areas below a depth of 36 inches; slopes of 0–20%; moderate shrink-swell potential	Moderate to severe: slopes of 0–20%; moderate permeability

The heifers and calves have direct access to the spring and stream and have destroyed or removed most of the vegetative growth surrounding the stream. The stream leaves the property to the southeast and meanders about a mile before emptying directly into the Little Bear River. The washwater from the milk house also drains into the spring area.

The NRCS took grab samples above and below where the stream empties into the Little Bear River. The results are summarized below in units of number per 100 mL of sample.

*Upstream of spring*

Total coliform count = 770  
Fecal coliform count = 590

*Downstream of spring*

Total coliform count = too numerous to count  
Fecal coliform count = 18 360

**NRCS Resource Conservation Plan**

This farm was identified by the Little Bear Hydrologic Unit Area coordinators as one of 100 that contributed excessive bacteria to the Little Bear River. A natural spring located on the farm provided drinking water to approximately 40 head of heifers and calves. As the spring flowed through the southeast portion of the farmstead, it ponded in low-lying areas creating a wetland area; the overflow left the property, and eventually drained into the Little Bear River. Livestock were allowed free access to the spring area. Drainage from the confined livestock areas and manure bunker and milk

wastewater emptied into and contaminated the spring-fed stream. The 3-ha (7-acre) field immediately adjacent to the dairy operation received all of the solid waste from the dairy operation. As a result, the NRCS needed to develop a resource conservation plan to reduce adverse water quality effects.

Chet was not happy about having to participate in the HUA water quality initiative. Todd was concerned about being tied to an inflexible waste management plan. The current NRCS guidelines required a 90-d storage capacity (120 d recommended) and the ability to retain a 25 yr/24-h storm event (6.4 cm [2.5 inches] of precipitation). The Bensons only provided information about their farming operation to appease the NRCS when directly asked; however, the NRCS needed to document the effectiveness of the voluntary compliance approach.

Todd felt three options warranted strong consideration. Chet felt that the government had no business meddling into their business. The three options were:

1. Do nothing. This was Chet's preferred option and it was a voluntary program.
2. Make minimal changes and bring the dairy under compliance. This provided the least risk and would allow the dairy to *get by*.
3. Make substantial operational and physical changes to the dairy. The cost share program could be used to position the dairy for the future. However, even with the cost-share program, this option could create additional financial risk.

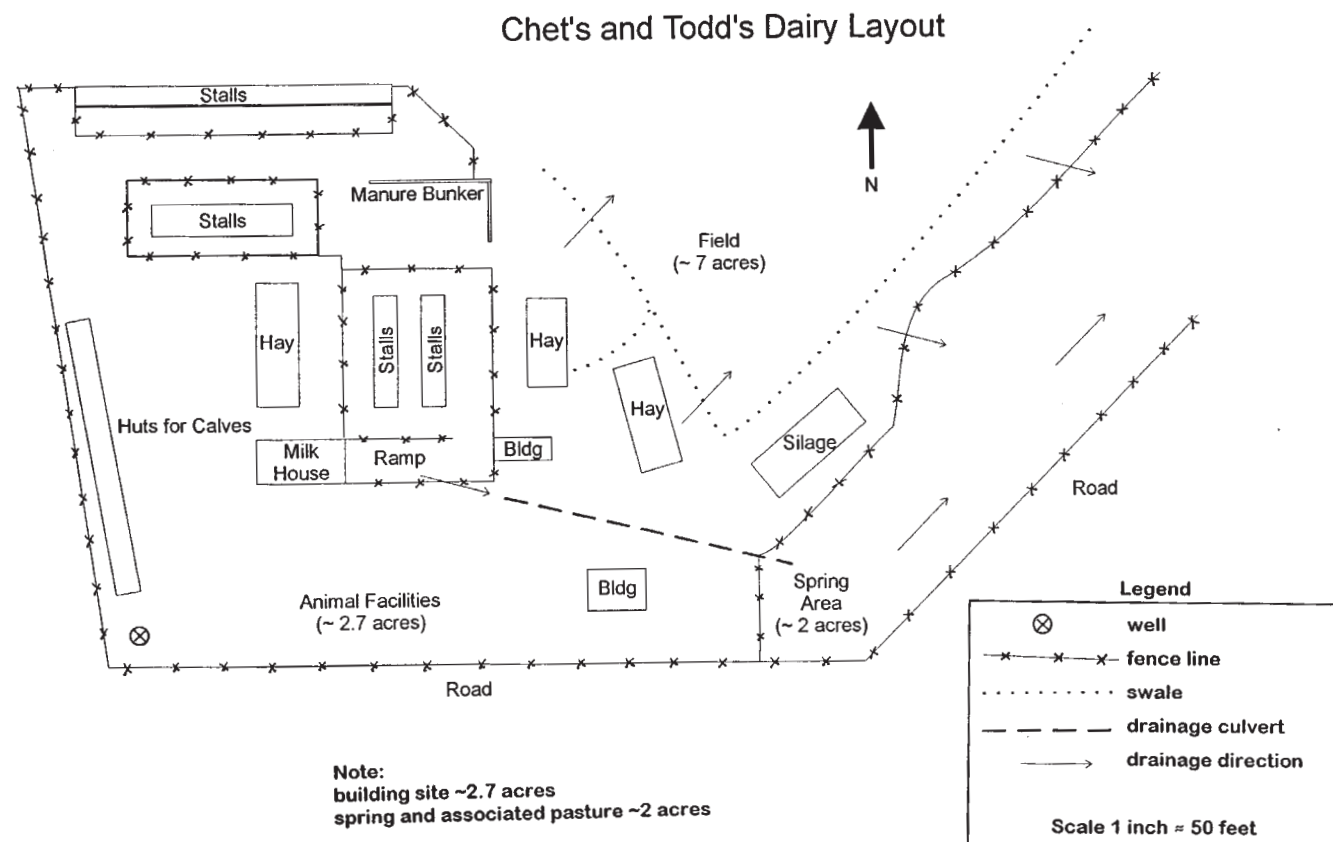


Exhibit 3. Schematic diagram of the dairy operation.

Todd needed to make a decision and inform the Utah DEQ of his decision. Utah State University ES was available for consulting regarding best management practices, and the NRCS field office was responsible to certify, through their engineering staff, that the management plan and any physical improvements would work.

Todd would need to make a decision regarding the dairy. The local Audubon Society and Ducks Unlimited chapters were watching this program to see if the *voluntary compliance* program was indeed working. The Utah Department of Environmental Quality agreed that plans that were acceptable to the NRCS and the ES would satisfy their regulatory agents.

Exhibits 4 and 5 provide additional information concerning the decision.

## TEACHING NOTE

### Case Objectives

The overall objective for this case was to provide students an opportunity to analyze and respond to a situation typical of producers facing environmental, and more specifically water quality, regulations, and issues *ex post facto*. There are more limitations when trying to improve an existing waste management system than when designing a new system. The case illustrates the social, economical, and

#### Exhibit 4. NRCS-Derived Animal Waste Management System Nutrient Analysis Job Sheet.<sup>1</sup>

United States Department of Agriculture  
Soil Conservation Service

Form UT-TCH-3  
October 1992

Landowner: Test  
County: Cache

##### A. Animal Information and Manure Production

Type	Head No.	Avg. Weight lbs	1000 lb Animal Units	Days Confined/yr	Manure Prod/1000 lb A.U.	Manure Prod/year
Milking	120	1 400	168	365	80	4 905 600
Dry	30	1 300	39	365	82	1 167 270
Heifer	20	800	16	365	85	496 400
Calf	20	400	8	365	85	248 200
Total			231			6 817 470

##### A. Manure Composition

Animal Type	Nitrogen		Phosphorus		Potash	
	lb/day/1000 A.U. <sup>2</sup>	lb/year	lb/day/1000 A.U.	lb/year	lb/day/1000 A.U.	lb/year
Milking	0.45	27 594	0.07	4 292	0.26	15 943
Dry	0.36	5 124	0.05	712	0.23	3 274
Heifer	0.31	1 810	0.04	234	0.24	1 402
Calf	0.31	905	0.04	117	0.24	701
Total		35 434		5 354		21 320

##### A. Nutrients Available After Storage

Type of Storage	%	Nitrogen % Remain	Available	Phosphorous % Remain	Available	Potash % Remain	Available
Bunker	100	70	24 804	85	45 551	85	18 122

##### A. Nutrients Available After Soil Incorporation

Type of Storage	After Appl. %	Nitrogen			Mineralization Rates			Nutrients Available for Plants		
		Leach Loss %	Denit. Loss %	N %	P %	K %	N	P	K	
Bunker	70	5	10	60	75	80	8 907	3 414	14 497	
Pasture	50	5	10	45	75	80	0	0	0	
Total							8 907	3 414	14 497	

##### A. Plant Requirements

Crop	Acres	Yield Dry wt. Lbs/Ac	N%	N Total	P %	P Total	K %	K Total
Alfalfa	133	10 000	2.25	29 925	0.22	2 926	1.87	24 871
Barley	57	3 840	1.82	3 984	0.34	744	0.43	941
Corn	60	15 400	1.1	10 164	0.25	2 310	1.09	10 072
Total				44 073		5 980		35 884

##### A. Acreage for Utilization of Nutrients

Crop	Avail.	N		Avail.	P		Avail.	K	
		Req. Ac	No. Ac.		Req. Ac	No. Ac.		Req. Ac	No. Ac.
Alfalfa		225	40		22	155		187	78
Barley		70	127		13	261		16	878
Corn		169	52		38	89		168	86
Total	8 907			3 414			14 497		
Pasture	0	57	0	0	11	0	0	107	0

<sup>1</sup> Actual NRCS-derived job sheet for Chet and Todd—no changes were made to the job sheet.

<sup>2</sup> A.U. = Animal Units.

environmental relationships between private land ownership and water quality. Upon completion of the case, students will have: (i) understood the relationship between water quality and waste management and (ii) participated in a group activity/cooperative learning activity to develop waste management system alternatives that are economically feasible and socially acceptable.

### Stimulant Questions

1. Should environmental regulations impact a small family farmer?
2. Who determines acceptable management practices on a dairy?
3. How might Chet's and Todd's viewpoints differ regarding environmental compliance? The students should consider the role of traditions in a farming enterprise.
4. What characteristics will be necessary for the final plan to be deemed successful by Chet, Todd, Utah State University Extension, Utah Department of Environmental Quality, and the USDA?
5. After an appropriate plan is developed and agreed upon, what are the consequences of violating the plan? Who should document the results of the plan? Who should monitor the plan?

### Use of the Case

This case has been used for approximately 4 yr in three different courses. The courses were designed for upper division undergraduate students. The courses were: (i) ASTE

#### Exhibit 5. Descriptions of slides for accompanying slide set.

Slide no.	Description
1	Title slide.
2	A typical dairy located in northern Utah.
3	The facilities are located in close proximity to the frontage road and are arranged to minimize land requirements. The farmstead layout uses the natural slope for runoff drainage.
4	A view of the facility density and sloping terrain.
5	A view of the sloping terrain.
6	Cows are confined in loafing sheds year-round in a drylot.
7	The operation has room to expand its facilities—currently, there are 120 milking cows.
8	The heifers and calves, about 40 animals, are kept in a lot adjacent to the spring.
9	The dairy raises its calves for replacement.
10	Manure is scraped on a daily basis...
11	and stored in a bunker until it is land applied.
12	The land adjacent to the dairy (approximately 7 acres) is highly valued by the operators for cropland. Chet and Todd grow the majority of the alfalfa, barley, and corn used to feed their herd.
13	There is a natural spring located under the large tree and in the same lot with the dry stock and replacement heifers. The average flow rate is approximately 10 gallons/min. Chet and Todd do not have water rights to this spring.
14	The vegetation has been removed by the animals.
15	The livestock have free access to the spring.
16	The spring forms a stream that drains through the lot...
17	and flows naturally off the property.
18	This gives you an overview of the spring and property draining to the spring area.
19	A wetland area is beginning to be established where the stream exits the property.
20	The spring-fed stream leaves the property via a culvert under the rail-road tracks.
21	Garbage has also been dumped along the stream, which adds to the contamination problem.
22	The stream winds about one mile before entering the Little Bear River.
23	Hopefully, the dairy can continue into future generations.
24	ASTE credit slide.

432—Agricultural Production Systems, (ii) ASTE 520—Analyzing Agricultural Issues, and (iii) ASTE 526—Impacts of Agricultural Practices on Water Quality. The case was used as a primary tool to: (i) allow students the opportunity to design and implement a nutrient management plan and a waste management system, (ii) stimulate discussion of the role of public policy in agriculture, and (iii) determine the best management practices, which may alleviate surface water concerns.

This case illustrates the voluntary compliance approach to water quality management. The use of incentives (i.e., cost-sharing) always produced lengthy classroom discussion. The instructor may also want to engage a discussion contrasting this approach with the regulatory approach. Students often do not recognize that regulations play an increasingly more critical role in the decisions made in production agriculture, even though they are technically capable of developing a compliance plan. The case is well suited for providing an opportunity for developing an integrated waste management system. Students can debate the merits of alternatives and may depend on expertise from members within their group for pertinent facts regarding the alternative under consideration. As the facilitator, it has been beneficial to encourage discipline/experiential diversity within groups. Final projects typically entail sections on agronomic issues (nutrient utilization), herd health and management of animal facilities, and an engineering component that details the animal waste management system. A written report details the plan and provides approximately half of the team's grade. The balance of the grade is derived from an oral presentation (40%) and peer evaluations (10%). However, students tend to rate the performance of each group member as either outstanding or above average.

### Student Reactions

Approximately 130 students have used the case. Most of these were from the Intermountain West and were familiar with production agriculture in the area. Most students have commented that they enjoy the opportunity to work with real-life issues; however, some students have become overwhelmed with the complexity of the issue due to the required plans and details. The students have, by and large, enjoyed the multifaceted nature of the case.

### Author's Analysis and Interpretation

Students have typically been resistant to spending time seeking alternatives to the waste management system. The problem solving process must be emphasized because the initial decision regarding the waste management system dictates all other aspects of the situation. It is imperative that the teams determine the fate of nutrients on the farm. The farm does have adequate land area to allow for waste utilization, but the manure will need to be hauled away from the adjacent 3-ha field. It also becomes apparent that physical facilities are not adequate to capture and retain the nutrient by-product. Livestock health issues, as well as housing requirements and traffic patterns, need to be developed. Students must be encouraged to explore many possibilities including the removal of the riparian area and spring from production. The water did not belong to the land owners and

could not be developed nor legally used for watering Chet's and Todd's livestock. (Ultimately, federal cost-sharing was available and the project was being conducted by federal and state agencies, so the plan had to be *legal*.)

Environmental issues are not usually looked upon favorably by Utah agriculturalists, our students included. This case developed an awareness of the complexity of the issues. It provided an arena for students to openly discuss a real situation involving environmental pollution, consumer activists groups (Ducks Unlimited and the Audubon Society), and a private agricultural business operation. A set of 24 slides is available at cost (approximately \$25), which shows the physical setting of the dairy operation.

### ***NRCS Suggested Solution***

The NRCS provided the management plan and conservation map of the jointly derived plan for the Benson's dilemma. These are provided for informational purposes only—this solution suggested by the NRCS is only one of many possible answers. (See Appendices A and B for the plan and map, respectively.) Often, the authors never even mention the ultimate decision made by Chet and Todd.

## **APPENDIX A**

### **Animal Waste Management System Operation and Maintenance Plan<sup>1</sup> for Dairy Unit Wellsville, UT**

General:

October 1993

The animal waste management system for this dairy unit has been designed to control animal waste materials from a dairy herd that consists of 120 milk cows, 30 dry cows, 40 heifers, and calves. The animals are kept in confined holding areas all year.

The animal waste management system has been planned to prevent the discharge of polluted waste materials into water resources for public health and safety reasons.

The concrete waste storage structures have been sized to store manure for a 120-d storage period. These structures have been designed to store the liquid runoff from storm events. Manure and liquids will be mixed and disposed of on the farm cropland.

Liquid runoff from the open earthen areas will be allowed to drain into the field on the northeast side of the dairy unit. This field will serve as a filter strip area to remove pollutants from the liquid runoff. Surface runoff from the dairy will not be allowed to enter the natural stream.

Construct a concrete holding tank to catch and store the milkhouse waste water. This tank will be sized for a 120-d storage period.

A new manure bunker will be constructed, on the east end of the enlarged holding area.

The driveway and open areas around the dairy unit that are not contaminated with animal waste materials will be regraded to be sure all liquid runoff from these areas drain away from the holding areas.

The owner of this dairy unit will be responsible for the proper field application of animal waste materials and the maintenance of the animal waste management system. Operator will conform to all state and local regulatory requirements regarding the control and placement of animal waste.

<sup>1</sup> This plan is based on Chet's and Todd's decisions and was developed by the NRCS.

The system has been planned and designed by the Soil Conservation Service. The intent of the planned system was to meet the operator's needs and the requirements specified in government standards and specifications.

### **Waste Utilization—Nutrient Management:**

There are approximately 123 000 feet<sup>3</sup> of animal waste (manure) produced each year in this dairy operation. Before storage and disposal losses, this dairy operation will produce the following nutrients:

Approx. amount:	Nitrogen	38 160	lb/yr
	Phosphorous	15 800	lb/yr
	Potassium	30 700	lb/yr

To be properly utilized this amount of animal waste needs to be applied to approximately 130 acres of cropland.

A complete waste utilization plan, which meets the requirements of the Waste Utilization standard, will be developed.

Manure will be hauled and applied to adjacent fields whenever field conditions permit and when spreading will result in minimum water quality problems. The storage facility should be emptied when the waste applied to the field will result in maximum use of nutrients by the soil and the growing crop. As a minimum, the storage facility should be emptied during the fall before the soil freezing and in the spring before planting.

The liquid waste from the milk house tank will be applied to the adjacent fields in one of two ways: (i) hauling and spreading with a liquid tank unit, or (ii) pumping through the installed waste transfer line and surface sprinkler lines. The liquid wastes will be applied to a different part of the field each time.

Apply waste material at least 100 feet from streams and water courses. Apply the waste on land and where it will soon be incorporated into the soil or where a good vegetative cover has been established.

Waste should not be spread on fields which may be flooded prior to incorporation of the waste into the soil.

Waste should not be spread within 24 h of a predicted rain, unless it can be incorporated at the time of application.

Waste spread on fields should be incorporated within 48 h to reduce the loss of available plant nutrients.

Small berms (approximately 1 foot in height) will be constructed on the field edges, in fence line, to keep waste materials on the fields.

The spreading of waste material on frozen soils or snow will be avoided to prevent pollution problems.

The timing and application of all nutrients (animal wastes) will be done when possible to meet plant needs. Application methods will be done in a way that will minimize leaching and runoff problems.

### **Operation and Maintenance:**

Waste management system components will be inspected and maintained as follows:

Concrete structures should be inspected annually. Check walls and floor, when the facility is empty, for cracks and/or separations. Check backfill areas around structure for excessive settlement. Determine if the settlement is caused by backfill consolidation, piping, or failure of the structure walls or floor. Make necessary repairs as rapidly as possible.

To prevent erosion, a good vegetative cover should be established and maintained on berms, embankments, and waterways. Vegetative plantings should be clipped 2 to 3/yr to kill noxious

weeds and encourage a vigorous growth. If the vegetative cover is damaged, the area should be revegetated as soon as possible.

Fences and safety barriers will be installed and maintained to prevent unauthorized people or livestock entry. Fences and barriers should be inspected at least annually and repaired when necessary.

Do not allow the operation of any equipment next to the walls or on the structure floor, which may cause major damage. Be careful when emptying the concrete structures; do not push on or bump the walls too hard.

The vegetative cover on the spring area next to the dairy unit will be reseeded as specified. The grass cover and the wetland vegetation will be allowed to grow and become well established. To maintain health and vigor of the plants, the plants can be moved or grazed on a regular basis. The period of time and number of animals allowed to graze the area will be controlled. Animals will not be allowed to graze the spring during wet periods or during the winter.

All loading and hauling equipment will be kept in good operating condition and operated in a safe manner (i.e., good brakes, spill tight gates, etc.).

Plan Recommended by: \_\_\_\_\_  
Soil Conservation Service—Logan F.O.

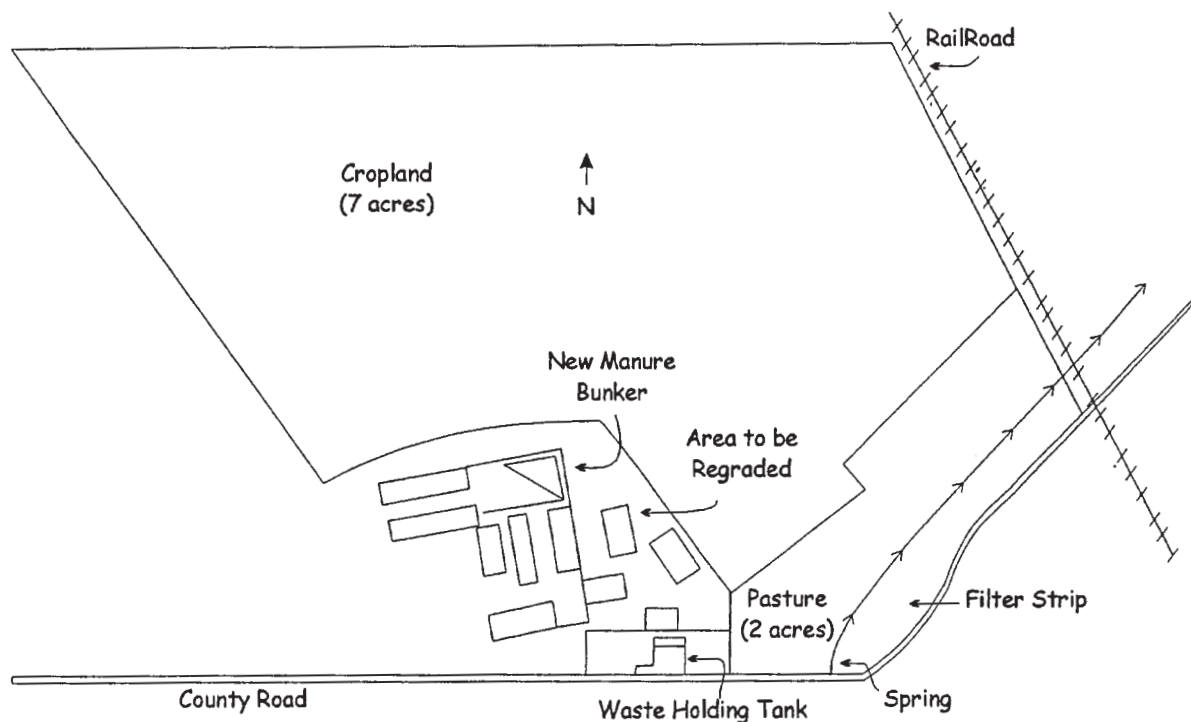
Plan Accepted by: \_\_\_\_\_  
Owner/Operator

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## APPENDIX B

### Conservation Plan Map for Chet's and Todd's Animal Waste Management System<sup>2</sup>



<sup>2</sup> This is a sketch produced by NRCS summarizing the physical changes as per Chet's and Todd's decisions.

# Eagle Creek Landfill: A Decision Case Study<sup>1</sup>

C. M. Biegel, J. G. Graveel, L. S. Lee, and J. J. Vorst\*

## ABSTRACT

Hickory Hills Development Company, a Virginia-based company, affiliated with USA Waste Services, had proposed to develop and operate a municipal solid waste landfill (sanitary landfill) in Eagle Creek Township located in the southernmost part of Lake County. The site was zoned for agricultural use and, therefore, not suited for use as a landfill unless rezoned for light industrial use, Conditional Development District (CDD). The rezoning request submitted by Hickory Hills was heard by the Plan Commission with the inference that a rezoning would facilitate the landfill proposition. Proponents of the new landfill stated it would provide many benefits to the citizens of Lake County: It would guarantee landfill space for many years into the future, and create jobs, tax revenue, school funds, and host fees for the Eagle Creek community. Landfill opponents, however, voiced concerns about the project, principally the location of the site. Limited and seemingly conflicting information regarding the suitability of the site for a landfill surfaced. The Plan Commission was to meet and consider the available information before deciding whether to grant the rezoning request.

LANDFILLS can cause a multitude of problems: water contamination, noise pollution, air pollution, health risks, vectors, vermin, erosion, blowing trash and dirt, and a negative impact on the growth and development of an area. Every part of a landfill has the potential to eventually degrade and breakdown. If the ground and surface waters are contaminated by the landfill, no alternate water supplies are available to the residents. With the siting of the Hickory Hills landfill in Eagle Creek Township on the southern edge of the Valparaiso Moraine, valuable farmland will also be lost.

## THE CASE

Mr. Dean Jones, the Lake County Cooperative Extension Educator since 1973, faced a dilemma. As a member of the County's Plan Commission, he was responsible for making decisions regarding the planning and development of unincorporated areas in Lake County, Indiana. Dean had degrees in both animal science and community development.

The nine-member Plan Commission board was involved in the planning and development of the county's unincorporated areas. Five of the Plan Commission members were citizens appointed by the county commissioners who served

staggered terms of office. The remaining four members were ex-officio: a county commissioner, a county council member, the county surveyor (or his designee), and the county cooperative extension educator, Dean Jones. A major responsibility of the Plan Commission was to hear zoning requests and then make recommendations to the County Council for final approval. The County Council typically accepted the decisions the Plan Commission made. In deciding whether a rezoning request was in the county's best interests, the Plan Commission considered: the county's most recent comprehensive plan, the present conditions and character of the land, the most desirable use for the land, conservation of property, and responsible growth and development.

For 8 h, Dean had listened to arguments both for and against Hickory Hills' rezoning request. Hickory Hills Development Company presented its case, emphasizing the services it would provide to the community. The new landfill would include landfilling capability, recycling facilities, and household hazardous waste collection. The county would have landfill space for many years to come and bring jobs and money into the community. After Hickory Hills spoke, remonstrators in the courtroom contributed additional information about the issue at hand and some strongly worded opinions. The local newspaper, *The Times*, had correctly predicted an emotional hearing. Ernie Niemeyer, a Plan Commission member, was quoted in the newspaper article as saying "I feel the pulse of the people is that it's not being handled right." As Dean listened carefully to each remonstrator, he tried to sort through and prioritize the case's many issues. He deduced that the issues seemed to be environmental, economic, political, and social in nature. It appeared like the arguments could go on all night. Dean had made many decisions that have influenced Indiana counties, but he couldn't remember any as highly charged and divisive as the one he now faced. He worried that he would not be able to adequately evaluate the reliability and importance of all the information he'd heard.

Both sides had argued their points since the meeting began at 7:00 p.m. By 2:55 a.m. the emotions were still running high. A decision had to be made: Was it in the county's best interest to grant Hickory Hills their rezoning request so they could continue with the landfill proposition? Dean had to weigh the county's needs, the available site information, as well as public opinion. Since a call for a vote had just been made, Dean's time of decision was at hand. Should the farmland be converted to a landfill?

## The Decision to Build the Landfill at Eagle Creek

Before the meeting the Lake County Solid Waste Management District Board evaluated three potential landfill sites in the county. The Eagle Creek site (Exhibit 1) was

**Abbreviations:** CDD, Conditional Development District; SCROD, South County Residents Opposed to Dumps; DNR, Department of Natural Resources; IDEM, Indiana Department of Environmental Management; ATEC, American Testing and Engineering Corporation.

<sup>1</sup> This journal uses SI units, according to the ASA-CSSA-SSSA style. Due to the circumstances of this case study, however, English units are used, either alone or along with SI units.

Purdue Univ., Dep. of Agronomy, 1150 Lilly Hall, West Lafayette, IN 47907-1150. Approved for publication as Purdue Agric. Educ. Journal Paper no. 32. Received 26 Sept. 1997. \*Corresponding author (jvorst@dept.agry.purdue.edu).



chosen after considering several criteria related to community, economic, and environmental issues. Of the three potential sites, Hickory Hills had the largest available area and the smallest population density near the site. It also had the greatest depth to groundwater and was the only one that could be constructed above the zone of groundwater saturation.

The legality of the Board's 12 to 11 vote that selected this site, however, had been called into question. A group called SCROD (South County Residents Opposed to Dumps) filed a lawsuit requesting the vote, which awarded Hickory Hills the landfill contract, be voided due to the ineligibility of two Board members (Exhibit 2). SCROD, a community group formed in early 1994 to fight the proposed landfill, consisted primarily of residents near the site, many of whom were commercial farmers and had lived there all their lives. Just recently, the city of Crown Point filed an additional lawsuit questioning the eligibility of yet another Board member. In Lake County, if a city or town had a landfill or waste incinerator within its boundaries, it was granted a seat on the Lake County Solid Waste Management District Board. The three disputed Board members came from cities or towns in the northern part of the county that had incinerators or landfills that were either no longer operating or were operating without proper licensing. Because of the operational statuses, the lawsuits alleged that these cities or towns should not have been granted memberships on the Board. All three of these disputed members voted in favor of the Hickory Hills site. If a judge eventually ruled that this vote was indeed illegal, the Lake County Solid Waste Management District Board would be required to revote on the choice of the landfill site. By that time, all new board members would have been elected, and the Hickory Hills site may no longer be selected. Without the contract with the county, the economic feasibility of the new landfill would be jeopardized.

### Is There a Need for the Eagle Creek Landfill?

Before the meeting, SCROD distributed copies of their Analysis and Research Report to as many residents as possible in which they concluded that the landfill was unneces-

sary (see Exhibit 3, page from the report). Two landfills were already operating in the county and an additional landfill had recently opened nearby, which was actively seeking Lake County's waste. Two other nearby landfills had also offered to take Lake County's waste for a guaranteed minimum of 20 yr. This guarantee would satisfy the county's current objective for having a 20-yr solid waste plan. SCROD estimated that Lake County would require only 9.84 ha (25 acres) of landfill space for the next 20 yr.

As a result of a state-mandated goal of waste reduction, the county has already significantly reduced the volume of its wastestream through recycling efforts, and would continue to do so in the future. The proposed Hickory Hills landfill would be a *mega-landfill*. To be profitable, it would require a minimum of 1800 metric tons (2000 U.S. tons) of waste per day, making it one of the largest in Indiana and perhaps the entire midwestern USA. While Lake County was generating this volume of waste, much of it was contracted to other sites. Each of the 17 cities and towns in Lake County independently contracted for its own waste removal and landfilling. The contracts were typically 2 to 3 yr in duration and were renewed on a staggered basis. Estimates indicated that Lake County could supply only about 450 metric tons (500 U.S. tons) of waste per day to the new site. The majority of the waste, therefore, would have had to come from out-of-state sources indefinitely.

The Lake County Solid Waste Management District Board's Citizen Committee, composed of volunteers, had repeatedly opposed the Hickory Hills landfill. It had recommended that the county actively seek a landfill that would accept only county waste. A committee member was quoted as saying, "It is one thing to ask residents to put up with the environmental and other impacts of taking care of their own trash, and quite another to ask them to accept the risks for other communities."

In addition, rezoning from agricultural to light industrial was contrary to the county's goals. The most recent "Lake County Comprehensive Plan for Unincorporated Areas" (Lake County Plan Commission, 1996, unpublished report) reported that the county was losing an average of 405 to 810 ha (1000–2000 acres) of farmland to development each year.



Exhibit 1. Photograph of the proposed landfill site in Eagle Creek township.

Preserving and protecting the agricultural areas was considered essential to the state's economy. The plan also stated that "Many of Lake County's outdoor recreation areas and natural open space systems are not protected by land-use management programs and are highly sensitive to continuing growth pressures." The Department of Natural Resources (DNR) and other nonprofit organizations had been buying land throughout Indiana in an effort to increase and protect the wildlife areas. The report further stated: "The amenities of southern Lake County (scenic quality, open space, productive agricultural land, natural systems and small town character) are threatened by development pressures." A weakness specifically identified in the plan report for the Tri-Creek area was "inadequate political representation." The plan also indicated that "increasing road congestion" was one of the current "threats" to Eagle Creek.

People who supported the landfill expressed concern that the older landfills in the county would soon reach their capacities and have to be closed. They also argued that a new state-of-the-art landfill would be less likely to contaminate the groundwater, provide many years of landfill space, and eliminate the need to depend on other municipalities and outside private companies for waste removal. Among other things, the facility would provide recycling capacity and household hazardous waste collection, and generate revenue for the Eagle Creek community through its host fees.

### Description of the Landfill Operation

The landfill site proposed by Hickory Hills would occupy about 130 ha of a 227-ha (320-acres of a 560-acre) site

B-2 Friday, June 21, 1996

## Eagle Creek Landfill Foes Challenge Vote

BY BOB TITA  
Times Staff Writer

Last month's vote on a contract for the proposed Eagle Creek Township landfill should be invalidated because of unauthorized members on the Lake County Solid Waste Management Board, according to landfill opponents.

South County Residents Opposing Dumps contends that Griffith and East Chicago are each entitled to only one board representative, instead of two members from each community.

"I feel the vote was illegal because of those two seats," said John Bryant Jr., a spokesman for SCROD.

Bryant said SCROD leaders are considering legal action because the outcome of the May 23 vote may have been different if the board had 25 members instead of 27. In the 12-11 vote to approve the county's contract with USA Waste Services-Hickory Hills Inc., East Chicago City Engineer Rich Sobilo voted for the contract, while East Chicago Mayor Robert Pastrick was absent.

Bryant said Pastrick should have been the only East Chicago representative eligible to vote on the contract because he is the mayor.

Bryant said Griffith also deserves only one vote on the board. Griffith Councilman Stanley Dobosz voted for

the contract, while the town's other representative, Councilman Rick Konopasek, was absent from the meeting at the county government center in Crown Point.

Jeff Langbehn, executive director of the Lake County Solid Waste Management District, said the legality of the extra members was addressed more than a year ago by Clifford Duggan, the solid waste district's attorney.

"The statute that created those positions gave us no guidance on removing them," Langbehn said Thursday. "Therefore, they're still there. I think Mr. Duggan's logic is wellreasoned, and I don't have a problem with it."

The 1991 legislation authorizing county solid waste boards provided that communities with landfills and incinerators be granted extra members. Because East Chicago had a trash incinerator and Griffith had a landfill, those communities received two members each. Gary was afforded extra members because it too has a landfill and is the county's largest municipality.

Since late 1993 the East Chicago incinerator has been inactive and the Griffith landfill no longer accepts trash.

Because of the prolonged inactivity at these waste facilities, SCROD maintains East Chicago and Griffith should have lost the extra board members.

Langbehn argues the incinerator and the landfill are indeed dormant, but they are not legally closed.

Neutralysis Industries Development Co. of Northfield, IL has applied for

state permits to retool the East Chicago incinerator into a facility that would transform trash into a rocklike material by burning it with clay and ash.

"It's not closed. It's in a state of limbo," said Langhegn, noting the permit applications haven't been acted on or withdrawn.

Griffith is in the midst of a six-year landfill shutdown plan that was authorized by the Indiana Department of Environmental Management. Langbehn said work is under way to comply with the state's environmental requirements for closing a landfill.

Langbehn said IDEM officials have concurred with the Duggan's assessment that no mechanism or standards exist for determining when some solid waste board members become ineligible.

"IDEM is coming up with the same conclusion we are," Langbehn said. "This is a gray issue."

IDEM has avoided involvement in the dispute over the alignment of the Lake County solid waste board, despite SCROD's appeals for help.

"We don't have jurisdiction over that," IDEM spokeswoman Jo Lynn Ewing said Thursday. "It's a local issue. It's something the state doesn't get involved with."

Ewing said IDEM's position doesn't preclude SCROD leaders from taking their complaints into court or appealing to the Indiana attorney general for an interpretation of the solid waste legislation.

(Exhibit 4). More than 90% of the ground surface elevation within the disposal area would be higher than 210 m (690 ft) above sea level. The landfill could accept up to 5900 metric tons (6500 U.S. tons) of waste each day, assuming the landfill could operate under high-intensity lighting an average of 6 d each week. Besides landfilling, the site would also provide a recycling facility, a yard waste composting facility, a household hazardous waste collection facility, a consumer drop-off facility for nonhazardous municipal solid waste, a construction-demolition waste disposal facility, a nonhazardous soil remediation facility, a generation plant to con-

vert landfill gases to electricity, and a soil borrow pit. Accessories for the aforementioned operations, such as an office building, scales, maintenance facilities, and leachate collection system would also be located on-site.

This landfill would meet or exceed all Indiana and federal regulations. The design, referred to as a *watertight bowl*. An impermeable layer was to be placed at the bottom of the site and, when the site was eventually closed, a water-impermeable layer was to be placed on top. Monitoring of the site for 30 yr following closing was required by law.

An extensive liner system, leachate, and methane gas collection, as well as monitoring systems, would be installed at this site. To help visually screen the site, a 60-m (200-ft) buffer zone made of a mixture of small ornamental, shade, and evergreen trees and a 7.5-m (25-ft) high berm was proposed to surround the site (Exhibit 4). After closing, Hickory Hills planned to convert the site to a public recreational area to include an 18-hole golf course, tennis courts, ski slopes, walking and jogging trails, picnic pavilions, and baseball and soccer fields. Hickory Hills had stated that it wanted the facility not only to be a state-of-the-art landfill but for it to be a future source of enjoyment to the local residents.

The landfill was expected to generate revenue in excess of \$1 billion over its lifetime. Besides providing jobs and generating tax revenue, Hickory Hills would pay *host fees* of \$1.00 per U.S. ton of waste accepted at the landfill to Eagle

**DOES LAKE COUNTY REALLY NEED  
A NEW LANDFILL?**

**THE BIGGEST WASTE HAULERS HAVE BUILT  
MORE LANDFILL CAPACITY THAN THE  
NATION NEEDS.**

Browning-Ferris owned 600 million cubic yards of unused capacity in 1984. They tripled that, to 1.7 billion cubic yards, in 1991, and plan to nearly double that again, to three billion cubic yards, by the year 2000. According to estimates by the EPA, that will represent a 10-year supply for the nation as a whole. And that is just one company. Waste management won't say how much its unused capacity is, but the WALL STREET JOURNAL estimates from 650 million to a billion tons.[1]

**RECYCLING AND WASTE REDUCTION HAVE  
BEGUN TO CUT INTO THE AVAILABILITY  
OF TRASH.**

Lake County's recycling program is just getting a good start. It has cut the amount of trash to the dumps by 35% already! Some towns around the nation have reached a 73% recycling rate, and other towns have instituted a pay-per-bag garbage plan that has got people focused on buying things differently, to reduce their personal waste and thus their personal costs. [2]

**YOU MUST ASK YOURSELF AND THE OTHER  
BOARD MEMBERS...**

If there is already plenty of landfill space nearby, why should we destroy another area to make more landfill space?

We always hear that we need to be responsible for our own trash. Don't you think that when the county reaches a 70+% recycling rate, that would be considered responsible?

[1] Jeff Bailey, "Space Available: Economics of Trash Shift as Cities Learn Dumps Aren't So Full," WALL STREET JOURNAL June 2, 1992, pg. A1.

[2] Editorial, "The price of garbage pickup is in the bag." The [Bergren, NJ] Record June 24, 1992.

Exhibit 3. Page from SCROD's "Analysis and Research Report" (SCROD, 1996).

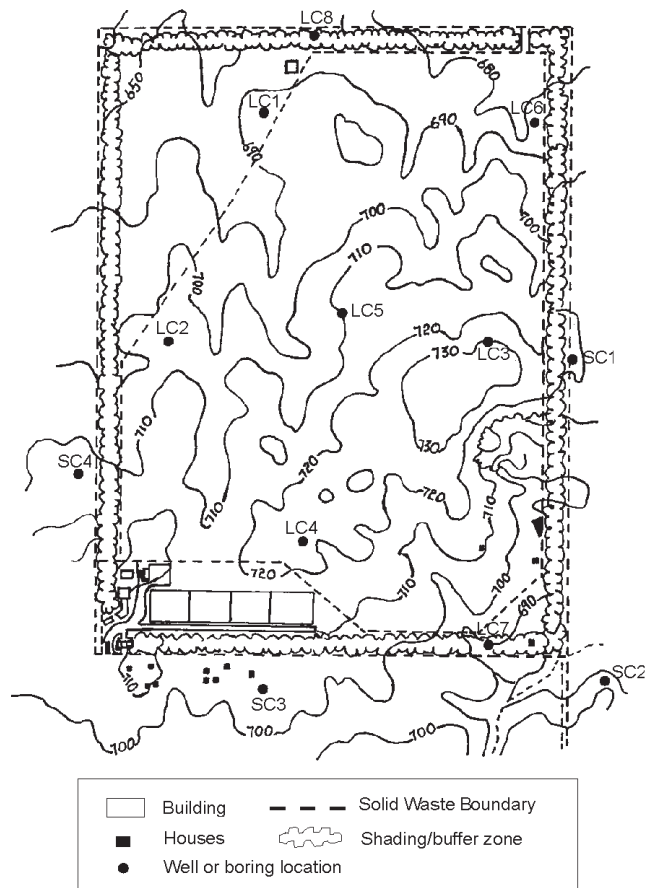


Exhibit 4. Proposed landfill operation with test boring and well locations (Hickory Hills).

Creek Township. Depending on the tonnage, Eagle Creek Township could receive between \$572 000 and \$858 000 every year, which would be used to fund the local school district and reduce property tax liability. The County Solid Waste Management District Board would also receive an identical amount plus \$25 per U.S. ton tipping fee. None of the fees paid to the Board was scheduled to go to Eagle Creek.

### Description of the Site

The population density near the site chosen in Eagle Creek was approximately 31 persons per square mile, which was considered low. The area was zoned almost exclusively for agricultural use. The site was located within the Kankakee River Basin, on the southern edge of the Valparaiso Morainal area, near the northern edge of the Kankakee outwash and Lacustrine plain, and was one of the highest elevations in the county (Exhibit 5). There was some confusion regarding the proposed positioning of the landfill as noted in Exhibit 5. A geologist hired by SCROD placed the site closer to the aquifer than what Hickory Hills reported. Based on information published by Schneider and Keller (1970), Hartke et al. (1975), and Gray (1989), groundwater elevation was approximately 200 m (660 ft) above sea level. The average depth to groundwater was about 15 m (50 ft). Groundwater flow was generally south toward the Kankakee River. Both the site topography and stratigraphy were locally variable. Underlying the Valparaiso Moraine was a thick glacial outwash layer known as the Valparaiso Aquifer, which was, in turn, typically underlain by another till or clay layer. The aquifer was composed of sand and gravel with interbedded cohesive soils, which may have been glacial till or lacustrine deposits. This outwash extended out from under the moraine to the south, where it was the surficial unit known as the Kankakee aquifer.

### Soil Sampling Data

The soil at the Eagle Creek site was alleged by some not suitable for a landfill. "You've got lousy soils up there," according to Dr. James Segedy, a professor in the Department of Urban Planning at Ball State University (Exhibit 6). There were no specific requirements on the number or type of soil samples needed for a rezoning request since rezoning requests were not the same as landfill operating permit requests. Without proper zoning, an Indiana Department of Environmental Management (IDEM) landfill operating permit would not be issued. The IDEM would become involved in the case only after the operating permit request was filed. Requirements for the permit included a minimum of 66 on-site soil borings and a site-specific hydrogeologic evaluation (Indiana Administrative Code Title 329). The additional borings and hydrogeologic evaluation would be conducted if and when the land was rezoned.

Two sets of four soil borings each and four test wells had been made at the site before the rezoning request to assess soil types and depths to the groundwater. Sampling and well locations are shown in Exhibit 4 and test results are summarized in Exhibits 7 and 8. The first set (LC-1–LC-4) was contracted by Hickory Hills and done by ATEC Associates, while the second set (LC-5–LC-8) was contracted by the Lake County Solid Waste Management District Board and done by K&S Testing and Engineering. All borings were sampled with a split spoon device and most samples were continuously sampled borings.

Results from the ATEC borings indicated that the morainal deposits (glacial till consisting of silty clays) extended down to an elevation of about 200 m (660 ft), where the upper portion of the Valparaiso aquifer was encountered. ATEC reported that this information conformed with the previously published accepted regional

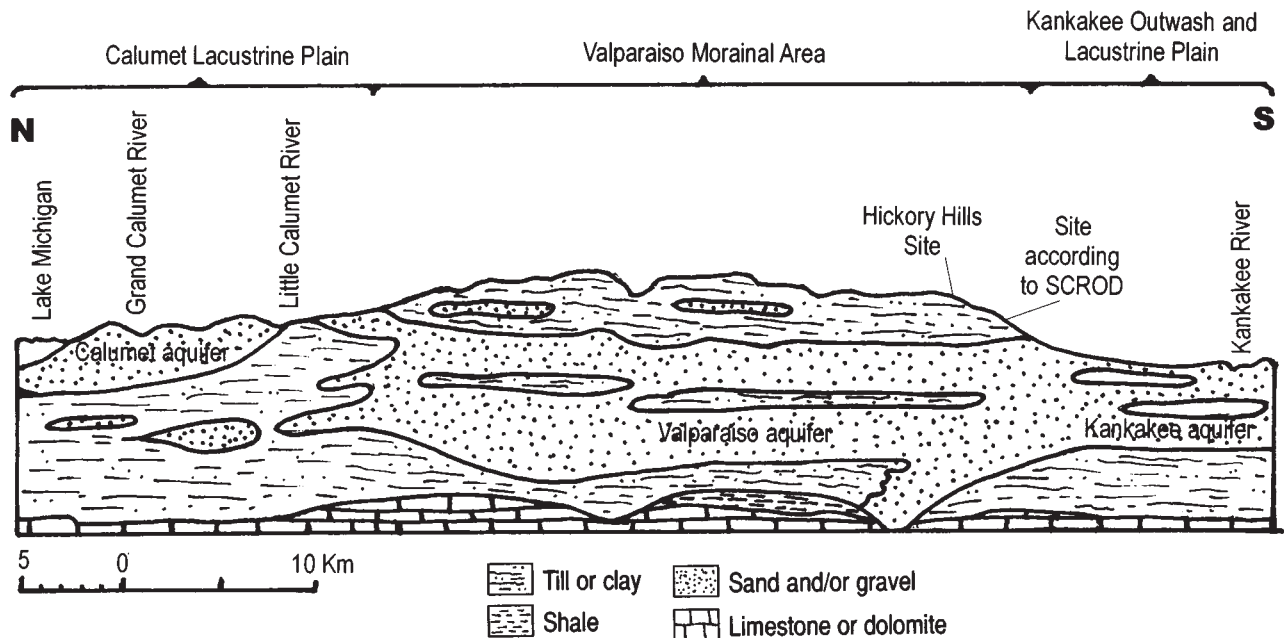


Exhibit 5. Regional north-south geologic cross section (Gray, 1989).

geologic mapping. They concluded that a large portion of the site had a substantial clay thickness above the Valparaiso groundwater aquifer. Consequently, ATEC judged the site to be suitable for a landfill since a minimum of 3 m (10 ft) of clay could be maintained below the bottom of the landfill at elevation 200 m (660 ft) and above the aquifer. K&S reported that their boring results agreed with the ATEC data. SCROD, however, expressed concern that cores sampled with the split spoon may not result in a proper representation

of the soil at the site. A split spoon device is most effective at recovering cohesive, compressible soils such as clays and has more difficulty recovering loose sands and gravels. Therefore, any time cores have <100% recovery, there is a risk that split-spoon sampling will skew the data, indicating a higher density of clay than what actually exists.

The depth to groundwater based on the boring log data had been challenged at the meeting. No wells were installed in either the ATEC or K&S borehole locations. K&S and

# Professor Fears Tainted Water

## Landfill site makes urban planner 'nervous'

### 'You've got lousy soils up there.'

Dr. James Segedy; Ball State professor who has studied the environment of Lake County.

THE TIMES

A Ball State University professor who has, for the last two years, studied the environment of Lake County strongly discourages siting a landfill in Eagle Creek Township.

"It makes me real nervous," Dr. James Segedy said of the Eagle Creek site proposal. He said his fear is based upon possible groundwater contamination. The soil in the Three Creeks area is not stable enough to support the landfill operation, Segedy said. And he points to the noise and dust that truck traffic to the site would create.

Segedy, a professor with Ball State University's Department of Urban Planning, has headed the university team charged with drafting a master plan for unincorporated Lake County. That plan, which will be discussed at a public forum tonight, takes a look at critical issues regarding unincorporated Lake County's transportation, growth, economics and environment.

The unincorporated, agricultural areas within the Three Creeks area—Eagle Creek, West Creek and Cedar Crook townships—are covered in the report with respect to how Ball State recommends the land be developed.

BY DIANE KRIEGER SPIVAK  
Times Correspondent

### Public forum

**What:** The final draft of the plan for unincorporated Lake County will be unveiled tonight at a public forum. The critical issues include: the county's rapid development to minimize sprawl that is encroaching into farm-land, improving air quality, expanding transportation systems and coordinating water treat services.

**When:** 7 tonight

**Where:** Commissioners/Council Chamber, Lake County Government Center, 2293 N. Main St.

**What's next:** The plan will be presented again in its entirety to the Lake County Plan Commission for public hearing purposes at the commission's July 2 meeting.

Segedy's opinions on the suitability of the site for a landfill are not contained in the written report.

Still, Segedy is concerned about the impact of the landfill.

"Generally, we think (the Three Creeks areas) should not be heavily developed. They can deal with some development, but not anything of that nature.

"In our plan we certainly discourage it. I don't think it's a good location," Segedy said. "The soils are not conducive to a landfill operation. You could get leachate into the groundwater."

Landfill construction standards aside, Segedy is concerned about seepage from the proposed site. "I know

they have to be managed, and there are all kinds of restrictions that they have to follow, but I haven't known a landfill yet that's been able to be perfect."

Segedy admits he does not claim to be a "soil scientist or a subsurface hydrologist, but my guess is, if something got into the groundwater system because of the high water table and because it is such a natural, free-flowing groundwater system, it would spread quickly."

Not to be dismissed, Segedy said, is the wear and tear by garbage trucks on the road leading to the proposed landfill, as well as the noise and the dust that could be generated from the traffic.

County Plan Commissioner William Putz shares Segedy's concern about the water quality.

"It would seem a difficult place (for a landfill)," Putz said. "You don't know what's going to happen to the water, and there's no other water available. If it drops into the water table and pollutes the wells around there, where are you going to go?"

"There's no plan to bring Northwest Indiana water out there. Are they going to provide bottled water? I doubt it."

John Bryant Jr., a spokesman for South County Residents Opposing Dumps, said his organization plans to attend the public forum.

"If they want to preserve the agricultural land in the area, this mega landfill is not the thing to promote it," Bryant said.

Segedy returns to the soil argument. "The bottom line is, I don't think that's the best area (for a landfill). You've got lousy soils up there."

Exhibit 6. Newspaper article questioning suitability of the proposed landfill site in Eagle Creek (Spivak, 1996).

ATEC measured the depth to groundwater, the depth from ground level to the top of the water in the hole, immediately upon completion of drilling (Exhibit 8). However, the rule-of-thumb for clayey soils is to wait at least 24 h after drilling before measuring water levels. Water levels can either rise or fall over time depending, in part, on the type and order of the soil layers present. SCROD alleged that Hickory Hills presented skewed soil and water information to gain approval for their project. In 1995 SCROD hired an independent research company, Hydro-Search, to study the site. Hydro-Search reported that data from two of ATEC's

four well logs indicated a discrepancy of 6 m (20 ft) in the water level taken during and after boring completion. (The water levels in these two holes actually dropped upon waiting.) SCROD installed piezometer wells near the site perimeter. The results from these wells, SC-1-SC-4, are also summarized in Exhibit 8. No other site-specific information regarding the hydrogeology of the site, such as direction and speed of groundwater flow, and locations of glacial outwash stream beds within the till had been collected before the rezoning request.

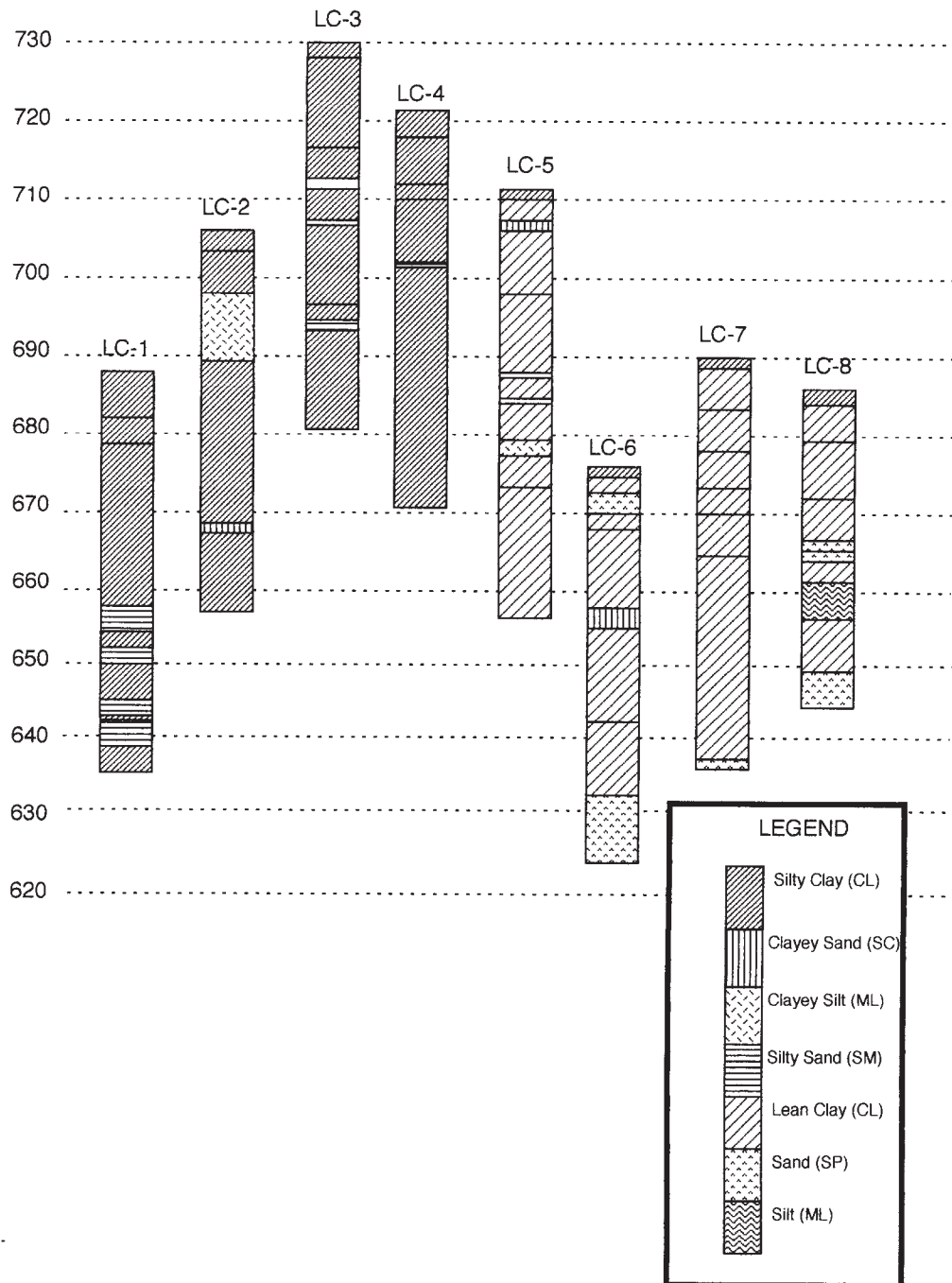


Exhibit 7. Soil descriptions for soil borings LC1-LC4 sampled by ATEC Associates and LC5 - LC8 sampled by K&S Testing and Engineering (McDonough Environmental, 1995, unpublished report).

## Public Opinion

There had been much opposition to the landfill, repeatedly referred to as the “unpopular 360 acre landfill” in the local newspaper. Some southern Lake County residents were prepared to secede from the county to block the landfill. Residents feared that the county would be overwhelmed with out-of-state solid waste. The site, already one of the highest elevations in the county, would become a mountain of garbage and one of the first things people saw as they entered the area. Residents were not convinced that the county even needed a new landfill, especially one of this size. A small but vocal minority even alleged that Hickory Hills *bought* the Lake County’s Solid Waste Management Board’s approval for the project with the promise of community host fees and out-of-state tipping fees. Gary, a city located in the northern part of the county, was scheduled to receive the largest percentage of these moneys.

Residents who lived near the proposed landfill feared problems frequently associated with landfills. Not all of their fears were groundless since the company that would operate the Hickory Hills landfill, USA Waste, was known to have used poor landfill management techniques in the past. SCROD had videotaped a small, 85-acre landfill in Buffalo, IN, which USA Waste operated. The video was taken during one of its many *white-outs* caused by extensive blowing and drifting of trash. In an effort to reduce some of the residents’ concerns, Hickory Hills had developed a property value guarantee program in which homeowners within one-half mile of the site would be reimbursed the full amount of any devaluation of their property from the current market value. Homeowners located 0.8 to 1.6 km (0.5–1 miles) away would be compensated for only the house and up to one surrounding acre. Hickory Hills would be bonded as required for all permitted landfills.

## Environmental Concerns

The large site area and its heterogeneity heightened environmental concerns. SCROD had warned people that the proposed site was actually topographically lower and the aquifer higher than what are being reported. Without additional geological and hydrogeological information, SCROD maintained that the environmental risks the landfill posed could not be adequately evaluated. There was too little geological and hydrogeological information available on the site. The outwash channels, filled with sand and gravel, could act as conduits for contaminants. The old stream beds, which are often relatively narrow and meandering, are difficult to intercept without numerous soil borings. Hickory Hills countered SCROD’s arguments by again stating that the landfill would meet or exceed all Indiana and Federal Regulations.

Ned Bleuer, a geologist with the Indiana Geological Survey, ranked the site’s aquifer sensitivity an 8 (on a 20-point scale where 1 is the least sensitive and 20 is the most). The sensitivity scale estimated the rate at which contaminants leaving a site might enter a nearby aquifer. Sites that have either no aquifer or one that is at considerable depth below ground surface are ranked 1. Bleuer’s evaluation was made using ATEC’s soil borings and 31 Indiana Geological Society data base records. He pointed out that the presence of the aquifer automatically made the site inherently “sensitive” but stated that “with a thick clay base and good lateral seal, the aquifer at the site was unlikely to be affected by the landfill.”

The waste disposal area could be built above the Valparaiso aquifer with at least 3 m (10 ft) tight clay supplementing the proposed synthetic lining, which would reduce the risk of groundwater contamination. The site had good natural drainage. Stormwater that contacted the solid waste would be handled as leachate. It would be collected, stored on-site, and then transported to a wastewater treat-

Company	Ground Elevation	Date/Time Drilled	Date/Time Logged	Static Water Level
<b>ATEC</b>				
LC1	685 ft. (209 m)	02/03/94	†	31 ft. (9 m)
LC2	705 ft. (215 m)	02/02/94	†	42 ft. (13 m)
LC3	728 ft. (222 m)	02/01/94	†	28 ft. (8.5 m)
LC4	720 ft. (220 m)	02/02/94	†	44 ft. (13 m)
<b>K&amp;S</b>				
LC5	710 ft. (216 m)	10/09/95	†	29 ft. (9 m)
LC6	675 ft. (206 m)	10/09/95	†	35 ft. (11 m)
LC7	690 ft. (210 m)	10/10/95	†	42 ft. (13 m)
LC8	685 ft. (209 m)	10/10/95	†	35 ft. (11 m)
<b>Hydro-Search</b>				
SC-1	715 ft. (218 m)	6/10/95	6/24/95	67.4 ft. (21 m)
SC-2	676 ft. (206 m)	6/21/95	6/24/95	23.7 ft. (7 m)
SC-3	695 ft. (212 m)	6/10/95 (9:00 am)	6/10/95 (12:00 p.m.)	48.7 ft. (15 m)
SC-4	715 ft. (218 m)	6/14/95	8/31/95	49.7 ft. (15 m)
† immediately after drilling				

Exhibit 8. Water level results (ATEC Assoc., 1994, unpublished ATEC boring logs; McDonough Environmental, 1995 unpublished report; Hydro-Search, 1996, unpublished report).

ment facility off-site. Surface water that had not directly contacted the waste would be diverted through a run-off control system designed to collect and control the run-off from the active portion of the landfill. No nonstormwater discharges from the site would be made.

Opponents of the landfill stated during the meeting that if the ground and surface waters near the site became contaminated by landfill leachate, the consequences would be severe since both area residents and businesses used the waters. Indiana solid waste management regulations required landfill permittees to replace any currently used sources of groundwater in the event of contamination. Despite their proximity, neither Lake Michigan nor the Kankakee River could be used as a water source. Digging deeper wells would also be unacceptable because of high levels of naturally occurring fluoride. Fifty-nine homes were located within a 1-mile radius of the site, each with its own drinking well. The nearest private drinking well was approximately 300 m (1000 ft) from the site. The nearest significant groundwater pumping facility was approximately 2.4 km (1.5 miles) east. Eagle Creek, also known as Singleton ditch, drained the site, and eventually emptied into the Kankakee River. There were 15 registered *significant withdrawal points* off Singleton ditch below the landfill site from which water for crop irrigation was drawn. Uncontaminated water is essential for food production. Even if the risk of contamination was low, the potential consequences were high. SCROD likened the situation to the *storing dead rats in one's refrigerator*.

SCROD insisted repeatedly during the meeting that all landfills eventually leak. In addition, because of the *water-tight bowl* design, it was highly unlikely that leachate problems would show up until after the 30-yr postclosing monitoring period had ended. As a result, the leaks would not be quickly identified and stopped. The source of SCROD's environmental information had been primarily *Rachel's Hazardous Waste News* (<http://www.erf@igc.apc.org>), a biweekly newsletter that summarized the results of research in the area of landfill contamination and leakage. Rachel's newsletter had reported that the USEPA admitted that the new advanced containment systems would only delay the introduction of leachate into the environment. The USEPA stated that every part of the landfill will eventually degrade and breakdown, and "even when properly carried out, closure cannot guarantee against long-term environmental problems at landfills." Liner damage, which can be damaged by lightning strikes (especially if the site is located at a high elevation and/or has a large area), and chemical and physical pressures in landfill masses, is inevitable. Many ordinary household products, such as margarine, shoe polish, and even alcohol, can degrade the polyethylene liner. Some organic chemicals had been shown to diffuse through a three-foot thick liner in as little as 3 yr. Because of the limited site-specific information and the site's heterogeneous nature, locating a liner leak would prove difficult, according to SCROD.

### The Decision

Hickory Hills' rezoning request was up for a vote. Dean Jones needed to decide what his vote would be. How should Dean vote?

## TEACHING NOTES

### Case Objectives

- Upon completion of this case, students should be able to:
1. Evaluate risk potential, consequences of risk, and levels of risk associated with solid waste disposal.
  2. Identify factors to consider when evaluating a site for a landfill.
  3. Describe the appropriate data necessary to assess the suitability of a potential landfill site.
  4. Recognize the potential for misuse of data and identify situations in which data might be used to draw incorrect conclusions.

### Uses of the Case

This case study was designed to teach environmental resource management issues to undergraduates in science, natural resources management, or liberal arts courses. While the case integrates environment, politics, and sociological issues, students may find that some background knowledge of soil science is helpful. Students will use decision-making skills to integrate the scientific, social, legal, economic, cultural, political, and ethical components of the case. The case, based on actual events, provides students an opportunity to conduct preliminary site evaluations and risk assessments even though there may be insufficient, conflicting and/or incorrectly interpreted data. In evaluating the information, students should learn to evaluate both the reliability of the data and its source. One last note: this case focuses on the rezoning request. The importance of political considerations in deciding community issues is emphasized in the fact that even if students decide that rezoning should be granted, the landfill could still be blocked by IDEM denying Hickory Hills a landfill operating permit.

### Implementation of the Case

This case can be used in a variety of ways. For those who are new to case studies, Herreid's (1994) article, "Case Studies in Science: A Novel Method of Science Education," is recommended. Since some students mistakenly believe that the case itself provides all the information they will need to make an educated decision, you'll want to direct them to locate additional sources of information. The students may find helpful Henry and Heinke's (1989) *Environmental Science and Engineering* and website locations, such as <http://www.epa.gov/epaoswer/non-hw/muncpl/landfill.htm>.

Some suggested strategies for using this case include:

1. Assign the case as outside reading and use small group discussions in class to discuss the questions, followed by a general class discussion of what decision should be reached, and how this decision is justified. Memos or written reports could be assigned for grading purposes, if desired.
2. Students can role-play the major characters participating in the rezoning request. This strategy is best for classes with small enrollments. The advantages of role-playing include practice in public speaking and an increased awareness of people's hidden goals and agendas.



**Table 1. Instructor's Reference. List of 19 criteria used by the Lake County Solid Waste Management District Board to evaluate the suitability of three different potential landfill sites in Lake County.**

Criteria	Weight of criteria	Hickory Hills response
Access from interstate interchanges (miles)	88.33	2.50 miles
Litter control program (yes/no)	83.17	Yes
Population density (persons/mi <sup>2</sup> )	78.33	31
Ultimate land use (public/private/none)	77.50	Public
Tipping fee (\$/ton)	75.00	\$25/ton
Fee for host community (\$/ton)	75.00	\$1.00/ton
Flood hazard (floodplain zone)	74.50	500+ yr
Recycling facility (yes/no)	72.50	Yes
Groundwater depth† (depth to aquifer)	71.17	30–60 feet
Area capacity (acres)	70.83	560 acres
Height (above/below grade)		150–200 ft/10–40 ft
Volume (acre-feet)		112 000
Wetlands (percentage of site)	70.00	0.5%
Visual screening (yes/no)	68.33	Yes
Fee for district (\$/ton)	59.17	\$1.00/ton
Construction/demolition recycling facility (yes/no)	59.17	Yes
Local landowner compensation (yes/no)	56.83	Yes
Household hazardous waste program (yes/no)	53.33	Yes
Yard waste/composting facility (yes/no)	51.67	Yes
Educational program funding (yes/no)	45.00	Yes
Historical sites (distance from site)	38.33	0.5+ miles

† Based on Indiana geological survey study.

3. The case could be distributed and read in class, followed by either small group or whole class discussion of the case and/or selected questions from the list of discussion questions. While this method requires the least amount of class time, it also provides for the least opportunity for student reflection on the issues.

A videotape, which can be used to supplement the case, is available. There are four segments to the tape. The first part of the tape, filmed and narrated by the head of SCROD, John Bryant, shows a small, 85-acre landfill in Buffalo, IN, operated by USA Waste, exemplifying one of the many *white-outs* caused by extensive blowing and drifting of trash. The second segment shows the Hickory Hills site. The last two segments of the tape show interviews with people living near the site. The interviews highlight the impact the siting of this landfill has had on the local community. To order a copy of the video, request the “Eagle Creek Landfill Case Video” from Distance & Media-Based Educational Programs., Purdue University, 1586 Stewart Center, Room 116, West Lafayette, IN 47907; phone 765-494-2748, fax 765-494-0567. The cost will be approximately \$20.00.

## DISCUSSION QUESTIONS AND ANSWERS

**1. What environmental impact do you think the Hickory Hills landfill would have?** Students will inevitably realize that there was very little site-specific information available at the time of the rezoning request. Students can be guided in their responses by asking related questions. Does the type of waste that will be placed in the landfill affect the suitability of its design? For example, the disposal of asbestos and petroleum-contaminated soil, which are considered *special* rather than *hazardous* waste, would require no special precautions in the new landfill. How great are the risks of groundwater contamination and surface water contamination? The likelihood and consequences of the environmental impact can be addressed in terms of each of the following: water contamination, noise

pollution, air pollution, health risks, vectors, vermin, erosion, blowing trash and dirt, and the effect on the recent economic growth and development of the area.

**2. How would you prioritize the factors to consider when determining where to locate a landfill?** Students should be able to develop and prioritize a list of criteria important to landfill siting. Table 1 in the Instructor's Reference section lists the actual criteria used in this case. This list can be shared with the students after the students have generated their own lists.

**3. Is it the Plan Commission's responsibility to determine the site's suitability for a landfill?** The Plan Commission has to decide whether it is in the best interests of the county to have a landfill at this site. If the Plan Commission believes that the site is unsuitable for a landfill for any reason, including the loss of productive farmland, or that the county would not benefit from this landfill, they would vote to deny the rezoning request. At the time of the rezoning request, very little soil information was available, making it difficult for the Plan Commission to adequately evaluate the suitability of the soils at the site. An additional factor to consider is that few, if any, of the Plan Commission members had the background necessary to adequately assess the site data. As noted in the case, much more specific site information was collected and analyzed before filing the operating permit application with IDEM.

**4. Which of the issues in the case influenced you the most in making your decision, and why?** Diverse student responses to this question can be expected since this case has strong environmental, political, economic, and social issues. Students may identify how the landfill could change community structure; if economic advantages outweigh the disruption of the quiet, rural lifestyle; or if the groundwater contamination risk is worth the anticipated economic benefit. The relative importance of social issues vs. technical issues can be discussed here. The instructor may need to make sure several issues are not overlooked in technical courses, and vice versa in social service courses.

**5. What additional information would have made it easier for you to arrive at a decision, and why?** Student responses may range from “Since the landfill is completely unnecessary, no additional information is needed to make a decision. Dean should just vote no,” to “People will continue to need more landfill space but there are just too little site-specific data in this case to evaluate the environmental risks. Additional soil borings should be made.” This question can help students realize there are times when a decision must be made when only insufficient or inconclusive information is available. Students may wish to discuss the way to make decisions based on incomplete information. They might prioritize the importance of the available information, and decide which information has the most bearing on the case and should therefore be weighted most heavily.

**6. How do the types of soils at the Hickory Hills site affect the suitability of the site for a landfill?** Refer to the case exhibits for details. Additional questions that could be asked in conjunction with this one include: How does the type of soil parent material affect the complexity of the site? Are there enough site-specific data to adequately describe the soil profiles throughout the site?

**7. Were any of the data used incorrectly to draw incorrect or unjustifiable conclusions?** Using the same data, Hickory Hills and SCROD draw very different conclusions. Both Hickory Hills and SCROD would naturally tend to stress data that support their particular agendas. For example, SCROD reported that the soil boring results show the unsuitability of the site while Hickory Hills says it showed suitability. SCROD used the boring information to support claims that the site is too heterogeneous and too sandy. They further maintained that split spoon sampling skews the data, indicating a smaller amount of sand than is actually present. You can ask students if this is true, or have them further research the issue.

**8. Should a community encourage the construction of a landfill that would be used to accept garbage from outside the state?** Accepting out-of-state waste would increase the landfill's profitability margin. The host community would benefit from the landfill host and tipping fees. Communities that have no landfill space in their state depend on out-of-state facilities to accept their waste. Arguments against accepting out-of-state waste include the loss of available landfill capacity for the home community, increased potential for environmental problems, and possibly less emphasis on recycling. It is solely the decision of the landfill owner-operator whether to accept out-of-state waste or not. The Indiana government can neither ban nor require a landfill take out-of-state waste.

**9. How would you evaluate the validity of the water levels in the wells and boreholes? Are there any discrepancies among the reported information?** These questions require students to critically examine scientific data for accuracy, and to consider any personal biases the data interpreter may have.

**10. As Dean Jones, how would you evaluate the significance, relevance, and accuracy of the information contained in Exhibit 3, SCROD's "Analysis and Research Report?"** This question can be used to stimulate student discussion about potential hidden agendas and biases. See also Question 11 below.

**11. Which of the participants in the meeting do you believe were most influenced by personal or hidden**

**agendas?** Hickory Hills probably would be most interested in the profit to be gained. SCROD members were probably influenced most by concerns about how the landfill would affect their properties and the environment. The Plan Commission members might have political aspirations influencing their opinions.

**12. How did hearing other students' decisions affect your opinion?** This question can be used after everyone in class has had the opportunity to express their views. This question will help students to identify important issues they may have overlooked, and to develop an appreciation for viewpoints other than their own.

## ACKNOWLEDGMENTS

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# The Midwest Oil Pipeline Leak: A Decision Case Study

C. M. Biegel, L. S. Lee, J. G. Graveel,\* and J. J. Vorst

## ABSTRACT

On 13 June 1996 a Midwest Oil Company's<sup>1</sup> pipeline carrying crude oil ruptured, releasing an estimated 360 m<sup>3</sup> (95 300 gal) into a farmer's field in central Indiana. The accident site was approximately 0.4 km (0.25 mile) south of a small rural community. Actions were taken to immediately contain and remove the oil. Approximately two-thirds of the release was either lost to evaporation or recovered during the initial response/cleanup efforts, leaving a large amount of residual oil in the soil. Nancy Hopkins<sup>1</sup>, Midwest Oil's environmental safety supervisor, was in charge of the cleanup. She needed to evaluate the situation and make a recommendation to her operations manager.

REMEDICATION TECHNOLOGIES such as bioremediation, phytoremediation, bioaugmentation, and bioventing are used to clean up many contaminated sites (Pepper et al., 1996; Alexander, 1994). This case study encourages students to evaluate remediation techniques for a petroleum contaminated site. This case is based on an actual situation faced by a supervisor of an environmental company where a pipeline carrying crude oil has ruptured, releasing oil into an agricultural field. The supervisor must make a recommendation to her operations manager on a remediation technique that is quick, economical, and amenable to the property owner.

## THE CASE

### The Accident

At 0017 h on 13 June 1996, Midwest Oil Operations Center noticed a sudden drop in crude oil pipeline pressure. Shutdown procedures were initiated at 0018 h and completed by 0020 h. By the time the line was shut down, approximately 360 m<sup>3</sup> (95 300 gal) had sprayed over a cultivated field, covering an area approximately 150 m by 150 m. Nancy Hopkins, Midwest Environmental Safety Supervisor, arrived with other Midwest representatives later that same morning. At that time, Nancy noted that much of the crude oil had collected in a dry swale approximately 180 m long in the center of the sprayed area. The nearest house was 550 m from the accident site.

The broken pipeline, buried 0.9-m below ground level, was excavated. Examination revealed that the rupture occurred in a spot previously damaged by an *unknown outside force*. Near the rupture site the pipeline coating exhibited small dents and surface gouges. Seventeen meters of pipe were removed and replaced. The line was restored to

<sup>1</sup> Name has been changed to maintain anonymity.

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<http://www.agronomy.org/journals/jnr/1998/>

service by 0540 h the following day, 14 June 1996. The 56-cm line, installed in 1951–1952, had last been pressure-tested in 1975. At the time of the accident the property damage was estimated at \$500 000.

The first priority after the release was containment and collection of the oil. Crude oil is primarily composed of paraffinic, cycloparaffinic, and aromatic hydrocarbons with no more than 10% polycyclic aromatic hydrocarbons. Minor amounts of S, N, and/or O<sub>2</sub>-containing organic compounds may be present, in addition to trace amounts of heavy metals such as Ni, V (vanadium), and Pb. Hoosier Environmental Services, Inc.<sup>1</sup> was contracted by Midwest to monitor and perform the site remediation.

Trenches approximately 0.9 m deep were dug to help concentrate and collect the oil. Two underflow dams were installed to collect the oil that had entered and flowed through a drain tile system into a small drainage ditch located approximately 1060 m from the rupture site. For 4 d workers at the site tried in vain to locate a 41-cm county field tile believed to be acting as the conduit for the oil. The county surveyor's map ultimately proved to be inaccurate. Only after a neighboring farmer brought over a 40-yr old hand-drawn map were the tiles finally located. Vacuum trucks suctioned oil from small pits dug near where the oil collected in the swale and from the drainage ditch. A newspaper article that appeared approximately 2 wk after the accident is shown in Exhibit 1. While containment and collection activities progressed, an investigation to determine the extent of the impact and the subsurface conditions was conducted. The results are summarized below.

## Results of Investigation

### Soil

The oil sprayed out and away from the pipe at a 45° angle toward a swale (topographic depression) located to the northeast of the rupture site. Thirty-seven GeoProbe borings were made in June 1996 to determine the extent of contamination at various depths. The areas where crude oil visibly accumulated in the spray pattern and in a low spot near the northeast end of the swale were confirmed as the sites of greatest accumulation. The results for total petroleum hydrocarbons (TPH) of soil samples, taken at locations shown in Exhibit 2 to assess the initial extent of contamination, are summarized in Exhibit 3. In late June 1996, *tributary* trenches were added to enhance recovery of oil. All the pumpable oil was removed, leaving an estimated 37 500 m<sup>3</sup> of contaminated soil that still needed to be remediated.

The medium to fine-textured soils at the site were formed in a thin mantle of loess overlying loamy glacial till. These soils, part of the Crosby-Brookston association, were typi-

**Abbreviations:** TPH, total petroleum hydrocarbons; MW, monitoring wells; BTEX, benzene, toluene, ethylbenzene, and xylene; MCLs, maximum contaminant levels; UST, underground storage tank; IDEM, Indiana Department of Environmental Management; EAE, environmentally acceptable endpoint.

**The Indianapolis Star/News**

**July 3, 1996**

**By Michelle Barbercheck  
Correspondent**

SHERWOOD, Ind. - A broken pipeline that dumped 95,000 gallons of crude oil into a field near Sheridan remains under investigation by Oil Co. officials and the Indiana Department of Environmental Management.

Susan Gross, IDEM external affairs spokesman, said the leak occurred in a privately owned farm field near the intersection of 262 and Malong about a mile southeast of Sherwood.

Gross said Midwest officials reported the release immediately and began an intensive cleanup effort with help from emergency rescue teams from several surrounding communities.

Gross said vacuuming collection points were placed at the point of breakage in the pipeline and that trenches were dug to "basically recover the free product" and to keep it from contaminating surrounding land or seeping into the water supply.

She said the 2,268-barrel spill was contained on one property and would not affect area water supplies.

Gross said IDEM will not be able to estimate the full extent of damage done until a site evaluation is complete.

"Long-term remediation has yet been determined," she said. Midwest spokesman Henry Hertz said the leak in the pipeline, which was installed in 1951 and carries crude oil from Illinois and Ohio, was discovered when a significant loss of pressure registered on monitoring equipment.

Hertz said that although the official cause of the break has not been determined, initial tests indicate the pipeline may have been "nicked by something mechanical" in the past and that subsequent corrosion of the weakened area eventually resulted in a leak.

Midwest is taking full responsibility for the accident, Hertz said, but he does not know how the owners of the affected property will be compensated or if the farmland will be usable in the future.

Hertz said the crude oil did not reach the water supply but the investigation into the incident and its long-term effects on the land would continue. He said the pipeline has been restored and is back in service.

"We're continuing remediation. We're doing the best we can," Hertz said.

cally deep, nearly level, somewhat-poorly to poorly drained, with a hydraulic conductivity of approximately  $10^{-6}$  cm/s. The site was subject to frequent, but brief, flooding.

The site stratigraphy was fairly uniform. On average, 0.24 m of silt loam overlaid a clay or clay loam horizon that extended to a depth of 1.1 to 2.3 m below the ground surface. Beneath the clay or clay loam layer was a sand or sandy clay that ranged in thickness from less than 0.03 m to more than 0.9 m. A dry glacial till (clay loam) was encoun-

tered beneath the sand/sandy clay horizon. Hoosier Environmental expressed concern over the presence of some coarse sand lenses (layers) in the fine-grained sands because they could serve as preferential pathways for migration of the crude oil.

Water levels in the borings in June 1996 were 1.4 to 2.5 m below the soil surface. During the monitoring period water levels rose to depths of 1.1 to 1.2 m from the surface in some of the borings/wells.

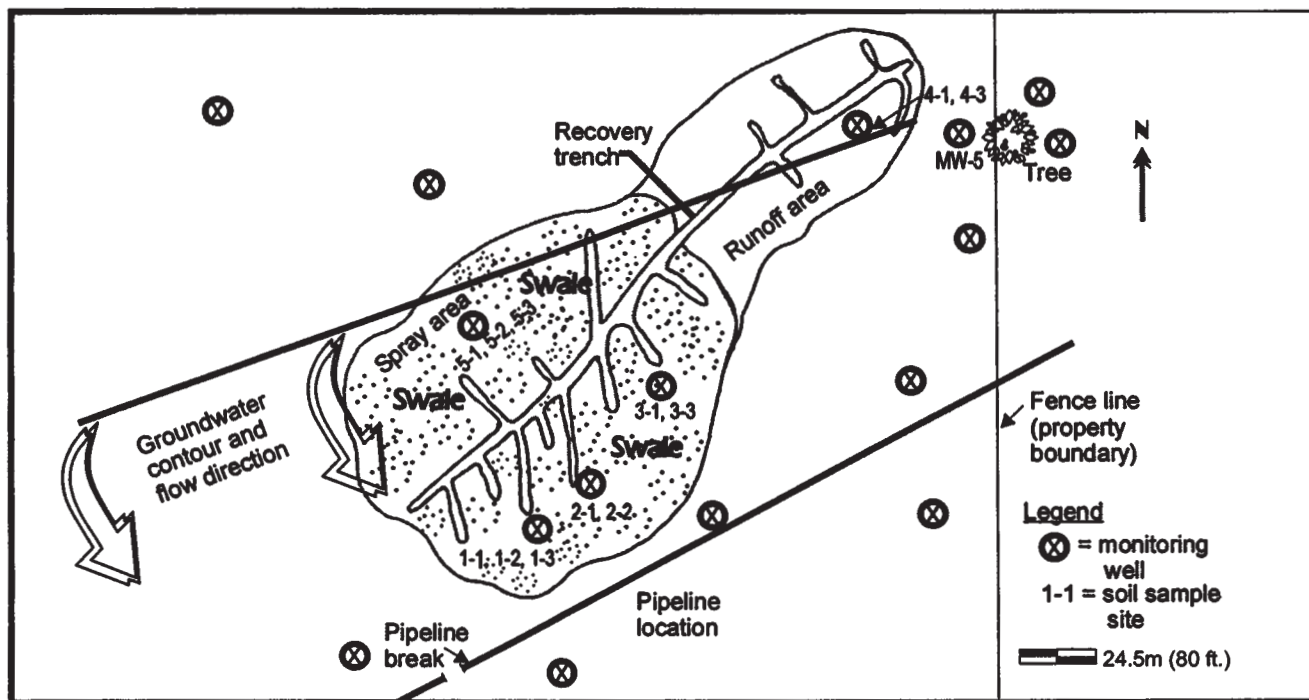


Exhibit 2. Spray area and well location. (Midwest Preliminary Report of Emergency Response and Remedial Activities, 1996, unpublished report.)

**Exhibit 3. Total petroleum hydrocarbons (TPH) for soil samples taken for initial site characterization from locations shown in Exhibit 2 (Hoosier Environmental Report, 20 July 1996).**

Soil sample ID	Sample depth	TPH
	cm	
1-1	0-46	6 950
1-2	46-76	47
1-3	76-122	37
2-1	0-46	10 000
2-2	46-76	690
3-1	0-46	2 230
3-3	76-122	794
4-1	0-46	27
4-3	76-122	298
5-1	0-46	3 470
5-2	46-76	5 150
5-3	76-122	1 180

### Groundwater

Three temporary piezometers, installed shortly after the release, identified a shallow groundwater flow toward the southeast (Exhibit 2). Based on this information, 11 groundwater-monitoring wells were installed at shallow depths in May 1997 to monitor groundwater quality and verify flow direction. The hydraulic gradient was 0.02 m/m based on June 1997 measurements. Groundwater velocity was estimated to be approximately 7.9 m/yr.

No oil phase was ever found floating in any of the monitoring wells (MW). Benzene, toluene, ethylbenzene, and xylene (BTEX) were detected only in MW-5, but the concentrations never exceeded the Maximum Contaminant Levels (MCLs) established by the Safe Water Drinking Act (1977). Movement of the oil phase through the soil, if any, was slow due to the oil's high viscosity and its entrapment within soil pores. Dissolved petroleum constituents (i.e., BTEX) were also retarded relative to groundwater flow due to sorption by soils. Sorption is the accumulation of chemicals on the soil and is a function of both soil and chemical properties (Schwarzenbach et al., 1993).

### Air

Benzene monitoring tubes were installed in the most contaminated regions of the site to sample the ambient air. The amount of benzene present was always either below detection limits or at negligible levels. It was concluded that the air at the site was safe for the workers to breathe and that no further benzene air monitoring would be necessary.

### Cleanup Objectives

There were no formal government regulations concerning the extent to which the soil needed to be cleaned. Under the Underground Storage Tank (UST) Program, Indiana Department of Environmental Management (IDEM) had historically recommended a limit of 100 mg/kg total petroleum hydrocarbons. In December 1996 Midwest Oil, Hoosier Environmental, and IDEM representatives agreed that IDEM's recommendation of 100 mg/kg TPH would be sufficient. A stricter cleanup was not considered necessary since the groundwater had not been impacted. Average and maximum primary contaminant and TPH concentrations in soil samples taken at the site since the initial characterization are summarized in Exhibit 4.

**Exhibit 4. Average and maximum primary contaminant and total petroleum hydrocarbon (TPH) concentrations for site soil samples (Midwest Work Plan, July 1997, unpublished report).**

Compound	Site sample avg. †	Site sample maximum
	ppm	
Benzene	1.9 (7)	6.8
Toluene	8.6 (9)	34
Ethylbenzene	2.7 (9)	8.7
Xylenes	22.9 (10)	78.4
TPH	5 504 (24)	60 300

† Value in parentheses refers to the number of samples averaged.

Nancy Hopkins wanted to see the site remediated as quickly and economically as possible. The property owner was an elderly woman with plans to enter a nursing home soon. Her adult children feared that the oil company did not have their mother's best interests at heart and that their mother was not handling the situation properly. Like the average citizen, none of the family members had a technical background. Scientific misconceptions are common among the general public, not through their ignorance, but simply through lack of experience and education. The family, for example, requested that the soil be tested for PCBs and heavy metals, even though these contaminants are not usually found in petroleum. Not surprisingly, the samples came back negative for PCBs. Small amounts of heavy metals, however, were detected. The family assumed that petroleum was the only source, unaware that the fertilizers that had been used for many years also contained trace levels of heavy metals. During discussions of potential cleanup strategies, Midwest presented the idea of using sludge from their wastewater treatment facility to inoculate the soil with hydrocarbon-degrading organisms. The family refused, believing that this was only going to further contaminate the soil.

### Selection of a Remediation Strategy

Site and contaminant properties affect the feasibility of a remediation strategy. For example, a sandy site that has little organic matter typically allows a pollutant to migrate much more rapidly than a clayey soil. The nature of the contaminant is also very important. A hydrophobic contaminant, such as petroleum, will sorb to the organic matter in the soil, whereas an anionic pesticide will be repelled by the negatively charged soil.

Factors to consider when selecting a strategy include: type and quantity of contaminant(s); toxicity and mode of exposure; location of the contaminant; soil and hydrogeology site characteristics; presence of wells, buildings, or other structures on or near the site; climate; future use of the land; public opinion; cost; and length of time required to clean up the site. The site had historically been used to grow corn (*Zea mays* L.) and soybean [*Glycine max* (L.) Merr.]. There were 33 drinking wells within a 1.6 km (1 mile) radius of the spill.

Remediation can be conducted in situ or ex situ. In situ remediation is more aesthetically pleasing because site disturbance is minimal. Ex situ remediation requires massive excavation of the soil that increases the risk of exposure, and

**Exhibit 5. Brief description of remediation strategies (Pepper et al., 1996; Sparks, 1995; NRC, 1997).**

Remediation strategy	Description
Air sparging	Air sparging is the injection of air or another gas, under pressure, into the saturated zone. It is combined with a vacuum extraction system when state regulations require collection of contaminant vapor known as off-gas. The process can also be used to enhance bioremediation through the addition of air. Air sparging is slow and effective only with relatively volatile organic compounds.
Asphalt incorporation	Soil is excavated and incorporated in hot asphalt mixes. During heating, some of the contaminants are volatilized or degraded. Any contaminants remaining are immobilized in the asphalt. This process is state-regulatory specific and subject to finding someone who will actually take your wastes for recycling. There is one company near the site that has the technology but might soon lose its asphalt incorporation license. Asphalt incorporation works best with sandy soils. The long-term product stability is still not fully known. Costs are similar to landfilling costs but do not have its long-term liability.
Bioaugmentation	Bioaugmentation is a special type of bioremediation where naturally occurring microbes or genetically engineered <i>superbugs</i> are introduced to enhance existing populations. Bioaugmentation can be done in situ or ex situ similar to traditional bioremediation. In situ bioaugmentation is a slow process, and the introduction of superbugs in situ is difficult because they rarely survive in a new environment for more than a few weeks and can be misperceived by the public. However, addition of microbes can be efficient in aboveground treatment systems, especially with the use of superbugs.
Bioremediation	Bioremediation is the biologically driven conversion of contaminants into relatively harmless substances, such as carbon dioxide and water. The presence of a microbial population capable of degrading the contaminant is required. It is effective on many nonvolatile compounds and can be conducted either ex situ or in situ. In situ bioremediation is slow and only feasible with permeable soils. Ex situ bioremediation, which requires excavation, can be conducted on or off-site, and is generally faster than in situ remediation because of soil amendments. Biopiles and biocells are more economical than off-site landfilling when soil quantity is more than 3-5000 yd <sup>3</sup> . Bioremediation can be referred to as either passive or active. Passive bioremediation, also known as intrinsic bioremediation, requires only monitoring of the site while natural attenuation processes occur. For active bioremediation additional steps are taken to enhance degradation rates such as the addition of oxygen, nutrients, and/or microbes.
Bioventing	Bioventing is technique that combines bioremediation and soil venting where oxygen is added directly to the site of contamination in the unsaturated zone. Vented pipes are trenched into the unsaturated zone and a vacuum is drawn on wells surrounding the zone of contamination to accelerate air movement through the contamination zone. A simple windmill type fixture placed at the top of the pipe can be used to create a small vacuum as it is propelled by the wind. Off-gas can be captured in a soil vapor system or passed through aboveground soils beds that act as biofilters (the latter process is known as <i>biofiltration</i> ).
Containment	The migration of the contaminants is physically prevented or impeded by the installation of a physical barrier, such as a wall or liner. Containment is usually one of the first steps after a spill and is not generally considered a permanent solution since it requires continual upkeep to prevent long-term risks. While the process is initially inexpensive, the maintenance costs can be prohibitive. The contaminants are not destroyed.
Excavation and landfilling	The contaminated soil is excavated and transported off-site to a landfill. No special preparation or pretreatment of the soil is required. Replacement soil is typically placed onsite. Excavation increases the risk of volatilization and exposure to the contaminants. The process does not destroy the contaminants and the company remains liable for the wastes, even after they are landfilled. Available landfill space may be limited.
Incineration	The contaminated soil is excavated and heated to high temperatures. The contaminants are degraded and/or volatilized. Some states require collection/treatment of the gases. The excavation increases the risk of volatilization and exposure to the contaminants because the soil is disturbed. Incineration is not a common practice because of the high energy costs.
Land treatment/land farming	The contaminated soil is excavated and spread out so that natural, degradative processes can occur. Some residual contamination frequently remains. Land farming includes active management of the soil once it is spread (such as adding nitrogen and growing plants).
Low-temperature thermal desorption	Using infrared energy and vacuum extraction, contaminated soil is heated to 430–650°C (800–1200°F) in an ex situ batch process. The processing units are small, modular, and resemble a modified asphalt plant. Complete destruction of the contaminants is possible. Some states prohibit the release of the volatilized contaminants. The process does not render the soil infertile.
Phytoremediation	Green plants remove, contain, or render contaminants harmless. The feasibility of this method depends on the depth and nature of contamination, and extent of site preparation required. The vegetative cover reduces the potential for contaminant runoff and may enhance the rate of biodegradation in the root zone. Cleanup is limited to the root zone and, therefore, does not work with really deep spills. Some contaminants are toxic to plants. Phytoremediation is inexpensive but slow and, therefore, can only be used with contaminants that are not readily leachable or highly toxic. The site remains aesthetically pleasing during cleanup.
Pump and treat	Contaminated water is pumped up from the saturated zone, followed by treatment and disposal or reinjection into the aquifer. The treatment depends on the nature of the contamination. Pump and treat works well with water-soluble contaminants, whereas hydrophobic contaminants become increasingly difficult to remove with time. The majority of the expense is the pumping cost.
Soil vapor extraction/soil venting	Air is pumped through a contaminated unsaturated zone to enhance removal of volatile contaminants. When required by state regulations, off-gas can be captured by a vapor extraction system.
Soil washing/flushing	In soil washing, soil is excavated and washed with a solution containing an organic solvent and/or surfactant capable of extracting contaminants from the soil. The extracting solution is then removed, filtered, and treated. Soil flushing is washing soil in situ where similar solvent/surfactant solutions are injected into and extracted from the contamination zone with a series of injection and extraction wells. Contaminants are removed through extraction from soils, or dissolution and mobilization of a separate contaminant phase such as gasoline or oil. In situ flushing is limited to more permeable and homogeneous soils.
Steam injection	Steam is injected into the ground, reducing the sorption of organic contaminants. The large energy costs are offset by no excavation costs and a reduced cleanup time. The process is difficult due to soil's poor heat capacity and permeability. Steam injection requires all the same equipment as air-sparging plus additional energy and materials (e.g., pipes). Process may sterilize the soil.

requires costly transportation if the soils are taken offsite; however, the cleanup time is generally much faster. Cost is an important factor to any company, but not necessarily the most important one. The longer it takes for cleanup, the greater the chance of exposure and movement of the contaminants off the site; therefore, if a contaminant is particularly hazardous or has a high potential for movement, a quick cleanup can be the best option, even if it is more costly. A slow, seemingly inexpensive strategy can also add to the overall cost when it prevents the land from being used for long periods of time or requires prolonged site maintenance. The time needed for site remediation depends on the

cleanup method, the nature and extent of the contamination, and site characteristics.

Midwest wanted to clean the site quickly in an effort to minimize further inconvenience to the property owner. Various remediation strategies are briefly described in Exhibit 5. Approximate 1997-based remediation costs excluding any associated engineering or site investigation expenses are summarized in Exhibit 6. The selected strategy in this case had to be amenable to the landowner. The landowner obviously did not want any short or long-term health risks, decline in property values, or reduced crop yields as a result of either the contamination or cleanup.

**Exhibit 6. Approximate remediation costs in 1997 per discussions with environmental consultants from remediation firms throughout the USA (personal communications).**

Remediation strategy	Approximate costs
Air sparging/vapor extraction	\$38/m <sup>2</sup> (\$500 000/ha)
Asphalt incorporation	Cost mostly due to excavation \$7–13/m <sup>3</sup> (\$5–10/ yd <sup>3</sup> ) and transportation \$13–27/m <sup>3</sup> (\$10–20/ yd <sup>3</sup> )
Bioaugmentation	Ex situ: \$20–100/m <sup>3</sup> (\$15–75/ yd <sup>3</sup> )
Bioremediation	“Active” bioremediation \$26/m <sup>3</sup> (\$20/ yd <sup>3</sup> ) Biopiles ~\$40–65/m <sup>3</sup> (\$30–50/ yd <sup>3</sup> ) Passive remediation, cost ~ site monitoring costs
Bioventing	\$15–65/m <sup>3</sup> (\$10–50/ yd <sup>3</sup> )
Containment	Physical barrier, such as a slurry wall, \$270–540 per facing m <sup>2</sup> (\$25–50/ ft <sup>2</sup> )
Excavation and landfilling	Excavation, transportation, landfill costs \$140–250/m <sup>3</sup> (\$105–195/ yd <sup>3</sup> ) Replacement soil \$13/m <sup>3</sup> (\$10/ yd <sup>3</sup> )
Incineration	Excavation and transportation \$125–220/m <sup>3</sup> (\$95–170/ yd <sup>3</sup> ) plus incineration \$60–120/m <sup>3</sup> (\$45–90/ yd <sup>3</sup> )
Land treatment/land farming	Onsite: \$30–40/m <sup>3</sup> (\$20–30/ yd <sup>3</sup> ) which includes excavation costs Offsite: add transportation costs of \$13–27/m <sup>3</sup> (\$10–20/ yd <sup>3</sup> )
Low-temperature thermal desorption	\$70–90/m <sup>3</sup> (\$60–70/ yd <sup>3</sup> )
Phytoremediation	Depends on degradability, depth of contaminants, and extent of site preparation required \$2.50–12.40/m <sup>2</sup> (\$25 000–125 000/ ha)
Pump and treat	\$10 000– \$15 000 per well, plus water treatment costs, which will vary with treatment choice and chemical class
Soil washing	Excavation costs \$7–13/m <sup>3</sup> (\$5–10/ yd <sup>3</sup> ) Washings costs \$80–\$100/m <sup>3</sup> (\$60–150/ yd <sup>3</sup> )
Soil flushing	Cost of injection and monitoring wells similar to pump and treat Flushing solution and post treatment/disposal of solutions similar to washing costs.
Steam injection	\$60–75/m <sup>2</sup> (\$750 000–1 000 000/ ha)

### THE DECISION

If you were Nancy Hopkins, Midwest Oil’s Environmental Safety Supervisor, what remediation strategy would you recommend to clean up the residual oil in the farmer’s field? The strategy must be suited to the nature of the contaminant and the site. In addition, it should also be amenable to the property owner.

### TEACHING NOTES

#### Case Objectives

Upon completion of this case, students should be able to:

1. Compare and contrast soil remediation strategies.
2. Evaluate the feasibility of various soil remediation strategies using site-specific data.
3. Recognize the potential for public misconceptions regarding science or engineering-related issues.
4. Identify and locate additional sources of information if needed.

#### Uses and Implementation of the Case

This case study is designed to introduce college students to remediation strategies used on petroleum-contaminated soils. Students develop and use decision-making skills to select the most appropriate strategy while examining the scientific and legal aspects of the case as well as public perception. The primary use of this case is in the environmental sciences even if specific remediation strategies are not explicitly taught. For example, this case was used in Purdue University’s Agronomy 544 dual-level course entitled Environmental Organic Chemistry in which pollutant behavior in soil and water systems rather than remediation strategies is taught. The Midwest case allowed students to apply fundamental knowledge of contaminant behavior in a very new context. This case was also used in Purdue’s Natural Resources and Environmental Sciences 290 undergraduate course entitled Soil, Air & Water Contamination. The undergraduates did not report lacking sufficient infor-

mation or background to satisfactorily work the case. Students from both the dual-level and the undergraduate course reported that they enjoyed working through the case and learned a lot about remediation strategies in the process.

The way that the case is implemented is important to its success. Implementation should be appropriate to the ages and backgrounds of the students as well as the course goals. This case can be implemented in a variety of ways. Herreid’s (1994) “Case Studies in Science—A Novel Method of Science Education” is an excellent reference for the first-time decision case study users. Students can be instructed to study the case and answer discussion question no. 1 before class. During class the students can be organized into small discussion groups in which they then discuss the problem and come to a consensus. By interacting with students with diverse backgrounds they can identify more approaches and share more information. They can draw on each other’s expertise and experiences. Another implementation approach is to divide the students into four groups and have each group study the case from a different perspective. The groups can represent the USEPA, the property owner, Midwest Oil Company, and some neutral fourth party. A comparison of group responses can be made with respect to how different people vary in their priorities and objectives.

This case can also be used to lead into additional topics such as risk assessment, biodegradation, or land reclamation strategies. If a more comprehensive discussion or evaluation of remediation strategies is desired, the students can be instructed to select one specific strategy and further investigate it as a follow-up to this case.

To simulate real-life decision making, students should be encouraged to identify and locate additional references that they believe would be useful in making an educated decision. Some potential sources include *Innovations in Ground Water and Soil Cleanup* (NRC, 1997), *Environmental Soil Chemistry* (Sparks, 1995), and *Pollution Science* (Pepper et al., 1996). *Soils in Our Environment* (Miller and Gardiner, 1998) and *Nature and Properties of Soils* (Brady and Weil,

1996) provide good introductions to soil science. Some of the remediation strategies presented in Exhibit 5 are impractical for this case, but were included so that the students would be introduced to them and have to evaluate their feasibility.

### What Actually Happened in the Case

Students invariably ask for the *correct* answer upon completing discussion of a decision case study. However, any logical justifiable decision that a student can make should be considered correct. The strategy actually chosen in this case was onsite ex situ bioremediation. The soil was excavated, amended, and placed in biocells. A major factor in the selection process, according to Midwest, was the ownership of the land. After 2 yr of legal wrangling, Midwest bought the land from the elderly owner's estate. By this time, the ex situ remediation had already begun so they opted to continue with it. Midwest indicated that, in hindsight, they would have purchased the land immediately after the accident and used a different strategy.

### DISCUSSION QUESTIONS AND ANSWERS

**1. What soil remediation strategy, or strategies, should Nancy Hopkins recommend to the operations manager?** Students can select any remediation strategy if they can justify their selections. Examples of factors students might consider include: time to clean up the site; the potential for offsite migration of the contaminant; cost; characteristics of the soils; water table levels; risks associated with the strategy; proximity of site to people and water wells; and inconvenience to the landowner. Students should weigh the advantages of each method against its potential disadvantages, such as: time vs. cost; and short-term vs. long-term risks.

**2. What additional site-specific information, if any, should Midwest Oil collect before selection and/or implementation of the cleanup strategy?** Students might report that additional information, such as data on soil texture, organic matter content, pH, soil moisture holding capacity, bulk density, permeability, hydraulic conductivity, and topographic features such as slope length and steepness, is needed. Factors, such as ease of access, road conditions, and climatic conditions should also be considered. Students should be encouraged to identify how additional information would be used. For example, if in situ bioremediation is proposed, additional information that would be useful include analysis of the soil for permeability and oxygen and nutrient status.

**3. Is there any additional monitoring or testing that should accompany the remediation strategy you selected?** Students may indicate that groundwater monitoring and soil sampling should continue during the cleanup process.

**4. Which would work better at this site, an in situ or an ex situ method and why?** The soils are somewhat-poorly to poorly drained. The soil has poor hydraulic conductivity and low permeability. The site is also subject to periodic flooding. As a result, the soil is not conducive to in situ remediation. Ex situ remediation increases the ability to amend and improve soil properties. Ex situ remediation could be conducted onsite or offsite. The advantage to an onsite ex situ cleanup is the reduced transportation costs.

**5. Would an increase in rainfall have helped or hindered the collection of oil?** Some additional rainfall would have helped increase the flow of petroleum into the collection trenches, but very large amounts of rainfall would have increased the potential for runoff.

**6. If bioremediation is used, what problems do you foresee and how can these problems be overcome?** The soil has poor hydraulic conductivity and low permeability. Because these characteristics retard the flow of nutrients and oxygen to the degrading population, bioremediation would work best if the soil is excavated, amended, and then placed in cells. Onsite ex situ bioremediation would be more effective and quicker than in situ.

**7. What is an appropriate compensation for the farmer/property owner?** Possible answers include: buy the field at greater than or equal to the fair market value; reimburse the farmer for lost crop revenue; pay punitive damages. Students may discuss the ethical issues surrounding the spill and how much society is willing to invest in the tradeoff between inexpensive fuel and a pristine environment.

**8. Was there anything the Midwest Oil Company should have done differently following the spill?** Most students will probably believe that Midwest acted swiftly and responsibly in their cleanup efforts. They were quick to shut down the line to prevent additional contamination. They were also quick to initiate containment procedures. The company reported that, in hindsight, they would have purchased the property immediately after the accident to eliminate problems and delays in dealing with the owner. The company did everything they could to minimize the owner's stress and inconvenience. The 15-mo delay in initiating the cleanup of the residual oil was due to lack of agreement between the owner and oil company personnel on the remediation strategy of choice.

**9. How could accidental spills, like what happened at the Midwest site, be avoided in the future, or do you believe that accidental spills are inevitable?** There are ways to minimize the potential for accidents, but there is no way to completely eliminate accidents. Some of the ways to reduce the risk for accidental breaks in buried pipelines include: bury the pipes below the frost line, bury the pipes below the plow depth, construct the pipes of materials that cannot corrode over time, and inspect or pressure-test the pipes more often.

**10. How would containment and cleanup be affected if pollutants were released into the air or water vs. the soil?** Pollutants released to the air would be virtually impossible to contain and clean up. Pollutants released to a body of water would be difficult to contain depending on the nature of the pollutant. The aqueous solubility of the pollutants would especially affect its fate in the water. The fate of pollutants in the soil is affected by the properties of both the soil and the pollutants. For example, pollutants that have an affinity for the soil would move slower than anionic pollutants that would be repelled by the negatively charged soil surfaces. The weather, especially rain events, is also an important factor in containment.

**11. How can it take years after a contaminant is released to the environment for cleanup to begin?** Students are usually amazed to learn that it took approxi-



mately 15 mo plus negotiations in court for remediation in this case to begin. Midwest and the landowners had to come to an agreement on the remediation strategy before cleanup could start. Some of the reasons why the initiation of cleanup might be delayed include location of the contaminant release, issue of land ownership, issue of liability, and the inability to finance the cleanup.

**12. Who do you think should be responsible for establishing an environmentally acceptable endpoint (EAE), the point at which a site is considered *clean*? What difficulties do you think people would encounter in setting an EAE?** Students may indicate that the government, the citizens, the *experts*, or industry should be responsible for determining the EAE. The discussion can be directed to examine how and why these groups may differ in what is a desirable EAE. Like many countries, the USA does not have a Clean Soils Act and, thus, no defined EAE. This discussion question can be used to introduce students to the difficulties associated with establishing site-independent EAEs. Establishment of EAEs should be primarily dependent on what level of soil contamination may be left onsite without posing a significant threat to the groundwater. Some factors to consider when deciding a cleanup standard include potential health hazards associated with the contaminant(s), potential rate of transport in the environment, and potential for human exposure. Mobility of a contaminant (i.e., release to the water phase) is greatly influenced by both site characteristics and the contaminant's chemical and physical

nature. A contaminant would move more readily through a low organic matter sandy soil than one that is clayey or has a restrictive layer.

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# Muskegon County Wastewater Management: An Effluent Application Decision Case Study

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## ABSTRACT

In the 1970s, Muskegon County, Michigan, successfully stopped the environmental deterioration of its waterways caused by the direct discharge of inadequately treated wastewater. The lakes, used for both recreation and industry, had been showing increasing signs of pollution: visible direct pollution, foul odors, severe algal blooms, and weed buildup. Swimming and boating had become unpleasant and unsafe. A wastewater treatment facility was built in 1974 that included a system by which the wastewater effluent could be stored and then used to irrigate cropland. All direct discharging stopped when the wastewater treatment facility opened. Due to the land application of the wastewater effluent, the level of phosphorus (P) in the irrigated soil steadily increased over time. Unless something was done, the soil P levels would continue to rise, and eutrophication would once again become a problem. The plant manager needed to decide how to slow or stop the P buildup.

APPLICATION of manures, biosolids, and wastewater, and the overuse of fertilizers have resulted in the buildup of phosphorus (P) in soils and eutrophication of water bodies in many areas (Stout et al., 1998; Miller and Gardner, 1998). This case encourages students to use soil science and water chemistry to find a cost-effective and environmentally sound method to dispose of municipal wastewater high in P concentrations. The case is based on an actual situation faced by the manager of a wastewater treatment facility where the problem with P buildup in soils has resulted in a need for strategic changes in management.

## THE CASE

Effluent leaving any wastewater facility is never 100% pure. Wastewater treatment procedures typically remove large solids plus a percentage of the dissolved organic matter. Unless the water is further processed using either a tertiary wastewater treatment or a biological nutrient removal system, it will still contain many dissolved water pollutants, such as plant nutrients (phosphates and nitrates) and dissolved organics. Tertiary treatment is both expensive and difficult, and many cities are unable or unwilling to pay for this additional expense. The Muskegon facility, however, had found a way to turn these undesirable substances into a valuable resource. The wastewater was sprayed onto cropland instead of being directly discharged, thereby providing crops with necessary nutrients and water while keeping undesirable substances out of the waterways, all at minimal

cost. Additional benefits of land application included reduced fertilizer application and reduced environmental problems. For example, in 1975, the wastewater provided 55 000 kg P, 68 000 kg nitrogen (N), and 100 000 kg potassium (K) as fertilizer that year. The use of wastewater for irrigation turned unproductive soil into useful cropland while optimizing water usage and minimizing contamination of water sources.

The Muskegon County Wastewater Management Treatment System, built in 1974 as a demonstration land application project for the USA, was located on 4460 ha of sandy, unproductive soil (Exhibit 1). While designing the system, engineers and scientists estimated that the total life expectancy of the soil at the treatment facility would be about 40 yr (i.e., the excess P in the wastewater could no longer be removed by the soil). Their estimate was based on information about the soil composition, the average application rate, average P content of the wastewater, and the crops to be grown. Once the soils become saturated, the risk of ground and surface water contamination would increase, leading to a return of eutrophication problems. Even as recently as the last 10 yr, many scientists believed that soil has a limitless capacity to bind P (Goetz, 1998). Scientists now realize that the leaching of P from soil or sediment transport of P-containing soil can pose a significant environmental threat. The amount of P in the soil is not the sole criterion determining the potential for leaching. Factors such as topography, presence of drainage network, vegetation, and climate also are important.

The buildup of P in the water is so undesirable that the use of P in detergents and laundry soaps has been completely banned in the USA because very little P is removed during typical wastewater treatments. The concern over P buildup in USA soils has become so great that soil chemists, horticulturists, and agronomists are actively conducting research in an effort to stop the buildup. Researchers at Purdue University, for example, are currently investigating diverse solutions such as increasing a plant's ability to take up P and reducing the P content of pig (*Sus scrofa*) manure.

While P has no known adverse health effects, at concentrations above 1.0 mg/L, it may interfere with coagulation in water treatment plants; consequently, microorganisms may not be completely removed (Water Resource Characterization DSS—Phosphorus). Eutrophication, however, is the primary reason why P buildup is detrimental. *Eutrophication* refers to the physical, chemical, and biological changes associated with the nutrient enrichment of a body of water. Eutrophication endangers drinking water supplies. Phosphorus is usually the limiting nutrient in biomass production in inland waters. With increasing inputs of P, aquatic plant growth is stimulated, especially algae. As continued algae growth results in the coverage of the water, unpleasant odors and discoloration can result. Algae can choke off waterways and clog water inlet filters. Algae decrease water

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transparency, and, therefore, reduce the ability of underwater plants to photosynthesize. With the loss of oxygen-producing plants, aeration and fish habitat are reduced. As the algae overgrowth dies and decays, dissolved oxygen levels drop, further stressing the aquatic life. Undesirable changes in species composition and population can result. Some algae, such as red tide, are toxic and can produce massive fish kills. Humans and wildlife are at risk of serious illness or death if they consume seafood contaminated with toxic algae.

Tim Westman, the plant manager, had been studying the P issue for a long time. He started working at the plant as a chemist and was quickly promoted to laboratory director. He became assistant plant manager in 1980 and plant manager in January 1989. He had already been seeing algal blooms periodically in the water exiting the drainage network, indicating that P was already occasionally passing through the soil with the irrigation water. Mr. Westman felt strongly that if he didn't resolve the P problem soon, Michigan's waterways would be endangered and that he would have failed in his role as plant manager. Something had to be done or the fate of the Muskegon facility would be jeopardized. He had to come up with a management plan to either keep the soil from becoming saturated with P or to minimize P concentrations in the discharge and he had to do it soon.

### The Wastewater Treatment Facility

The County of Muskegon purchased 4460 ha for the facility from approximately 30 different property owners in the early 1970s. The site was selected because of its conve-

nient location and the availability of a large land area required for the project. Aerial views of the wastewater facility and its surroundings are shown in Exhibits 1 and 2. The county was using about 70% of its 4460 ha site. About  $1.25 \times 10^8$  L of wastewater entered the facility each day. The wastewater was collected in downtown Muskegon and then pumped to the plant for treatment and storage before irrigation. Approximately 50% of the wastewater came from nearby paper mills, 25% from other types of industry, and the remaining 25% from domestic sources.

### Aeration and Storage

Aeration was the first step in the cleanup process. For 1.5 d, air was injected into continuously stirred water in a full-mix lagoon. The water then flowed to an aerating-settling lagoon where it was retained for 3 d to allow the solids to settle. Only aeration sufficient to keep the system from becoming anaerobic was provided during retention in the aerating-settling lagoon. Each settling lagoon was used for 2 yr before it required cleaning. While one lagoon was cleaned the wastewater was diverted to a second settling lagoon. More than 90% of the original organic compounds had been removed by this point in the process through either volatilization, sedimentation into the sludge, and/or biodegradation. The compounds still remaining tended to be relatively nonvolatile and/or resistant to bacterial consumption.

The processed water was held on-site in storage (impoundment) lagoons until it was used for crop irrigation. The facility had a  $1.9 \times 10^{10}$  L storage capacity, which was

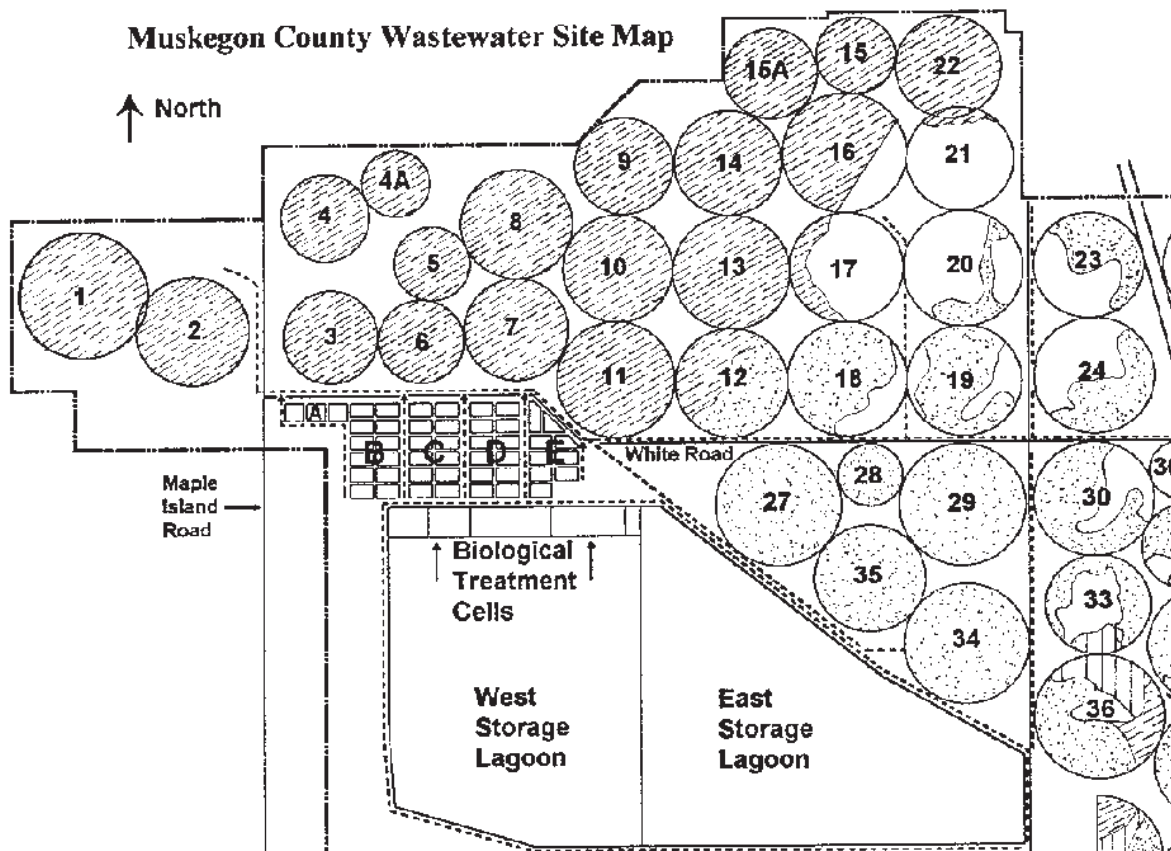


Exhibit 1. Aerial view of the Muskegon Wastewater Facility, which occupies 4460 ha (adapted from USEPA, 1979).

sufficient, even during the winter when no irrigation was possible. The lagoons' large surface areas facilitated further removal of certain contaminants through volatilization, sedimentation, biodegradation, and/or photodecomposition.

Less than 1% of the water's original organic matter remained by this point.

Surrounding the storage lagoons were interception ditches. The soil underneath the lagoon had already become sat-

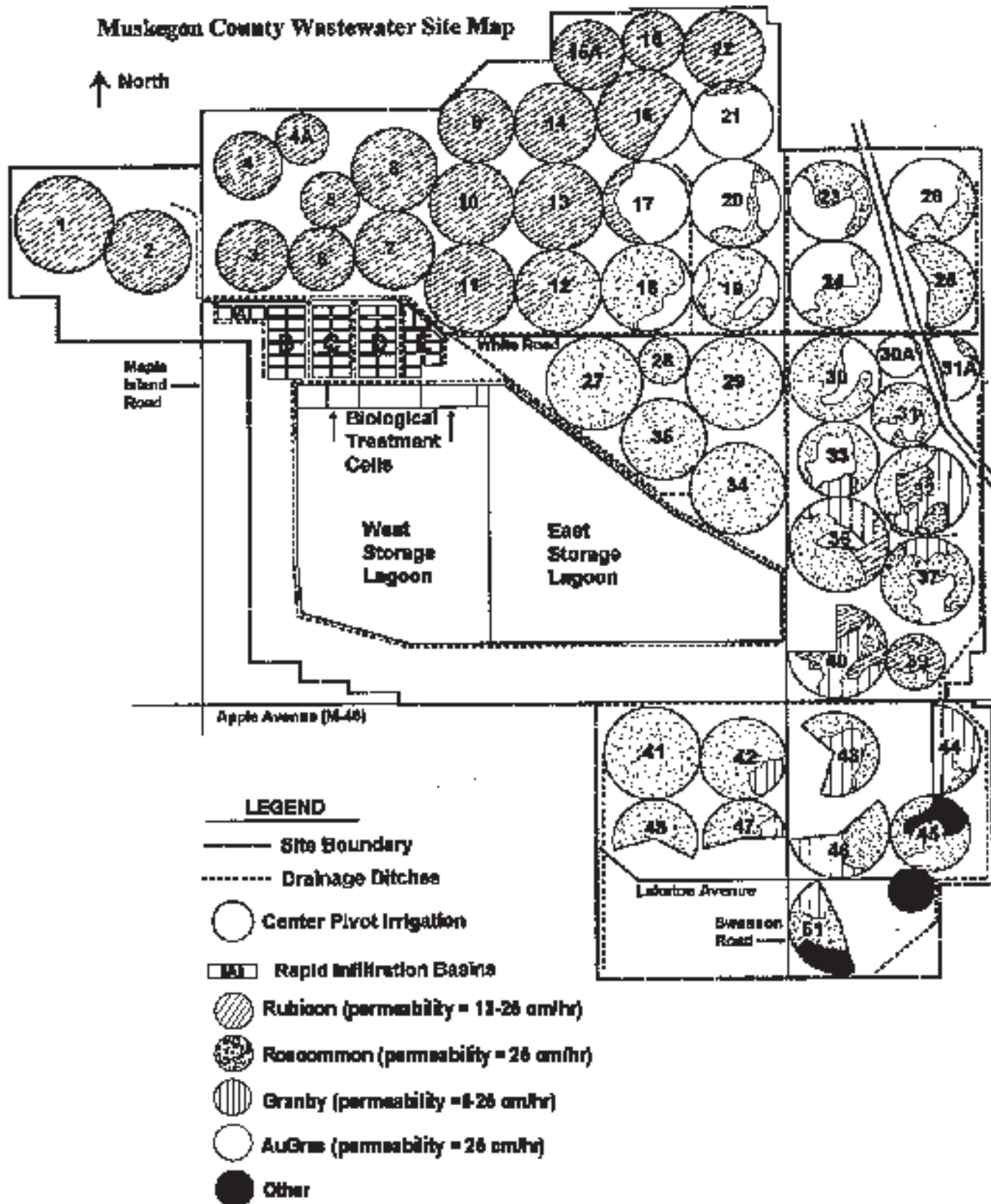


Exhibit 2. Location of irrigation fields, drainage ditches, and infiltration (adapted from USEPA, 1979).

**Exhibit 3. Summary of phosphorus application rates (kg/ha) by soil types for selected years from the Muskegon lab records (unpublished Muskegon lab data).**

Year	Average kg Bray-P1 P/ha applied				
	Rubicon soil	Roscommon soil	Au Gres soil	Granby soil	Other soils
1976	38 (30–45)	31 (17–50)	31 (19–38)	16 (7–26)	11
1979†	27 (19–34)	31 (11–78)	38 (20–70)	25 (0–47)	34
1984	120 (62–150)	59 (24–100)	72 (24–140)	16 (0–40)	11
1989†	100 (68–130)	58 (15–87)	56 (16–97)	29 (0–57)	5
1995	54 (22.5–68)	30 (15–48)	29 (10–53)	9 (0–29)	3

† Rates include application of P through fertilizer for 28% of the fields in 1979 and 4% of the fields in 1989. The high and low values are provided in parentheses.

**Exhibit 4. Typical crop yields and approximate amounts of P contained in selected crops (adapted from Foth, 1990).**

Crop†	Typical crop yield in the USA‡		P content in crop (as P)‡	
	Mg/ha	per acre	kg/ha	lb/acre
<b>Grains</b>				
Barley (grain)	2.7	40 bu.	7.8	7
Barley (straw)	2.2	1 ton	3.4	3
Corn (grain)	9.4	150 bu.	25.8	23
Corn (stover)	10.1	4.5 tons	17.9	16
Oat (grain)	4.3	80 bu.	10.1	9
Oat (straw)	4.5	2 tons	7.8	7
Rice (grain)	5.4	80 bu.	10.1	9
Rice (straw)	5.6	2.5 tons	5.6	5
Rye (grain)	1.9	30 bu.	5.6	5
Rye (straw)	3.4	1.5 tons	4.5	4
Sorghum (grain)	3.8	60 bu.	12.3	11
Sorghum (stover)	6.8	3 tons	10.8	9
Soybean (grain)	3.8	60 bu.	22.4	20
Soybean (stover)	--	--	14.6	13
Wheat (grain)	2.7	40 bu.	12.3	11
Wheat (straw)	3.4	1.5 tons	3.4	3
<b>Hay</b>				
Alfalfa	9.0	4 tons	20.2	18
Bluegrass	4.5	2 tons	10.1	9
Coastal bermuda	17.9	8 tons	34.7	31
Cowpea	4.5	2 tons	12.3	11
Peanut	5.0	2.25 tons	12.3	11
Red clover	5.6	2.5 tons	12.3	11
Soybean	4.5	2 tons	10.1	9
Timothy	5.6	2.5 tons	12.3	11

† Barley, *Hordeum vulgare* L.; corn, *Zea mays* L.; oat, *Avena sativa* L.; rice, *Oryza sativa* L.; rye, *Secale cereale* L.; sorghum, *Sorghum bicolor* (L.) Moench; soybean, *Glycine max* (L.) Merr.; wheat, *Triticum aestivum* L.; alfalfa, *Medicago sativa* L.; bluegrass, *Poa* sp.; 'Coastal' bermudagrass, *Cynodon dactylon* (L.) Pers.; cowpea, *Vigna unguiculata* (L.) Walp. subsp. *unguiculata*; peanut, *Arachis hypogaea* L.; red clover, *Trifolium pratense* L.; timothy, *Phleum pratense* L.

‡ This journal uses SI units, according to the ASA-CSSA-SSSA style. Due to the circumstances of this case study, however, English units are used, either alone or along with SI units.

urated with P and, therefore, was being treated with ferric chloride to precipitate out the unacceptably high levels of P. The sand in the rapid infiltration basins filtered out this precipitate.

### Irrigation and Farming

Before irrigation the effluent entered a discharge cell where it was disinfected with chlorine to meet health standards. Center pivot irrigation rigs were used to spray the treated wastewater over 2200 ha of land on which various crops, such as corn (*Zea mays* L.), soybean [*Glycine max* (L.) Merr.], and occasionally alfalfa (*Medicago sativa* L.), were grown. In early spring and late fall, drop-pipe irrigation was used to prevent water from freezing on and damaging the rigs. The volume of wastewater needed for irrigation depends on the particular crop being grown, the soil type, and current wastewater composition. On average, 6 to

**Exhibit 5. Actual crop yields at the Muskegon site (unpublished Muskegon lab data).**

Year	Corn		Soybean	
	Mg/ha	bu/acre	Mg/ha	bu/acre
1974	1.8	28	--	--
1975	3.8	60	--	--
1995	4.3	69.3	2.3	36.6
1996	4.4	70.8	1.9	30.0

10 cm of wastewater were applied per week during the growing season. Muskegon received an average of 79 cm of rain and 277 cm of snow each year.

The P application rates from wastewater irrigation, which varied by year (amount and composition of wastewater applied) and soil type, are summarized in Exhibit 3. Only data from selected years are presented. The level of P needed for crop production depends on both the type and yield of a crop. Typical U.S. crop yields and their P contents are provided in Exhibit 4. Some of the crops listed in Exhibit 4, however, might not be suitable to Muskegon's climate. Nutrient uptake can vary with season and plant variety. Plant residues that are left in the field, ultimately decay and replace the nutrients they removed from the soil while they were growing. The actual crop yields at the Muskegon site for selected years are summarized in Exhibit 5. The poor soils at the site are responsible for the relatively low crop yields.

### Postirrigation Collection and Discharge

For land application to be successful the soil must remain aerobic in the upper portion of the profile and, therefore, good drainage was essential. The majority of the soils on-site conducted water rapidly enough that neither infiltration nor hydraulic conductivity was a problem. The fields used are shown in Exhibit 2. The soil types and their corresponding saturated hydraulic conductivities are also provided. To both ensure adequate drainage and to be able to collect samples of the renovated wastewater after it filtered through the soil for analysis, a drainage network (tiles, wells, and ditches) was installed (Exhibit 2). The tiles were placed approximately 1 m below the soil surface. Before installation, the groundwater table in many of the fields was close to the soil surface. Only the Rubicon soil (sandy, mixed, frigid Entic Haplorthods) was initially well drained. After installation of the drainage network the water table was lowered.

The drainage network helped protect the groundwater while it prevented the soil from becoming waterlogged. After the water had percolated through the soil it was collected by the drainage network, sent to ditches, and, ultimately, lakes. Some of the renovated water went through Mosquito Creek into Muskegon Lake while the rest passed through Big Black Creek into Mona Lake before emptying into Lake Michigan (Exhibit 1). Once the soil becomes saturated with P, excess P in the wastewater can leach into the drainage network and ultimately into these waterways, resulting in the eutrophication problems similar to what occurred when direct discharging was allowed.

During percolation of the irrigation wastewater, the soil acts as an adsorbing medium, a *living filter*, while the crops reclaim the nutrients. The soil removes wastes through bio-

**Exhibit 6. Concentrations (mg/L) of selected substances at different stages in the treatment process (USEPA, 1979).**

Parameter	Influent	After aeration	After storage (before irrig.)	After soil renovation
	mg/L			
Total P	2.4	2.4	1.4	0.05
Ammonia-N	6.1	4.1	2.4	0.6
Nitrate-N	Trace	0.1	1.1	1.9
Zinc†	0.57	0.41	0.11	0.07
BOD <sub>5</sub> ‡	205	81	13	3
COD§	545	375	118	28
Fecal coliform	>10 <sup>6</sup> /100 mL	>10 <sup>6</sup> /100 mL	10 <sup>3</sup> /100 mL	<10 <sup>2</sup> /100 mL

† Representative of heavy metal content

‡ BOD<sub>5</sub> = Biochemical oxygen demand (5 day test)

§ COD = Chemical oxygen demand

logical, chemical, and physical means. Suspended matter is filtered out by the soil while organic matter sorbs to the soil and/or is decomposed by soil microorganisms. Heavy metals, color, certain solutes, and viruses are sorbed by soil organic matter and particles. Sorption is the accumulation of chemicals on the soil and is a function of both soil and chemical properties (Schwarzenbach et al., 1993). The concentrations of selected components at various stages in the treatment process are presented in Exhibit 6.

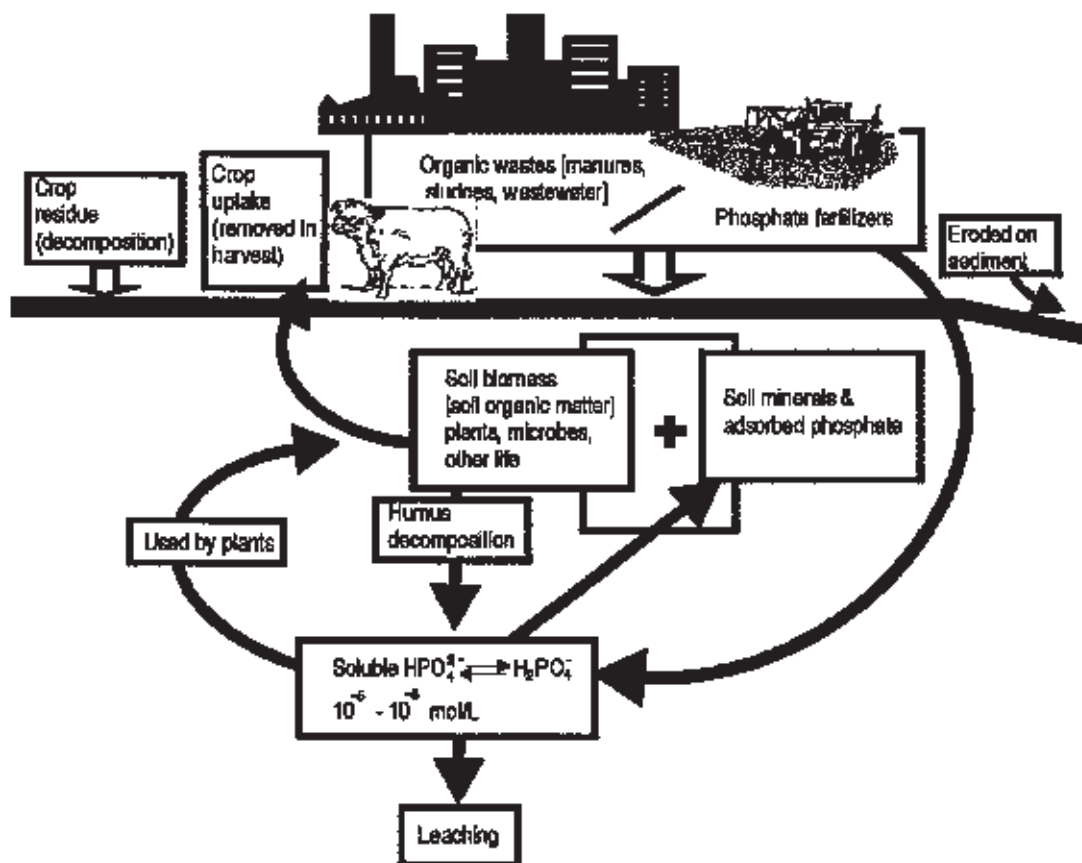
Land treatment may not remove all impurities from the wastewater. Salts and other trace levels of contaminants, such as heavy metals, can build-up in the soil, resulting in phytotoxicity. Nitrate not removed by the plants has a high potential for leaching. Routine sampling was done to monitor the efficacy of the treatment and to ensure that the sur-

face and groundwaters were not degraded. Occasionally, algal blooms were observed in the water even after it had percolated through the soil. Samples were taken from every step of the treatment process, plus from the groundwater and surface waters. Leaching of salts, nitrates, or heavy metals was not observed.

### The Phosphorus Issue

The P cycle is summarized in Exhibit 7. As P is added to the soil through application of fertilizers, organic wastes, or wastewater, it can be immobilized by organic matter and/or quickly react with other ions present in the soil, such as calcium (Ca), iron (Fe), and aluminum (Al), forming insoluble precipitates. At a pH less than approximately 5.8 to 6.1, P quickly reacts with Fe and/or Al, whereas above a pH of about 7.0 to 7.5, it reacts with Ca. The P compounds formed are relatively water-insoluble. Optimal P-availability to crops occurs at approximately pH = 6.5 for mineral soils and pH = 5.5 for organic soils. The average pH value of most of the irrigated fields was  $7 \pm 1$  pH units. Leaching of P is unlikely unless the available Ca, Fe, and Al ions become depleted.

Both weathering and dissolution of the inorganic precipitates and the decomposition of soil organic matter release soluble forms of P. Soluble P is susceptible to leaching and may continue to cycle through reactions with both inorganic and organic components of soil. The soluble P that is bioavailable is the dissolved inorganic phosphate ( $H_2PO_4^-$ ,  $HPO_4^{2-}$ ). The Bray- P1 test, a common soil P test, is a good indicator of bioavailable P. Particulate phosphate, which



**Exhibit 7. Phosphorus cycle showing major routes of inputs, outputs, and transformations (modified from Miller and Gardiner, 1998).**

**Exhibit 8. Average soil P levels (mg P/kg soil) with depth for selected years for each major soil type (unpublished Muskegon lab data).**

Depth, cm	Fall 1973	Fall 1974	Spring 1975	Fall 1995	Fall 1996
(mg P/kg soil)					
Rubicon soil					
0–30	39.0	29.1	44.5	139.2†	210.4†
31–60	45.8	42.5	47.1		
61–91	32.8	33.3	13.3		
Roscommon soil					
0–30	8.3	13.0	8.8	81.9†	89.9†
31–60	5.8	8.3	9.7		
61–91	15.8	8.6	20.3		
Au Gres soil					
0–30	11.3	10.8	12.1	100.1†	123.6†
31–60	17.7	9.8	13.2		
61–91	13.4	14.1	13.1		
Granby soil					
0–30	10.5	10.1	7.0	70.0†	81.7†
31–60	5.5	5.2	3.8		
61–91	8.2	7.5	4.8		

† Average from soil samples taken at 0 to 21.5 cm for 1995 and 1996. Bray-P1 values are reported.

does not leach but can be transported via erosion, can serve as a very slow-release source of P.

The major mechanisms by which P in soils reaches surface water have long been believed to be soil erosion and surface runoff. Gachter et al. (1998), however, have recently challenged this idea. Using in-situ sprinkling experiments, Gachter et al. (1998) identified soil macropores and artificial drainage as the most important pathways for vertical and lateral movement of soluble, reactive P. Macropores and artificial drainage reduce the amount of time the water remains in contact with the soil by providing preferential flow paths. As a result, much of the water bypasses the soil filter.

Phosphorus was being added to the soil at a rate 2 to 3 times faster than the crops could remove it at the Muskegon site. Soil P data, taken from a limited number of soil samples, during selected years (Exhibit 8) clearly indicated a rise in soil P levels. Soil properties that directly impact its life expectancy with regard to P included: initial P levels, P adsorption capacity, and binding strength for P. Initial P levels varied among the different soil types. The Rubicon sand was relatively high in P, even to a depth of 122 cm. The Au Gres (sandy, mixed, frigid Typic Endoaquods) and Roscommon (mixed, frigid mollic Psammaquents) sands contained lower concentrations phosphorus than the Rubicon sand whereas the Granby sand (sandy, mixed, mesic Typic Endoaquolls) contained varying amounts of P. The average maximum P adsorption capacity of all but the Granby ranges between 125 to 160 mg/kg. The capacity of the Granby soil is 4 to 5 times lower than this (Ellis et al., 1979). Both sorption capacity and the strength to which soils bind P are important factors to the availability of P for leaching and plant uptake. The relative binding strength of these soils for P is as follows: Rubicon > Roscommon > Granby > Au Gres.

### THE DECISION

What should Tim Westman, the plant manager, do to control the soil P levels at the Muskegon facility? What options

does he have to prevent eutrophication of Michigan's waterways? Signs of eutrophication in the water exiting the drainage network have already appeared, so something must be done soon.

## TEACHING NOTES

### Case Objectives

Upon completion of this case, students should be able to:

1. Describe how soil purifies wastewater chemically, biologically, and physically.
2. Identify advantages and disadvantages of land application compared with traditional wastewater methods.
3. Describe the role of plants or phytoremediation in land application.
4. Describe which physical and chemical characteristics of the soil affect nutrient sorption and water movement.
5. Compare and contrast the characteristics and behavior of soluble and particulate forms of P in soil and water.
6. Identify how and why P can pose an environmental risk.

### Uses of the Case

The goal of this decision-based environmental case is for students to develop problem-solving skills while learning about wastewater management and reuse. Advanced undergraduate or graduate students who are studying soils, wastewater technology, plant sciences, or environmental science, in general, can benefit from this case. No specific prerequisites are required. Students examine wastewater treatment and reuse in a multidisciplinary context and develop a practical solution to the problem of P buildup resulting from land application of the effluent. During their investigation, the students will study the chemistry of P, the environmental fate of P, different types of wastewater treatments, and soil science. Student feedback on the case has indicated that decision-making groups containing students with diverse backgrounds helps students broaden their perspectives.

### Implementation of the Case

One of the advantages of case studies is that they can be implemented in many ways and tailored to fit most curricula, teaching styles, and learning objectives. Herreid's *Case Studies in Science—A Novel Method of Science Education* (Herreid, 1994) is an excellent reference for those just starting to use case studies. Helpful P-related references for use by either the instructor or student include Sims (1993), Sims et al. (1998), Sharpley et al. (1996), and Tunney et al. (1997). The Sims et al. (1998) reference contains additional discussion questions that can be used to supplement this case. One way to implement this case is to have students answer the first two discussion questions, and report their answers in the form of a memo written from the perspective of Tim Westman. Once they have developed their own solutions, the students can be organized into small groups and asked to discuss their responses. After groups reach a consensus they can present their decisions to the class. By first discussing Questions 1 and 2 as a group, the students are then able to provide more insightful answers to the remaining discussion questions.

This case has been successfully used at Purdue University in three very different classes including: AGRY 696 (Soils Seminar), NRES 290 (Environmental Contamination), and AGRY/ANTH 460 (Contemporary Issues). In the soils seminar, the students role played the major characters in the case. In the other two classes, the students were assigned to small groups for decision-making, followed by whole class discussion of their answers. Without exception, student feedback has always been positive when case studies have been used.

### Discussion Questions

#### 1. What are the environmental impacts of P?

Eutrophication is the major detrimental effect of P.

**2. How can Mr. Westman reduce the rate of P buildup in the soil?** During the discussion of this question, remind students to distinguish between particulate and soluble forms of P. The majority of the particulate P in the wastewater, for example, is removed before irrigation. Also, once soluble P comes in contact with the soil, it tends to form insoluble precipitates. If students ask for the *real* decision, you may tell them that the Muskegon plant has made no actual decision to date.

#### A. Reduce the rate of P entering the soil:

- Identify and control the sources of P before the wastewater enters the plant.
- Reduce the amount of P in the wastewater before it is land applied. The P in the wastewater might be precipitated and filtered out, for example, in the storage lagoons. Another option is to use the wastewater for hydroponics rather than applying it to the land.
- Reduce the amount of effluent applied to any one location and, therefore, the rate of buildup.
- Completely eliminate the use of effluent as irrigation water and switch to a traditional tertiary wastewater treatment or a biological nutrient removal system.

#### B. Increase the rate that P is removed from the soil:

- Use phytoremediation. By selecting crops that require large amounts of P and maximizing crop yield the rate of buildup can be reduced and possibly reversed. Plants can also be genetically engineered to enhance their ability to uptake and use P. The DNA that codes for phosphate transporters—protein molecules that actively take up P—has already been identified. If these genes can be incorporated into alfalfa, a super-phosphate-absorbing plant could be produced (Goetz, 1998). Any crops selected by the students must be suitable to Muskegon's growing season and soils. The length of the growing season is provided in the case. The P present in any crop residue left in the field will ultimately return to the soil. An additional, often overlooked, factor to consider is whether a crop must be dried in the field before harvesting. During field drying, land application must stop and the wastewater diverted to some other field until the crop is harvested.

#### C. Other miscellaneous methods:

- Develop a predictive model on P accumulation and use the results to minimize P accumulation.
- Immobilize the P in the soil. Phosphorus can be immobilized by adding cations such as Ca, Fe, or Al. Several

types of coal combustion by-products have also been shown to immobilize P. Students should evaluate the pros and cons of adding cations or by-products to the soil before selecting this option.

- Use a biofilter on the drainage pipes leading away from the irrigation fields.
- Alter soil management techniques to reduce erosion losses and the subsequent transport of P off-site. Management options include no-till or minimal till operations, and/or planting trees or shrubs around the perimeter of the irrigation fields and drainage ditches. Note, however, that losses at the Muskegon site due to erosion are believed to be minor since the site is relatively level.

**3. What factors should you consider in selecting a solution?** Some of the factors that students might consider include ease of implementation, economic feasibility, and whether the solution is temporary or permanent.

**4. In addition to effluent, are there other possible sources of P in the soil?** Phosphorus-containing fertilizers are not being used. Runoff and erosion from other fields onto the irrigated plots plus P released during mineral weathering would both be insignificant sources. Another source of P is from decaying plant residues left in the field.

**5. How and why do the soluble and particulate forms of P behave differently in the environment?** Soluble P, which is the bioavailable form, is much more mobile than the particulate form. Most forms of P in soils are relatively *insoluble*, which means that, even at equilibrium, very low concentrations of soluble P are possible (Miller and Gardner, 1998). Soil reactions with P are more rapid than crop uptake; therefore, P is expected to first be adsorbed by soil or precipitated with cations in the soil solution. As plants remove P from the soil solution, additional P is slowly released into solution, allowing continued uptake by the plants. As a result, the soil tends to accumulate P in early spring and late fall when no crops are grown.

**6. Are there any seasonal variations in the effectiveness of this wastewater treatment process?** Phosphorus will be removed faster by plants that are actively growing; therefore, P will build up at a greater rate in early spring and late fall. Less volatilization and microbial degradation of organic matter occurs during the cooler months.

**7. What are the advantages and disadvantages of land application compared to traditional wastewater methods?** Some of the advantages include: less expensive, eliminates direct discharge of wastewater, allows for recycling of plant nutrients, and allows soils with poor water holding capacity to be farmed. Some of the disadvantages include: greater land requirement and P buildup.

**8. Would land application of wastewater work equally well with all types of soil? Explain.** Some of the factors affecting the suitability of land application are:

- Soil texture and composition. Land application works better with sandy soils than on clayey soils. If the water drains too slowly, the upper part of the soil profile will not remain aerobic; if the soil drains too quickly there is a greater risk of groundwater contamination. The *life expectancy* of the soil was estimated using the amount of Fe present in the soil (Ellis et al., 1979). The amount and type of soil organic matter is also important.



- **Climate.** In very cold climates, a larger storage capacity is needed since the growing season is shorter. The effluent can be applied when the ground is frozen, but it is more likely to run off the frozen surface. In addition, since plants are not actively growing, the P will accumulate. In very rainy climates, the excess water from rainfall can decrease soil aeration, increase leaching, decrease retention time, and, therefore, reduce the extent of biodegradation. If rainfall increases, the amount of wastewater used in irrigation will decrease.

**9. Describe whether land application of wastewater would be feasible for your home community.** Student answers will vary. Wastewater characteristics, the local climate, the availability of large tracts of land, the soil types, and the availability of funding for the project are things to be considered.

### ACKNOWLEDGMENTS

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# The Brucellosis Bacterium: Small but Mighty—An Infectious Animal Disease Decision Case (Abridged)

Charla R. Hollingsworth\*

## ABSTRACT

Yellowstone National Park officials managed the park under a natural regulation policy for many years. The park's wildlife populations naturally increased, or declined, as food supplies and environmental conditions dictated. The winter of 1996 was extremely harsh for the park's bison, causing many to migrate from the park in search of forage. Livestock producers near the park feared infected bison would transmit brucellosis (*Brucella abortus*) to their cattle. The disease causes abortions and still-born deliveries in cattle, as well as undulant fever in humans. Brucellosis became the focus of strict nationwide animal health control policies and federally enforced quarantines. Wyoming governor Mike Sullivan orchestrated the creation of a multiagency management committee entitled The Greater Yellowstone Interagency Brucellosis Committee, to be formed in addressing the disease in wildlife, namely bison and elk (*Cervus elaphus*). Its purpose was to establish a practical management plan to reduce migratory bison fatalities, preserve the park's natural regulation policy, and ensure the retention of adjacent states' brucellosis-free status from the USDA Animal and Plant Health Inspection Service. Montana governmental agencies and area livestock producers feared economic difficulties for the cattle industry in that state due to a rescission of their federal brucellosis-free status resulting from the park's bison intermingling with cattle. By late 1996, National Park Service employees hazed, corralled, and later shot bison in attempts to keep the animals from associating with Montana livestock. This case illustrates a multiagency management dilemma, interest group backlash, and the roles inadequate scientific knowledge and sensationalism can play in addressing a national controversy.

RECORDS documenting the presence of Yellowstone area bison date back to the mid-1800s. The herd is genetically linked to the only free-roaming bison herd (mountain bison) (*Bison bison athabascaae* Rhoads) to survive the slaughter and poaching crises (Reynolds, 1997). The few surviving mountain bison that were struggling against extinction were augmented in the early 1900s with the more abundant plains bison (*Bison bison bison* Linnaeus) (Meagher, 1973). Both species were held under ranch-like conditions until their numbers stabilized. These animals were then released into the Greater Yellowstone Area (GYA) and eventually weaned from human assistance.

Brucellosis was either transmitted to the mountain bison by the plains bison, or was already a contaminant at the holding ranch. *Brucella abortus* infection was assumed to

have become widespread in the Yellowstone bison herd around the turn of the century (Thorne and Herriges, 1992).

The Park's bison experienced heavy early season mortality during the winter of 1996. Late-season rains saturated an already deep snow cover in the park, which later turned to ice when cold winter temperatures arrived. This created an impenetrable barrier between the bison and their forage. The hungry animals soon began a mass migration from the park in search of something to eat.

Large movements of bison out of the park caused concern for adjacent livestock producers and federal, state, and local governmental entities. Montana cattle industry representatives feared bison intermingling with local cattle would allow the disease to spread. Detection of the bacteria in domestic stock could prompt a federally sanctioned quarantine against Montana beef, with a possible rescission of the state's brucellosis-free status. National Park Service employees were required to haze, herd, corral, and finally shoot wandering bison to reduce the potential spread of brucellosis to Montana cattle.

The Greater Yellowstone Interagency Brucellosis Committee (GYIBC), encompassing a variety of governmental agencies, had wrestled with the issue since the committee's first meeting in 1994. Each member brought a different perspective to the negotiation table on how brucellosis could be contained, or removed, from wildlife in the greater Yellowstone area. Unfortunately, many of the GYIBC's members mistrusted each other, as their agencies had been publicly criticized for bison mismanagement in the past.

The political atmosphere under which the committee met became highly charged during the bison migration in 1996. Concerned citizens and special interest groups such as The Fund for Animals, The Humane Society of the U.S., The Biodiversity Legal Foundation, and Earth First! formed bison protection advocacy groups and vowed to stop the slaughter. Special interest groups promised court actions if a more acceptable brucellosis management plan was not pursued. Emotion, bison symbolism, and lack of solid scientific information all played key roles in fueling allegations against natural resource and land management agencies.

## THE CASE (Abridged)<sup>1</sup>

### History and Pathogenesis of Brucellosis

The mode of brucellosis transmission is identical for all susceptible animals, regardless of species. Exposure to the

<sup>1</sup> This is an abridged case. The original case contains 17 pages of text, 17 pages of exhibits, 8 pages of interpretive note, and 6 pages of text and exhibit references. For a copy of the original case for classroom use contact the corresponding author c/o Dr. Ron Delaney (rdelaney@uwyo.edu).

**Abbreviations:** GYA, Greater Yellowstone Area; GYIBC, Greater Yellowstone Interagency Brucellosis Committee; WG&F, Wyoming Game and Fish Commission; APHIS, Animal and Plant Health Inspection Service; ITBC, InterTribal Bison Cooperative.

Department of Plant Sciences, c/o R. Delaney, Univ. of Wyoming, P.O. Box 3354, Laramie, WY 82071-3354. Wyoming Agric. Exp. Stn., Laramie. Journal Article no. JA 1781. Received 11 Aug. 1998. \*Corresponding author c/o Dr. Ron Delaney (rdelaney@uwyo.edu).

organism occurs at the time of either fetal abortion or birth of a calf to an infected female. Animals become hosts to the bacterium by licking birthing fluids, dead fetuses, or newborn calves of infected cows (Thorne et al., 1991).

The bacteria enter the host's body via the mouth and initially become localized in the head and mouth areas. When a female host becomes pregnant, the bacteria are activated, causing abnormal interruptions in the life-sustaining transfer tissues between the cow and her developing fetus. Brucellosis is often responsible for either a fetal abortion or the death of a full-term calf following an otherwise uncomplicated birthing event (E.T. Thorne, 1997, personal communication).

Cattle abort an estimated 70% of the time following infection with *Brucella abortus*. Offspring not infected with the bacteria before the birthing process are often infected later via their mother's milk (E.T. Thorne, 1997, personal communication).

Because of the means of transmission, bison and live calves are contagious for only a brief period of time. Contamination risk to other animals is greatly reduced when the newborn calf is clean and dry and the after-birth products and fluids are consumed. The ability of the bacterium to remain viable apart from its host is influenced by temperature, substrate, and scavenger activities (Shubert et al., 1997).

University researchers at Texas A&M demonstrated that bison could transmit the bacteria to disease-free cattle in a controlled setting (Keiter and Froelicher, 1993). The experiment was criticized, however, as an example of poor scientific method. According to D.J. Shubert, an animal protection spokesman, researchers confined cattle and bison in a small corral while regularly over-dosing bison with the bacteria to ensure high infection levels. The confined bison were not only exposed to the bacteria in an unnatural way, but were forced into an artificially close relationship with cattle. Bison have a strong herding instinct, and rather than leaving the herd at calving time, they remain an active part of it. This increases the risk of bacterial contamination for other animals, bison and scavengers alike (Thorne and Herriges, 1992).

Brucellosis infection did not impact park bison as severely as it did the area's livestock. Studies indicated that mutual adaptation between the bison host and the bacterial parasite was responsible for a gradual increase in successful pregnancies over the years. A generally accepted theory among biologists suggested *Brucella abortus* may have coexisted with Yellowstone bison long enough that the animals acquired a natural immunity against it (Meagher, 1973).

### The Greater Yellowstone Area

The GYA is the largest ecosystem preserved in its "natural state" in the continental USA (Thorne et al., 1995). The area's inventory of federal lands includes the Yellowstone and Grand Teton National Parks, and Bridger-Teton, Shoshone, Custer, Gallatin, Beaverhead, Deerlodge, Targhee, and Caribou National Forests; three national wildlife refuges; and land under the auspices of the Bureau of Land Management (Exhibit 1).

Several federal and state agencies were responsible for managing public lands and natural resources in the GYA complex. Conflicting agency mandates and unclear legislative priorities frustrated multiagency orchestration of a holistic management plan. The resulting incongruence between management plans encouraged ecosystem segmentation and disruption of animal life cycles that naturally utilized multiterritories.

The GYA has an image as one of the world's most pristine and abundant wildlife areas, but not everything was how it appeared. Multiple-use legislation for livestock grazing on public lands allowed cattle to outnumber wild ungulates by a ratio of more than 4 to 1 (Souvigney et al., 1997). Opponents to the bison slaughter felt federal land agencies were favoring ranching interests at the expense of not only the park's free-roaming bison herd, but other large animal species as well. Federal lands, some said, should be reserved to support wildlife habitat, not the surrounding ranching interests.

The National Park Service's natural regulation policy was a controversial management technique since its inception in 1967. The policy allowed nature to take its course without interference from Park Service employees. Natural regulation in the park was intended to allow excess animals to starve as over-population increased competition for limited resources. Drawing upon a document entitled the "Leopold Report," The Park Service's Management plan recommended: "(b)ison management in Yellowstone National Park has a goal of maintaining a truly wild, free-ranging population subject only to the influences of natural regulatory processes" (Keiter and Froelicher, 1993).

Mary Meagher, a National Park Service Biological Resources Division scientist who studied Yellowstone bison for 38 yr, was convinced the policy allowed the park's bison population to grow as never before. "It's one of the most complex biological and social issues the park faces," Meagher said (McMillion, 1997a). Meagher suggested the bison population grew steadily during the 1990s despite hard winters, because groomed recreational trails expanded the animals' winter habitat and lowered critical energy usage during severe winter months (McMillion, 1997b). The National Park Service groomed some 560 km (350 miles) of trails and roadways every winter for snowmobile enthusiasts (Exhibit 2). In a 24 Jan. 1997 letter addressed to U.S. Department of the Interior Secretary Bruce Babbitt and others, an animal protection interest group wrote:

...according to the NPS's own bison expert, Dr. Mary Meagher, the existence of 25 foot wide groomed trails in Yellowstone is an indispensable factor in both the growth of the bison population and bison movements to these boundary areas. Bison use these trails as energy efficient travel routes to alternative foraging sites within or outside the Park.

(Crystal and Glitzenstein, 1997, unpublished letter)

The letter continued with a quote from Meagher:

The key in this harsh habitat is energetics, and the changes we have made to the bison energetics by providing a hard-packed energy-efficient winter road system to a stolid-tempered ungulate.

(Meagher, 1997, unpublished data [as quoted by Crystal and Glitzenstein, 1997, unpublished letter]).

Winter recreation in Yellowstone National Park became an important seasonal economic boom for GYA residents. As many as 2000 snowmobiles arrived at the park each winter day (Hutchinson, 1997). Yellowstone's gateway communities (Cooke City, Gardiner, and West Yellowstone, MT; and Jackson, WY) describe themselves as snowmobile capitals of the world (McMillion, 1997b).

Long-time resident and 1997 executive director of the West Yellowstone Chamber of Commerce, Vicki Eggers, remembers the lean days before snowmobile revenues revitalized the GYA area in the winter season:

There was a grocery store, the drug store, a gas station, two hotels. That's about it. And the fathers, the dads, every day got up and packed their lunches and went down to Earsel's gas station and played cribbage because there wasn't any work. Now, eighty percent of our businesses are open. People live here year-round, and that's because of snowmobiles and the fact the people like to use them in Yellowstone Park.

(Repanshek, 1998)

### The Greater Yellowstone Interagency Brucellosis Committee

In 1993, Wyoming governor Mike Sullivan invited Idaho and Montana governors to become involved with Wyoming in recommending a solution to the interstate brucellosis problem (Exhibit 3). Both Idaho governor Cecil Andrus and Montana governor Marc Racicot in turn indicated their support for the idea of a Tri-state Interagency Brucellosis Task Force.

In 1994, the three governors and several committed state agencies were informally joined by the secretaries of Interior and Agriculture when officials attended the National Symposium on Brucellosis in the Greater Yellowstone Area that was held in Jackson, WY. The late-September symposium was followed by the first, of many, GYIBC meetings to be held. A federal document or *memo of understanding* was signed by participating agencies around June 1995, which served to increase the committee's cohesion by granting the working group official recognition. After the paperwork was signed, the multiagency partner-

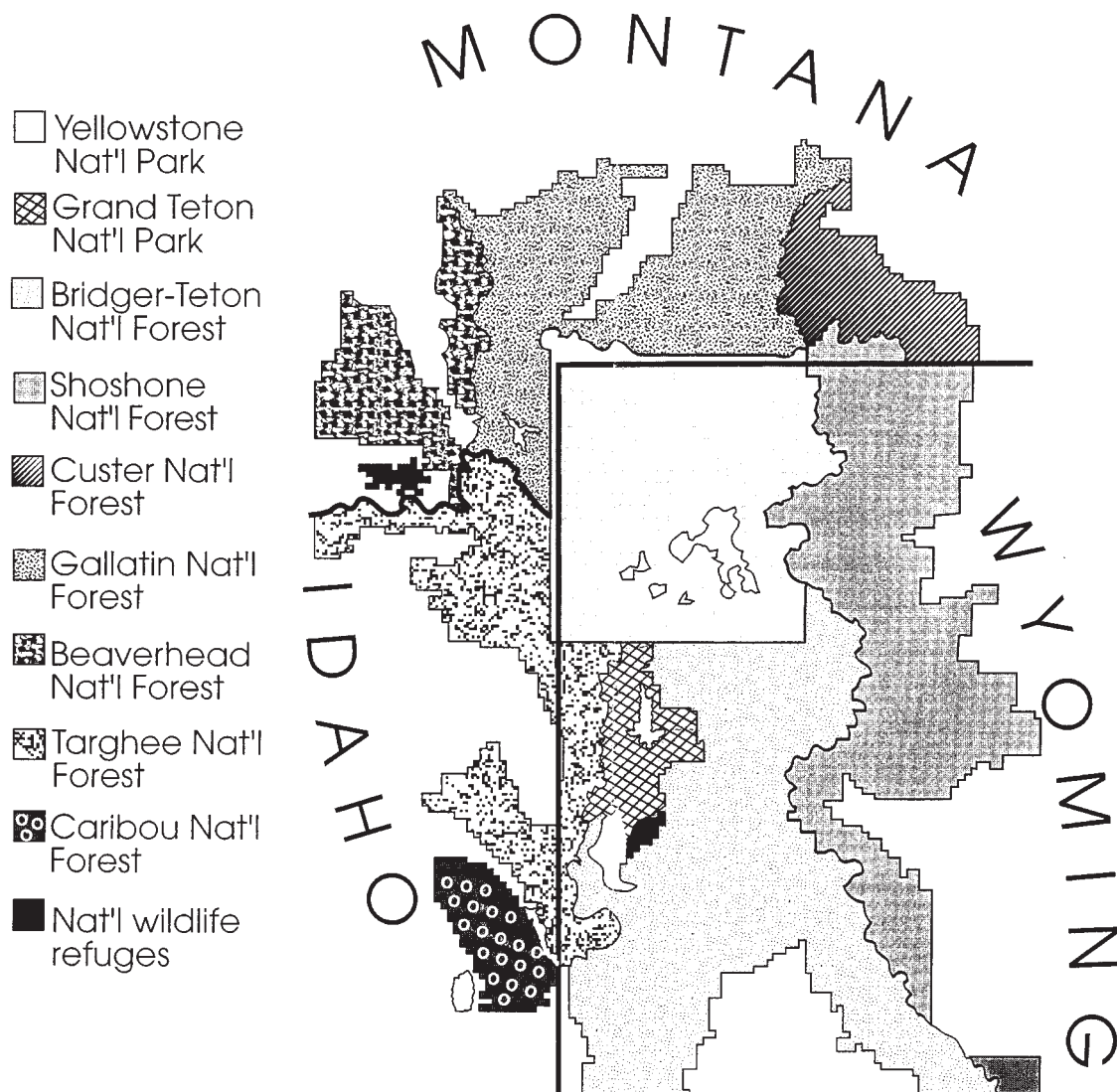


Exhibit 1. Map of federal land holdings in the greater Yellowstone area. The map was modified for a black-and-white format by Chris Madson, editor of the *Wyoming Wildlife* magazine, an official publication of the Wyoming Game and Fish Commission, Vol. 60, No. 12, December 1996.

ship was officially entitled the Greater Yellowstone Interagency Brucellosis Committee (GYIBC) (Thorne et al., 1996).

The GYIBC executive committee was composed of Wyoming, Idaho, and Montana state natural resource management and animal health agency representatives. Federal committee members hailed from the National Park Service, U.S. Forest Service, U.S. Bureau of Land Management, U.S. Fish and Wildlife Service, and Animal and Plant

Health Inspection Service. The committee was a force to be reckoned with, since it would propose final bison management and enforcement plans.

The GYIBC had much to consider at their April 1997 meeting. The bison slaughter issue had become politically volatile, and working relations between officials often reflected this fact. Distrust and lack of cooperation between the committee's members constantly threatened to unravel the fragile thread of cooperation that held them together.

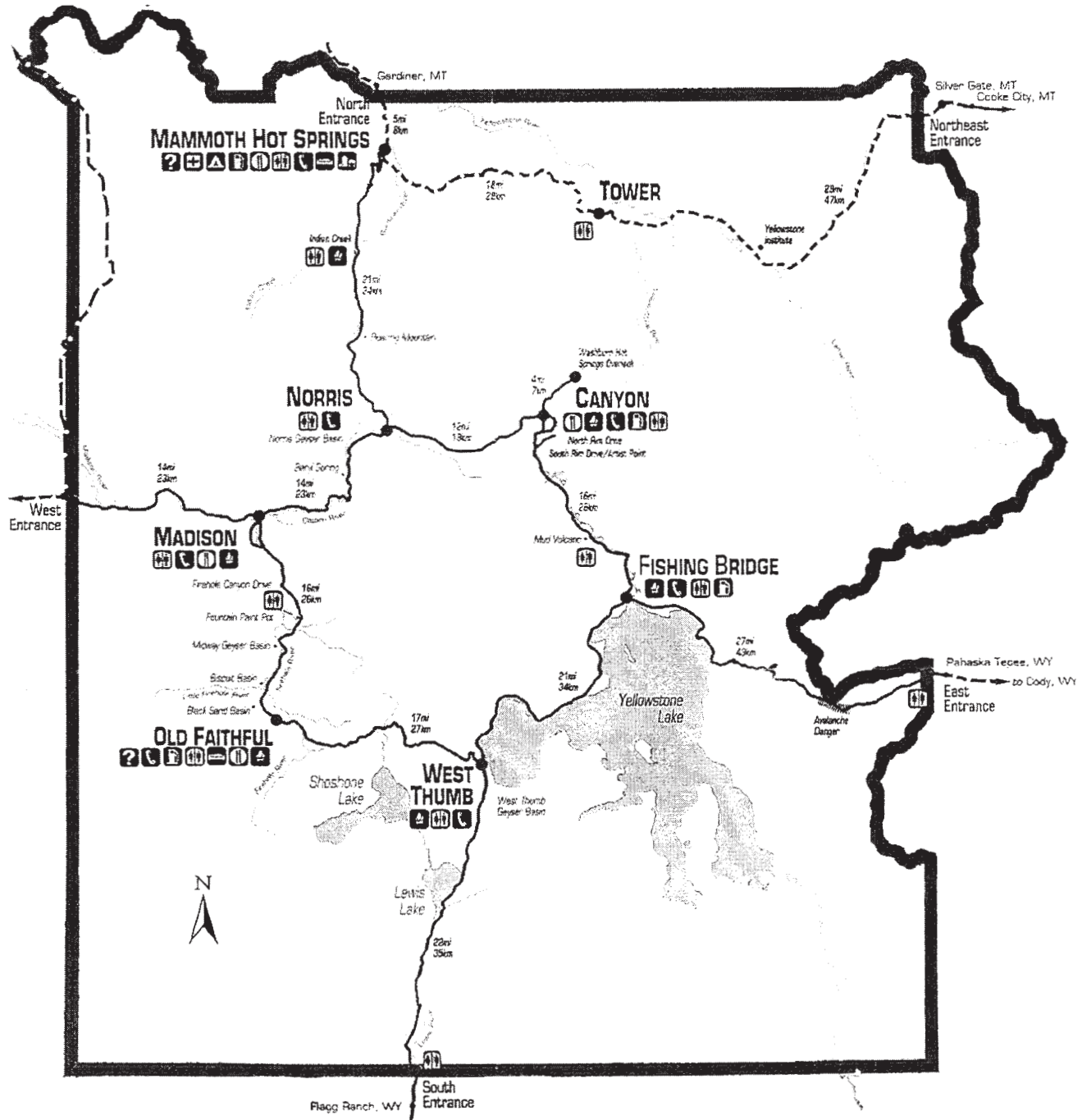


Exhibit 2. Yellowstone National Park map depicting snowmobile routes and roads groomed for winter season recreational use.



STATE OF WYOMING  
OFFICE OF THE GOVERNOR  
CHEYENNE 82002

MIKE SULLIVAN  
GOVERNOR

May 12, 1993

The Honorable Cecil D. Andrus  
Governor of Idaho  
State Capitol  
Boise, ID 83720

Honorable Marc Racicot  
Governor of Montana  
State Capitol  
Helena, MT 59620

Dear Governors Andrus and Racicot:

As I have previously mentioned to you, in the fall of 1990 I appointed a statewide task force made up of cattlemen, sportsmen, outfitters and affected state agencies to propose solutions to the conflicts caused by brucellosis in wildlife in Wyoming.

I have just recently received their report and recommendations. After reviewing their report I met with the Director of the Wyoming Game and Fish Department and some of his staff, the Director of the Wyoming Department of Agriculture and the Wyoming State Veterinarian to more fully discuss its content.

The report deals with some brucellosis issues that are unique to Wyoming, such as state administered elk feedgrounds in northwestern Wyoming. The task force has specific recommendations building upon and enhancing several long-term, on-going programs to eradicate brucellosis in feedground elk.

The task force, however, noted that although we can address those issues specific to the State of Wyoming, the larger, long-term problem is regional in scope and national in potential impact. Therefore, solutions to the brucellosis problem should be regionally devised and implemented.

The Greater Yellowstone Area (GYA) shared by Idaho, Montana, and Wyoming with its national parks, national wildlife refuges, national forests, other public lands, spectacular scenery, unmatched free ranging wildlife and agriculture industry is regarded as a national and, indeed, an international treasure. It is the largest, most nearly intact, most remote and inaccessible ecosystem in the lower 48 states and as such, tourism forms a major foundation to the economics of the tri-state communities surrounding the GYA.

The GYA, with its interstate migrating infected elk and bison, also serves as a brucellosis reservoir.

Within the past eight years Idaho, Wyoming and Montana were all declared "Brucellosis Free" under the Uniform Methods and Rules of the National Brucellosis Eradication Program. I believe that unless we collectively and cooperatively deal with brucellosis in wildlife in the GYA, our respective states' "Brucellosis Free" status could be compromised. In that event, the economic ramifications to our three states would be staggering.

In addition, I am very concerned about the whole host of adjunct issues which are interwoven with brucellosis in migrating wildlife. Some of those issues are: state liability for costs in the event wildlife are proven to have transmitted to livestock; the potential conflict between public land grazers who see their livestock are at disease risk while grazing public lands in the GYA and the environmentalists who believe the risk could be minimized if there was no grazing on public lands in the GYA; the potential for the animal rights movement to use any conflict emanating from brucellosis in the GYA to advance their agenda; and finally, but certainly not least, I am concerned about the potential human health risk factor due to brucellosis under any circumstances.

In addition, I am concerned that if the states do not collectively address this problem on a regional basis, the federal government, either through congressional action or regulation, will attempt to do so.

In that regard and based on the task force's main recommendation to me, I am respectfully requesting you join me in creating a Tri-state Interagency Brucellosis Task Force to coordinate activities and provide direction toward eradication of brucellosis without eradicating wildlife or livestock.

I would envision this tri-state task force could be modeled after the successful Interagency Grizzly Bear Committee (IGBC). As you are aware, IGBC has been a very successful approach to addressing regional grizzly bear management. The IGBC has a technical committee which serves to advise the IGBC on the more technical aspects of grizzly bear management. If you concur, I would propose the same scenario for the tri-state brucellosis task force.

The makeup of this task force should, most likely, be made up of affected state agency directors, state veterinarians, representatives of the governors' offices, affected federal agency administrators, and representatives of stockgrower and conservation associations. The advisory technical committee should, most likely, be made up of experts in the fields of disease, nutrition and habitat. Some of these experts could come from the already existing Ad Hoc Technical Committee on Brucellosis in Wildlife of the Greater Yellowstone Area which was formed years ago as a form of an idea exchange between federal and state agencies.

Regardless of the potential makeup of the task force and creation of an advisory technical committee, if you concur, as a starting point I would propose a meeting this August with our proposed nominees to more fully define this proposal.


The State of Wyoming would be glad to host this meeting in Jackson and I will make as many of my staff available as necessary to brief your respective attendees on what work we have done to date.

I believe brucellosis in the GYA is a problem. However, I also believe we can collectively and proactively address and begin solving this problem before it reaches its inevitable boiling point and we are placed into reactionary management.

Due to the urgency of this issue please advise me by June 12 of your views. If you agree with the concept of a tri-state interagency brucellosis task force would you be willing to send the above noted personnel to Jackson to discuss, evaluate, and fine tune its structure and mission, define its costs and develop the elements of its strategic plan? Thank you in advance for the consideration I know you will graciously give my request.

With best regards, I am

Very truly yours,

  
Mike Sullivan  
Governor of Wyoming

In a January 1997 letter to Montana governor Marc Racicot, Yellowstone Park superintendent Michael Finley stated that the Park's bison must be a shared responsibility between the two governmental bodies. In an answering letter to Finley, Racicot agreed that cooperation between the two offices should be cultivated, but later in the press was quoted as suggesting officials in Washington, DC, should also help in resolving the issue. Superintendent Finley mailed yet another letter to Governor Racicot after reading the newspaper. He wrote, "(n)ow, four days later, from quotations in the media, you seem to have abandoned that spirit of cooperation, and without further communication or discussion with us, want to have the matter resolved by people in Washington, DC" (Associated Press, 1997a).

Public opinion was also increasingly emotional over the continuing slaughter. "We want the National Park Service to remember that they are stewards of the buffalo, not executioners on behalf of shortsighted economic interests," said Mark Van Putten, National Wildlife Federation president (Associated Press, 1997b). Newspapers printed full-color pictures of mutilated bison carcasses on their front pages almost daily, citing updates on the latest number of slaughtered animals. In her January 1997 letter to the editor, Lisa Bonner of Laramie, WY, wrote "Recent pictures showing young buffalo waiting to be trucked to slaughterhouses and buffalo, gory and recently slaughtered, being sold to drooling collectors, are making me sick to look at the paper" (Bonner, 1997).

### *The Animal Protection Perspective*

D.J. Shubert, spokesman for The Fund for Animals, an animal protection organization, was not convinced that a contagious disease problem existed (D. Shubert, 1997, personal communication). While it was widely accepted that cattle, elk, and bison were all hosts for brucellosis, there was never a truly conclusive study concerning transmission of the bacteria from bison to cattle. The group soundly criticized the experimental technique utilized by the Texas A&M study not only because it forced cattle and bison into unnaturally close associations at calving time, but because researchers dosed bison with excessive amounts of bacterial inoculum to ensure adequate disease.

Mr. Shubert and others argued that in a natural setting wild bison would not come into contact with cattle at calving time. To reinforce this theory, Shubert relied on studies documenting the time of year that bison normally calve. The birthing process occurs from February to May for a large majority of the park's bison. Before this event, the animals tended to migrate to traditional calving grounds generally found within the park. Establishment of the time period that bison were contagious was a crucial factor in identifying a herd's disease risk. The interval between bison calving, and cattle being released on GYA grazing leases differed by at least 2 wk, and the viability of exposed bacterial cells declines quickly. Predators and weather conditions work to naturally reduce bacterial inoculum in the ecosystem before grazing animals could become infected. While risk to cattle might exist, The Fund for Animals believed the potential was extremely remote.

### *The Wildlife Management Perspective*

The Wyoming Game and Fish Commission (WG&F) vaccinated elk herds (a major source of brucellosis in Wyoming) since the mid-1980s. The program was both problematic and expensive, but long-term results were encouraging.

Elk vaccinations, using Strain 19 vaccine, were considered successful since elk had a large number of normal births. Governmental studies suggested disease occurrence in elk cows declined from 40% in 1985 to 12% in 1995 (O'Driscoll, 1997). Vaccination of elk generally took place at winter feedgrounds.

Vaccination of bison was more problematic due to their wide area of dispersal in the park and the difficulty of approaching them. Unlike elk, bison were not fed at winter feedgrounds and were not conditioned to congregate in one area for feed. This made a successful vaccination program highly improbable.

Additional complications arose due to the vaccine. Strain 19 had inherent drawbacks when administered to bison that elk and cattle did not experience. Its low effectiveness in bison could be enhanced somewhat with repeated vaccinations. Redundant disease treatments by government agencies were extremely unlikely due to the lack of processing and holding facilities, inadequate numbers of trained personnel, and unfavorable economic factors. Strain 19 also caused bison to falsely test positive for the bacterium. This further confounded efforts to separate the infected animals from uninfected ones. Research was ongoing to obtain a more effective vaccine, but there was reportedly no "silver" biobullet.

### *The Brucellosis Eradication Perspective*

Since 1935, the federal government has spent billions of dollars on brucellosis eradication. In fact, an estimated \$60 million was appropriated to the Animal and Plant Health Inspection Service (APHIS) over the course of each budget period to fund the brucellosis eradication program (D. Dittloff, Bison Coordinator with the Wyoming Wildlife Federation, 1998, personal communication). These enormous expenditures have not been in vain.

In 1945, surveys revealed that 5% of U.S. cattle herds were infected with the bacterium and >10 000 cases of undulant fever in humans were reported. Human symptoms of brucellosis (undulant fever) mirror those of severe flu. The disease begins with headaches and fatigue followed by bouts of high fever, muscle and joint pains, and appetite loss (Brucellosis Eradication Staff, 1997). In 1997, APHIS reported that <2% of U.S. cattle herds still remained infected, and only a handful of human brucellosis cases were known. Of the few human brucellosis cases still active, many were from out-of-country exposures (King, 1997).

States have also expended enormous sums of money over the years to ensure their brucellosis-free status was not jeopardized. Wyoming and Montana have been considered states free from brucellosis since 1985, and Idaho since 1990 (Thorne et al., 1991). To achieve this status, a state must not have any infractions, such as infected animal reports, for 12 consecutive months while under an active APHIS surveillance program.

After a state is designated free of brucellosis by the APHIS, requirements for moving cattle intra- and interstate are relaxed. This reduces costs incurred from livestock testing, vaccinations, and quarantines. Lower costs of doing business result in stronger local and state economies.

Occurrence of brucellosis in a cattle herd could cause a multifaceted hardship for the herd's owner (Thorne and Herriges, 1992). Depopulation of livestock was not uncommon if the bacteria was found. It required the destruction of entire herds if a reasonable number of cattle tested positive for the disease. Livestock producers not only sustained large economic losses, but also lost key animal bloodlines if their herds were depopulated (Thorne and Herriges, 1992). Damage claims and lawsuits have been filed against wildlife management agencies at the state and federal levels seeking compensation for herd losses. Additional lawsuits are expected in the future, since wildlife were identified as a potential source of the disease (Thorne and Herriges, 1992).

Implementing a wildlife depopulation program similar to the livestock program would solve the bacterial source problem quickly and efficiently. But such an approach would be biologically and logistically impossible to carry out, according to the Wyoming Game and Fish Commission. The American public, as well as the international community, would likely find the depopulation of wildlife in the GYA a repulsive antidote to a localized disease problem (Thorne and Herriges, 1992).

### *The Native Peoples Perspective*

Native American peoples have always had strong cultural, spiritual, and symbolic relationships with bison. The animals once sustained the Indian way of life, according to Louis LaRose of the Winnebago Bison Project based in Winnebago, NE. He believed the much earlier efforts to eradicate the bison were direct attempts to starve the Indians that depended on the animals. "The bison once took care of us," LaRose said. "Now we're in the position where we must take care of the bison" (Associated Press, 1997b).

The InterTribal Bison Cooperative (ITBC) comprises 32 tribes of native American peoples. They believed the large-scale slaughter of migrating bison was both politically and morally unacceptable (Dubray and Heckert, 1997). The ITBC proposed what it believed was a responsible alternative to return the bison to the wild.

They suggested all migrating park bison be captured and tested (Exhibit 4). If an animal tested negative for *Brucella abortus*, it would be transported to a federally certified quarantine facility on 1200 ha (3000 acres) of Choctaw Nation land located in southeast Oklahoma (Dubray and Heckert, 1997), or to a facility on 1600 ha (4000 acres) of the Assiniboine and Gros Ventre tribes' land at Fort Belknap. After construction, a quarantine facility would hold animals for the length of the quarantine period—approximately 1 yr (Kolman, 1997). Animals would be tested for brucellosis at regular intervals during the quarantine period, and those that tested positive would be destroyed. Bison that survived the year-long quarantine-testing process would either be released on reservation lands to supplement existing tribal herds or would be used to establish new ones (Dubray and Heckert, 1997).

The process was estimated to be costly. Expenditures for construction of a quarantine facility with monthly brucellosis testing were expected to exceed \$1 million (Kolman, 1997). The ITBC asserted a satisfactory conclusion to the bison slaughter was "the responsibility of each and every interested party, from the federal agencies, to the stock-growers, to the animal rights organizations..." (Dubray and Heckert, 1997). The organization encouraged each participant to aggressively promote funding so the problem could be resolved quickly and responsibly.

### **The GYIBC Recommendation**

The GYIBC executive committee was required to blend bison biological and behavioral characteristics; geographical and environmental complexities; and economic, technical, and educational considerations to obtain a comprehensive management plan. Their final management proposal should consider the cultural, religious, and symbolic significance bison have with many groups of Americans, as well as the political, economic, and moral ramifications of the tri-state region. In short, the committee must make publicly defensible decisions in the absence of clear scientific directives.

What bison management strategy should the GYIBC executive committee propose?

### **CASE EXHIBITS<sup>2</sup>**

1. The greater Yellowstone area map illustrating federal land holdings in the area most impacted by brucellosis. The map was modified for a black-and-white format by Chris Madson, editor of the *Wyoming Wildlife* magazine, an official publication of the Wyoming Game and Fish Commission (displayed in abridged case as Exhibit 1).

2. 29 Jan. 1997 article in the *Jackson Hole Guide* by McCrystie Adams reporting plans to sue the National Park Service if impacts from winter trail grooming in Grand Teton and Yellowstone National Parks were not studied.

3. Yellowstone map depicting snowmobile routes and roads groomed for winter season recreational use. The map (modified for a black-and-white format) was provided by Yellowstone National Park as a public service to further recreation in that area (displayed in abridged case as Exhibit 2).

4. 12 May 1993 letter to the Honorable Cecil D. Andrus, governor of Idaho, and the Honorable Marc Racicot, governor of Montana, from the Honorable Mike Sullivan, governor of Wyoming, suggesting formation of a committee to propose solutions to the conflict caused by brucellosis in wildlife in the tri-state region (displayed in abridged case as Exhibit 3).

5. 21 May 1993 letter to the Honorable Mike Sullivan, governor of Wyoming, from the Honorable Cecil D. Andrus, governor of Idaho, supporting the idea of forming a brucellosis task force; and 23 June 1993 letter from the Honorable Marc Racicot, governor of Montana, expressing interest in the proposed brucellosis task force.

<sup>2</sup> This list describes the complete number of exhibits found in the unabridged case. The abridged version includes only Exhibits 1, 3, 4, and 10 in their entirety.





*A COMMON-SENSE PROGRAM  
TO SOLVE THE BRUCELLOSIS PROBLEM  
IN YELLOWSTONE BISON*



The Wyoming Wildlife Federation strongly opposes the indiscriminate killing of bison leaving Yellowstone Park because of the allegation that they might spread brucellosis, a disease that affects domestic cattle. In order to protect Yellowstone's bison herd and the tri-state's livestock interests, WWF endorses a program first proposed by the National Wildlife Federation (NWF) and the InterTribal Bison Cooperative (ITBC). This nine-point set of alternatives is outlined in detail below. WWF, NWF and ITBC call upon all of the involved agencies (the Secretary of Agriculture, the Animal-Plant Health Inspection Service, the U.S. Forest Service, the Secretary of Interior, the National Park Service, and the governors and livestock agencies of all three states surrounding Yellowstone Park) to permit, adopt, and implement our common-sense alternative to the systematic destruction of the Yellowstone bison herd.

**OUR OBJECTIVE is to maintain a wild, free-roaming bison herd allowed to range inside and outside of Yellowstone Park without government sanctions being imposed on Yellowstone area livestock operations.** It is imperative that the Yellowstone herd be managed in the public trust and not by livestock bureaucrats. Our alternative is a complete, integrated program; no single component can independently resolve the issue.

1. A BISON HEALTH CERTIFICATION CENTER FOR BISON SHOULD BE ESTABLISHED OUTSIDE YELLOWSTONE PARK.

Rather than killing all bison leaving Yellowstone, whether healthy or not, bison should be safely captured and tested for brucellosis **when they congregate on private lands and human safety or property damage are concerns.** WWF, NWF and ITBC insist that state and federal agricultural agencies promptly approve this bison health facility and that it be located **outside** park boundaries on tribal, public or private land. Bison testing negative should be moved to the bison health certification center. Selected bison which test positive for brucellosis should be placed into a research program where non-lethal tests are developed to discriminate contagious from non-contagious animals. The ultimate goal would be to conserve animals with the genetic and immune capability to systemically defeat the *Brucella abortus* infection.

2. THE YELLOWSTONE BISON POPULATION SHOULD BE MANAGED SCIENTIFICALLY.

The involved agencies and the public should scientifically develop a population goal for the Yellowstone bison herd as a whole (including wintering populations outside Yellowstone Park). When the Yellowstone herd grows beyond the cooperatively established herd goal, strategic methods of herd management should be implemented utilizing standard, professional wildlife management techniques.

3. BISON CERTIFIED BRUCELLOSIS FREE AT THE HEALTH CERTIFICATION CENTER SHOULD BE RELOCATED TO TRIBAL LANDS.

ITBC member reservations are willing to accept health-certified bison from the Yellowstone area. Relocating the health certified bison not only conserves individual bison, but also maintains the genetic integrity of the Yellowstone herd through conservation of bison genes on tribal and, ultimately, public lands. The guiding philosophy of ITBC is that bison, treated as wildlife, are integral to the revitalization of the prairie ecosystem as a whole.

4. IF NEEDED TO KEEP THE YELLOWSTONE BISON POPULATION AT A COOPERATIVELY ESTABLISHED HERD GOAL, A FAIR-CHASE PUBLIC HUNT SHOULD BE ESTABLISHED ON PUBLIC LANDS OUTSIDE THE PARK.

Hunting is used as a professional wildlife management technique for every other big game animal. If implemented correctly, it would be an important tool for scientific management of Yellowstone bison as well. Herd management through hunting must not repeat the mistakes of the past by establishing "firing lines" at Park boundaries. Rather, hunts must be conducted consistent with the principles of fair-chase, and in an ethical and sportsmanlike manner on lands outside of Yellowstone Park.

5. ADDITIONAL WINTER RANGES AND KEY MIGRATION ROUTES OUTSIDE YELLOWSTONE PARK SHOULD BE ACQUIRED.

Purchase fee title or easements through a public/private partnership across private property for a bison migration corridor, allowing bison to safely travel to public lands beyond Yellowstone Park. In addition, key private lands adjoining the Park should be acquired from willing sellers to provide additional winter range and possibly a site for the health certification facility.

6. CATTLE GRAZING TIMES AND PATTERNS ON PUBLIC LANDS BORDERING YELLOWSTONE PARK SHOULD BE ADJUSTED.

Delay cattle grazing on appropriate public land allotments until bison have calved or until they have returned to Yellowstone Park or bison have moved to areas where cattle's grazing is not permitted. Relocate some allotments to areas where bison do not migrate. Provide financial incentives to reduce the financial burden on permittees.

7. CATTLE SHOULD BE VACCINATED ON A CONSISTENT AND ROUTINE BASIS.

Implement a mandatory cattle vaccination program utilizing the vaccine RB-51 within a "Brucellosis Management Area" surrounding Yellowstone Park. This precautionary measure will virtually eliminate the already minor threat to livestock. WWF, NWF and ITBC strongly recommend that the Federal Animal-Plant Health Inspection Service pay for this vaccination program.

8. A VACCINATION PROGRAM INSIDE YELLOWSTONE PARK SHOULD BE DEVELOPED FOR BISON.

Design a brucellosis vaccination program for bison inside Yellowstone Park only after a vaccine that is safe and effective for bison and other wildlife is developed. However, WWF, NWF and ITBC strongly recommend that only an oral vaccine be used.

9. THE WINTER MANAGEMENT OF YELLOWSTONE PARK'S ROADS SHOULD BE EVALUATED.

Some evidence suggests that current Yellowstone winter road management practices encourage and assist bison migration. WWF, NWF, and ITBC believe that further studies should be conducted to better assess changes in bison population dynamics, distribution, and movements caused by the current policy of plowing or packing snow-covered roads. Public participation in this study process is strongly recommended. The results of the study should guide winter road management in the future.

Exhibit 4. A nine-point fact sheet recommending alternatives for bison management.

6. March 1997 article in *Cow Country* by Stan Flitner, president of the Wyoming Stock Growers Association, suggesting responsibility for the brucellosis crisis is being passed around like a hot potato.

7. 15 Jan. 1997 article in the *Jackson Hole News* by Angus M. Thuermer, Jr., describing Yellowstone Superintendent Michael Finley's fears of continuing the bison slaughter to placate Montana's governor Mark Racicot.

8. Status of Negotiations and Other Discussions Regarding the Wyoming Interim Brucellosis Procedures Fact Sheet itemizing some of the Wyoming Game and Fish Commission's brucellosis-related expenses between 1990 and 1997.

9. January 1997 article in *Cow Country* by Cindy Garretson-Weibel pledging support for livestock producers in brucellosis transmission areas.

10. A Common-Sense Program to Solve the Brucellosis Problem in Yellowstone Bison—A Nine-Point Fact Sheet by the Wyoming Wildlife Federation, InterTribal Bison Cooperative, and the National Wildlife Federation (displayed in abridged case as Exhibit 4).

## INTERPRETIVE NOTE

### Case Objectives

Upon completing this case, students should have:

1. An appreciation of the strength of interest groups and the resources available to them during conflicts with government agencies.

2. An appreciation of the *shades of gray* present when dealing with an issue in the absence of clear scientific parameters.

3. An appreciation of the complexities of an issue when politics become intertwined with emotion.

4. An appreciation of the management consequences that inflexible legislative directives can have on biological systems.

### Use of the Case

This is a very complex decision case. It may be best suited for professionals in agriculture or biology, special interest groups, and capstone or graduate-level courses. Supportive course-work in agroecology, agricultural economics, animal science, agronomy, biology, ecology, and zoology would be helpful. The case provides an explanatory foundation for relatively recent case law in Wyoming, so it may also be suited for introductory natural resource law classes.

Discussion of the case may become emotionally charged over sensitive issues. Differences of opinion concerning interest group agendas, governmental policies, cultural beliefs, and economics may be channeled in such a way as to produce a synergistic learning experience for students. The instructor should help the class focus on possible solutions to the problems presented, rather than on the beliefs or personal characteristics of those involved in the decision case.

Comprehensive answers to the following discussion questions can be found in the unabridged case. Readers of

the abridged version will find it necessary to obtain a copy of the unabridged case for use in a classroom discussion situation. Please contact the author c/o Dr. Ron Delaney (rdelaney@uwyo.edu) for more information on obtaining the unabridged version.

## Discussion Questions

**1. The National Park Service has permitted a substantial winter recreational use (i.e., snowmobiles) in Yellowstone National Park. Should winter recreation be continued in Yellowstone National Park?**

**2. Brucellosis eradication can be achieved by destroying animals that carry the bacteria. Is there already a depopulation program in place?**

**3. How can Wyoming, Montana, and Idaho be considered brucellosis-free states when they have so many diseased animals within their borders?**

**4. Yellowstone National Park bison have evolved a degree of immunity against the *Brucella* bacteria. What might we expect to happen to this resistance factor if the GYA bison are depopulated?**

**5. What may happen to the USDA Animal and Plant Health Inspection Service when all U.S. livestock herds are free from brucellosis?**

**6. The USA has many bison ranches. In fact, the GYA herd constitutes a mere 3% of the total number of bison in this country. What special significance does the small Yellowstone herd have, and to whom?**

**7. Which is the best perspective?**

**8. What scientific information do officials need to make an informed decision about brucellosis eradication/management in wildlife?**

**9. Negotiation is a process whereby two or more parties strive to make a decision concerning their interdependent goals or objectives. While all parties must be committed to a resolution, there is generally an absence of clear methodology for making decisions (Hollingsworth et al., 1997, unpublished data). All disputants are invited to sit at the table during a negotiated process, regardless of their viewpoint's polarity. Did this happen with the GYIBC?**

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# UD-R-ALL Dairy: A Decision Case about Dairy Expansion

D. M. Vietor,\* P. B. Thompson, M. L. Wolfe, and David Jones

## ABSTRACT

Lynn, the owner of a dairy in central Texas, wanted to expand herd size to increase farm income and support a potential partnership with two sons (UD-R-ALL). An increase in herd size from 240 to 700 milk cows (*Bos taurus*) was expected to increase potential net income and income for labor contributed by family members. Yet, uncertainty about the constraints of existing state and federal regulations and demands of local activists made it necessary to develop and evaluate information about environmental impacts of the increase in herd size. Although an engineering consultant and federal agency evaluated the design of manure and wastewater handling and containment facilities, the owner needed additional information about potential losses of nutrients from the dairy, environmental risk, and opinions of neighbors and other stakeholders. This decision to increase the herd size provided a farm-level example of learning about issues that have emerged during the industrialization of animal agriculture. Issues concerning economies of scale, regulatory compliance, environmental and social impacts, and human rights have arisen as the size and density of animal operations have increased dramatically on finite land resources. The decision case was used to encourage students to develop and communicate management plans, to conduct qualitative risk assessments, and to consider values of diverse stakeholders in support of recommendations about expansion of the dairy. In addition, the case has been used to stimulate faculty thinking about methodologies and strategies that will enable students to make and evaluate decisions in real-world situations.

THE RESTRUCTURING of agriculture under pressures of increasing levels of capital and technology has potentially positive and negative consequences (Drabenstott, 1994; Ervin and Smith, 1994). On the positive side, increasing farm size and the associated consolidation of input suppliers and processors have helped producers realize economies of scale and improve their access to new technology and to markets for trait-specific food products (Matulich, 1978). The close coordination among production, processing, and marketing components can distribute and minimize financial risk within the food production system.

Lynn, the owner of a dairy in central Texas, wanted to expand the size of his herd of milk cows to generate enough income to support two sons and their families, in addition to himself. The partnership, supported by the expanded herd size of 700 milk cows, was to be named UD-R-ALL. One

son was interested in dairy herd management and the other son would take responsibility for managing land resources, crop production, feed supplies, and waste disposal for the dairy. Lynn and his wife were getting on in years and he anticipated that his sons would provide labor and management inputs in addition to two minimum-wage laborers, who were already employed on the dairy. Lynn described how tough it was for him to cope with the work load for 240 milk cows when one of the minimum-wage positions became vacant. Lynn expected his two sons to gradually replace his current inputs to labor and management in the expanded operation. His sons, in turn, would receive a major portion of net income and returns to labor once the expansion and partnership were well established. The owner perceived that an increase in herd size would enable UD-R-ALL, similar to other large dairies in central Texas, to realize economies of scale and remain competitive in the face of future structural changes in the dairy industry.

Lynn had to decide whether the potential advantages of an increase in herd size could be realized under the environmental and regulatory constraints of his situation. Lynn was well aware of the negative consequences of increasing farm size and associated restructuring of the dairy industry, including potential threats to environmental quality and limited market access of small producers (Ervin and Smith, 1994). Lynn stated in an interview, "We have been careful to avoid harm to our neighbors. We don't want anything that we do on our dairy to hurt anybody."

On a national scale, environmental degradation has been evident in the nutrient contamination of surface water and ground water on watersheds occupied by livestock (Ackerman and Taylor, 1995). Clusters of large livestock operations have created pathways of crop and livestock inputs and outputs that transcend spatial boundaries of a farm or watershed (Lanyon, 1995). Decisions about mineral nutrient pathways have shifted from managers of local land to large-scale businesses that manage imports of feed and exports of farm products. Site-specific monitoring and analyses are needed to factor environmental concerns, including regulatory constraints, into decisions about the size of livestock operations. The objective of this decision case was to involve learners in Lynn's decision about dairy expansion. The case encourages critical thinking about natural and management events and human values that are relevant to the decision to increase herd size.

## THE CASE

Lynn has been in the dairy business for 47 yr. Lynn and his wife started small, milking both by hand and with a single milking machine. They expanded their facilities, includ-

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**Abbreviations:** USEPA, U.S. Environmental Protection Agency; K, potassium; N, nitrogen; NPDES, National Pollution Discharge Elimination System; NRCS, Natural Resources and Conservation Service; P, phosphorus; PPP, pollution prevention plan; TNRCC, Texas Natural Resource and Conservation Commission; USDA-SCS, U.S. Department of Agriculture-Soil Conservation Service.

**Exhibit 1. Sources of family income for current herd size and potential income estimates for increased herd size of 700 milk cows on UD-R-ALL Dairy. The estimated income paid for family labor after expansion of the dairy to 700 milk cows and included an adjustment for increased labor efficiency compared to herd size of 240 milk cows (Matulich, 1978).**

Family income source	Cows in milking herd			
	240		700	
	1994	1995	1994	1995
	\$/herd			
Net income	45 750.00	25 688.00	128 100.00	74 900.00
Labor	26 880.00	24 130.00	78 729.00	73 562.00
Total	72 630.00	49 818.00	206 829.00	148 462.00

ing purchases of additional land and construction of a new milking parlor and open lot, during the late 1970s when dairying was profitable and their children were old enough to provide needed labor. They increased their herd size from 100 to 240 milk cows (*Bos taurus*) during the 1980s in response to advice from their local lending institution and to create income that would support, in part, two of their children. The increase in the herd size of the dairy coincided with the rapid growth in size and number of dairies in the surrounding area. The number of milk cows in their county, on the upper North Bosque watershed in central Texas, increased sevenfold to more than 70 000 cows during the past 19 yr.

A state extension specialist used a previous study of economies of scale in dairy production (Matulich, 1978) and data from dairy enterprise analyses of 1994 and 1995 to help Lynn anticipate the potential economic benefits of increasing his herd size. Assuming no expansions of the open lot and land holdings were needed, net income was expected to be 2.8 times greater for the larger herd size (Exhibit 1). In addition, income for the labor contributed by Lynn and his two sons was expected to increase threefold at the larger herd size. Lynn anticipated one capital cost of the expansion, \$25 000.00 for dredging of a wastewater lagoon and holding pond, but increasing the herd size to 700 milk cows reduced the annual cost per cow for servicing the interest and principal payments of this capital investment by 65%. Feed costs, the major component of annual costs per animal, were unchanged by the increase in herd size. However, costs of insurance and taxes per cow for 700 cows were 16% less than the current herd size of 240 cows (Matulich, 1978). Additional economies if scale included reductions of 32% in each the annual cost of dairy equipment and labor per cow for the herd of 700 compared to 240 milk cows. The total annual cost per cow was expected to be 6% lower if the herd size was increased from 240 to 700 milk cows.

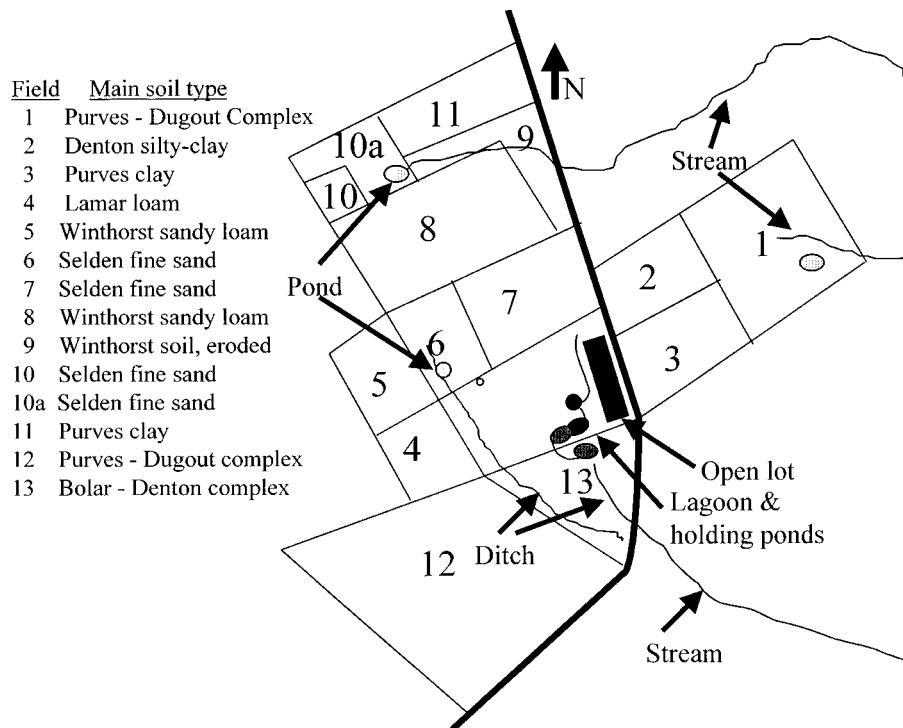
In 1989, regulatory oversight on animal agriculture was formalized at the state level. Existing Texas laws pertaining to management and disposal of organic wastes were consolidated into a set of state permit requirements for new and expanding dairies that confined and fed a minimum herd size of 250 milk cows. Dairies were required to obtain permits if the minimum herd size was confined in either covered or open lots of bare soil or paved surfaces for a total of 45 d or more in any 12-mo period (Pagano et al., 1994). To obtain a permit, producers were expected to control and manage wastewater and manure and to protect surface water

and ground water in accordance with the technical requirements of laws and regulations (Anonymous, 1990). The regulations have allowed application of manure and wastewater on agricultural land, but discharge of contaminated water from any dairy operation into Texas lakes, streams, and rivers has been prohibited. The only exception to *no-discharge* was a chronic or catastrophic rainfall event that caused overflow of wastewater from catchments and lagoons. The waste system, including lagoons, had to be designed, constructed, and operated to contain process wastewater (wash water from cow milking parlor and cow cleaners) plus the open-lot runoff from the maximum 24-h rainfall event that is expected to occur during a 25-yr period at the location of the dairy.

Lynn has confined and fed his herd of 240 milk cows on an open lot area of 2.3 ha (5.8 acres). In addition to the milk cows, Lynn and his two sons have maintained about 50 dry cows and 150 heifers on pasture. Within the small watershed that included Lynn's open lot, 4 ha was allocated to barns; confinement of horses, calves, and sick animals; and wastewater lagoons and holding ponds. The open lot was located on a high point of the property, adjacent to a paved road (Exhibit 2). Lynn owned and used the 160 ha (400 acres) of surrounding land for forage production and disposal of lagoon effluents and manure from open lots. Another 35 ha (86 acres) was leased for field applications of manure and grazing of heifers. Although producers who confined <250 milk cows did not need a Texas Natural Resource and Conservation Commission (TNRCC) permit, dairies of all sizes were inspected recently by TNRCC and USEPA agents. The inspections were imposed to ensure that dairies without permits did comply with regulations that forbid release of nutrients and microorganisms into surface waters. Dairies were given 30 d to correct deficiencies cited during inspections. Fines were imposed for noncompliance.

Manure from open lots and feed alleys of the dairy was scraped and stored temporarily in static piles on the open lot. Land was set aside for both manure and effluent applications throughout each year. Manure in the static piles was hauled from open lots every 14 to 21 d and local USEPA regulations required incorporation of manure within 48 h after application on land used for production of annual row crops. Manure that was applied to perennial grassland did not need to be incorporated. A sample from static manure piles in the open lot was analyzed in February. The concentration of N in manure was 10.3 g kg<sup>-1</sup>. The P concentration of the manure was 4.3 g kg<sup>-1</sup> and the K concentration was 10.4 g kg<sup>-1</sup>.

The wastewater level of Holding Pond 2 was kept near the operating level through pumping and sprinkler irrigation on Field 4 (bermudagrass [*Cynodon dactylon* (L.) Pers.] pasture and volunteer winter grasses) and Field 12 (rangeland) (Exhibit 3). As specified in TNRCC regulations, Holding Pond 2 was dewatered to the operating volume within 21 d after the lagoon level reached or exceeded a level corresponding to one-half of the design runoff volume (Operating volume + Design runoff volume = Total volume of lagoon). Field 4 was west of Holding Pond 2 and adjacent to another dairy (Exhibit 2). The eastern border of Field 4 was separated from the holding ponds by a ditch and a diversion terrace (Exhibit 3). The effluent was pumped from



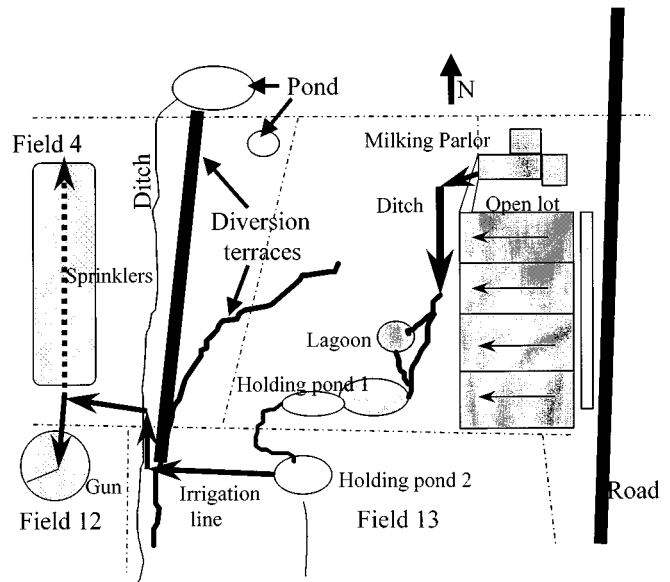
**Exhibit 2.** Sketch of field and open lot boundaries and other surface features of land that Lynn owned and managed in association with his dairy. The names of soil associations were taken from the Soil Survey of Erath County, Texas (USDA-SCS, 1973).

holding ponds to irrigation sprinklers at a rate of  $72 \text{ m}^3 \text{ h}^{-1}$ . A sample of Holding Pond 2 in February revealed a nitrate concentration of  $10.4 \text{ mg L}^{-1}$ , a P concentration of  $11.4 \text{ mg L}^{-1}$ , and a K concentration of  $211 \text{ mg L}^{-1}$ .

Lynn produced a large proportion of the forage requirements of the existing herd of milk cows, dry cows, and heifers on the land that he owned and rented. Hybrid bermudagrass [*Cynodon dactylon* (L.) Pers.], forage sorghum [*Sorghum bicolor* (L.) Moench], winter wheat (*Triticum aestivum* L.), and native grasses were among the plant species that were used for green chop, silage, hay, and pasture. The potential forage yields of these species were evaluated on local dairies and on the Texas Agricultural Research and Extension Center in Stephenville (Chasteen et al., 1994a, 1994b; Sanderson et al., 1994). Forage yields varied greatly from year to year and among the different fields on the dairy. Up to 1995, Lynn applied manure, wastewater, and 200 to  $300 \text{ kg ha}^{-1}$  of a balanced fertilizer (13–13–13) annually to provide the nutrient needs for production of sorghum, wheat, or bermudagrass. One of Lynn's sons had argued that fertilizer applications were not needed when manure was applied on fields that were used for sorghum and wheat production. In answer to the conflict about nutrient applications, Lynn arranged for soil tests on all fields that were owned by the dairy (Exhibit 4).

In addition to the increased herd size of 700 milk cows, UD-R-ALL was expected to maintain about 100 dry cows and 150 heifers per year. Both state and federal waste management permits were required for the herd of 700 milk cows. The state permit was issued by the TNRCC under regulations that were approved by the Texas Legislature (Anonymous, 1990). The TNRCC permitting process

emphasized front-end scrutiny of permit applications and facility design through administrative and technical stages of review within the agency. After review and approval of an application, the TNRCC would issue a draft permit. In his effort to expedite the approval process, Lynn obtained an example of a permit application from the Texas Agricultural



**Exhibit 3.** Blowup sketch of open lot, milking parlour, and facilities for wastewater containment and irrigation on Fields 4 and 12 of Lynn's dairy. The shading of the primary lagoon and Holding Pond 1 depict sediment accumulation. The directions of the slope and of surface runoff were represented by the arrows drawn on the open lot.

**Exhibit 4. Soil test results for samples taken from fields on Lynn's dairy in February 1995. The area and maximum slope of field surfaces and manure and fertilizer rates for the period from January through April 1995 were determined from interviews with the producer and field observations. The field numbers coincide with those on the sketch of field boundaries (Exhibit 2).**

Field	Soil test							Manure rate	Fertilizer rate			Slope	Area
	pH	NO <sub>3</sub> -N	P	K	Ca	Mg	S		N	P	K		
				mg kg <sup>-1</sup>				kg ha <sup>-1</sup>	kg ha <sup>-1</sup>			m / 100 m	ha
1	7.9	8	100	411	27 457	910	866	0	0	0	0	4	24
2	7.9	15	247	182	27 623	475	369	4 500	150	0	0	3	10
3	7.9	33	255	304	26 502	472	257	4 500	150	0	0	3	12
4	8.0	12	296	708	18 889	684	203	†	0	0	0	5	6
5	7.8	30	248	333	19 878	410	201	2 300	78	0	0	5	7
6	7.0	11	294	320	3 361	375	52	4 500	78	0	0	3	6
7	7.3	11	200	150	3 580	311	48	6 800	90	40	75	3	15
8	7.5	14	98	218	3 548	223	41	6 800	68	30	28	2	25
9	8.1	5	19	211	25 304	307	254	0	0	0	0	3	5
10	6.9	4	13	93	1 131	199	29	0	68	30	28	2	3
10a	6.6	1	4	55	646	168	19	0	0	0	0	3	5
11	8.0	3	34	112	5 522	179	64	0	68	30	28	3	8
12	8.0	3	43	152	15 167	500	166	0	68	30	28	2	30
13	7.3	12	44	498	27 799	679	441	680	0	0	0	2	4

† Wastewater from Holding Pond 2 was applied as irrigation during 1995.

Extension Service (Dairy Outreach Program, 1996). After a TNRCC draft permit was issued, a dairy was required to publish a public notice of their permit request. The TNRCC notified landowners adjacent to new or expanding dairies about the tentative approval of the permit application. The adjacent landowners and other citizens were given 30 d to comment and raise objections concerning the permit request. Any *affected* party could request a public hearing. If a hearing was requested, the permit moved to the contested case track. A large number of permit applications were contested in hearings during recent years. Opponents of permits hired legal counsel for hearings and permit applicants were forced to hire lawyers and pay legal expenses for periods of several months to even years (Pagano et al., 1994).

Under federal law, a National Pollution Discharge Elimination System (NPDES) permit was required for new and expanding dairies in Region VI (Oklahoma, Texas, Louisiana, and New Mexico) by the USEPA. The NPDES permit requirement for large dairies (>700 cows in confinement) emerged in response to political pressure from the Cross Timbers Concerned Citizens, with support from the Sierra Club of Austin (Pagano et al., 1994). It was noteworthy that legal precedents for citizen complaints against non-point agricultural polluters focused on water contamination under provisions of the federal Clean Water Act, but many of the citizen complaints in public hearings were about nuisance odor and dust. The NPDES permit required implementation of a Pollution Prevention Plan (PPP) (Dairy Outreach Program, 1996) that duplicated a similar TNRCC requirement. Under the federal USEPA jurisdiction, a "finding of no significant impact" was required for dairy expansion projects.

Lynn was concerned about the public hearing that was part of the permitting process. Up to now, Lynn's dairy had passed two TNRCC inspections. Yet, recent citizen complaints and >300 documented violations of state and federal regulations on other dairies during 1996 raised public concern about manure and wastewater management practices on dairies. Most common among violations were inadequate waste disposal records and failures to control feedlot runoff. In addition, a research institute at a local state university reported elevated P concentrations in reservoir and stream

sites of the Upper North Bosque watershed in central Texas. The P concentration in sampled sites were positively correlated with both dairy cow density and the percentage of waste application fields on associated drainage basins of the watershed (McFarland and Hauck, 1997). In a recent newspaper editorial (Brown, 1992), a spokesperson for the Cross Timbers Concerned Citizens group stated, "We believe it makes no sense to allow continued growth of the dairy industry until we have a better handle on controlling environmental problems that have resulted."

In his efforts to stay informed about government regulatory policies, Lynn had read articles about risk assessment in issues of the *Wall Street Journal* (Graham, 1994) and the *Texas Forage and Grassland Newsletter* (Vietor and Johnson, 1994). The articles suggested that before a target risk could be regulated, the magnitude of risk would need to be evaluated through quantitative methods. Conda (1995) wrote in the 23 January issue of the *Wall Street Journal* that sound science, i.e., quantitative estimates of contaminant impacts on environment and human health, would avoid waste of scarce public and private resources on insignificant health and ecological risks. The article in the *Texas Forage and Grassland Newsletter* indicated that risk assessment could inform producers, policy makers, and concerned citizens about potential hazards of nutrients in livestock waste and the effectiveness of management practices that were intended to minimize hazards.

An experiment station scientist suggested that Lynn use the results of risk assessment to illustrate and communicate the potential impacts of the proposed increase in herd size on water quality. Lynn was advised that risk assessment could document his awareness of potential hazards to water quality during manure and wastewater handling and demonstrate his ability to minimize those hazards through best management practices.

### The Decision

Lynn and his sons had to decide whether it was feasible to increase their herd size to 700 milk cows on their current land holdings. They viewed the increase in herd size as the one option that would enable each of them to earn enough

**Exhibit 5. Estimates of the potential volumes of wastewater that can be contained in the primary lagoon and Holding Ponds 1 and 2 of Lynn's dairy. The volumes were estimated from surface dimensions and Lynn's estimates of the original depth of the lagoon and holding ponds.**

Containment unit	Capacity	Level	Available
	m <sup>3</sup>		%
Primary lagoon	3 750	Full	0
Holding Pond 1	28 300	1 m under maximum	10
Holding Pond 2	23 500	3 m under maximum	80

Daily process wastewater volume for 240 cows = 25 m<sup>3</sup> d<sup>-1</sup>

income to support their families and create a framework for Lynn's transition into retirement. A lesser increase or no change in herd size would force one or both sons to find off-farm employment and Lynn might have to choose just one son as the heir to his dairy. Both sons had college degrees from a state university in their home town, but the partnership in UD-R-ALL offered greater potential incomes than other employment opportunities within driving distance of their current homes in the local community. The option of maintaining the current herd size could rule out financial support of either son and Lynn might have to sell his dairy herd and land holdings to the highest bidder when he retired.

Although the promise of adequate incomes and expected economies of scale supported the decision to expand the dairy's herd size (Exhibit 1), there were uncertainties about UD-R-ALL's compliance with environmental regulations. In the process of their applications for NPDES and TNRCC dairy wastewater control permits and of PPP development (Dairy Outreach Program, 1996), Lynn and his sons recognized gaps in information about current and expanded wastewater and manure management on the dairy. They have sought help from the NRCS and a hydraulic engineer during their evaluation of field plans, soil types, and the existing waste system designs for the dairy (Exhibits 2 and 3). The NRCS and consulting engineer computed lagoon and holding pond capacity in relation to expected rainfall, evaporative loss, wastewater volume, open-lot runoff, and irrigation (dewatering) pumping rates (Exhibit 5). Lynn was concerned about containment of process wastewater and runoff because sediment and manure solids had already displaced 75% of the primary lagoon capacity. In addition, the remainder of primary lagoon volume was usually full of wastewater, except during long summer periods without rainfall (Exhibit 5). Moreover, runoff from open lots had contributed sediment and manure solids that displaced 50% of the volume of Holding Pond 1 during the past 5 yr. The NRCS and the consulting engineer determined that the design runoff volume of the holding ponds was still sufficient to contain the maximum 25-yr, 24-h rainfall event, given the existing irrigation pumping capacity that was available to dewater Holding Pond 2. The engineer verified that clay soils beneath the open lot, ditches, the lagoon, and holding ponds were impervious to water and nutrients.

### Information Needs

The consulting hydraulic engineer used engineering knowledge, observations of structural components of the waste system, weather data, and information gathered from

the producer to estimate the probability of component failures that could lead to release of the nutrients in manure and wastewater. The producer indicated that the primary lagoon failed, i.e., overflowed into Holding Pond 1, on about 270 d of each year ( $P = 0.739$ ). However, he had experienced only one overflow of Holding Pond 2 in 35 yr ( $P = 7.8 \times 10^{-5}$ ). To estimate the probability of overflow of Holding Ponds 1 and 2 under current conditions, the engineer used 80 yr of rainfall data for Dublin, TX, in computer simulations of open-lot runoff and daily dewatering (irrigation) from Holding Pond 2. Even when daily open-lot runoff estimates were adjusted to account for rain-soaked soil, the computer simulation predicted overflow of Holding Pond 2 during only 2 d out of 80 yr ( $P = 3.42 \times 10^{-5}$ ).

Although the design and volume of wastewater containment was adequate for the existing herd size, more technical information was needed to complete the application for the waste disposal permit. In addition to the technical information, an explicit analysis of human values was needed to evaluate the owner's goals and to anticipate and respond to concerns of other stakeholders who might participate in a permit hearing and object to potential environmental and social impacts of an increase in herd size. Lynn and his sons prepared a list of their information needs:

- Amount and nutrient concentration of manure and wastewater that will be produced by 700 milk cows, 100 dry cows, and 150 heifers
- Feed and forage requirements of the expanded herd size
- Species, dry forage yield, and expected nutrient use of crops that were grown on each field
- Tillage, seeding, and weed-control practices that were used on each field
- Potential hazards and risk to water quality from manure and wastewater management
- The natural and management events in waste management that could contribute to environmental risk
- The human values and ethics that were inherent to the diverse world views of UD-R-ALL, regulators, neighbors, Cross Timbers Concerned Citizens, and other stakeholders

### TEACHER'S NOTE

#### Objectives

The general goal of the decision case was to illustrate the importance of both technical information and human values in firm-level decisions that contribute to the industrialization of animal agriculture. The case and associated exercises illustrated the need to integrate technical information about animal and crop management with explicit evaluations of human values to comply with regulatory constraints and to address the value-laden concerns of diverse stakeholders. The case was revised and specific objectives and directions were developed to achieve the goal for four different audiences.

**Agronomy Course.** The decision case was assigned as a term project at the start of the semester. In addition to slide-presentation of the case early in the semester, components of the decision case were used as real-world examples in support of discussions of course subject matter throughout the



semester. Students were organized into groups of three persons or less and were directed to serve as consultants who would advise the farmer. At the end of the semester, the students were required to present plans concerning a cropping system and manure and wastewater management, and results of a qualitative risk assessment, to justify their recommendation about the dairy's expansion. Their plans and recommendations were presented in a simulated public hearing and in a written report to UD-R-ALL. The information about risk assessment included tree diagrams that students completed or constructed. The tree diagrams represented the relationships among natural and management events that contributed to nutrient losses during manure and wastewater management (Fig. 1). Explicit instructions for the risk assessment—including definitions, theory, and directions for completion and construction of tree diagrams—were distributed to students with the decision case and project requirements. Students were given a class-participation bonus for speaking during their group's oral report and for asking questions that represented an assigned stakeholder role during the oral reports of other groups in simulated permit hearings.

**Agricultural Ethics Course.** The decision case was introduced relatively early during the semester to stimulate student discourse and discernment about human values before ethical theories were discussed in lecture. An oral description of Lynn's dairy and of the technical and regulatory dimensions of the decision about expansion was presented in class after students had an opportunity to read the decision case. After the presentation, students were asked to write a 1-page essay. Students were directed to assume the role of a family member who was not a partner in the planned expansion and organization of UD-R-ALL. The students' objective in the essay was to identify the important

moral dimensions of the decision about expansion and to advise those family members who planned to be involved in UD-R-ALL. The potential economic and social impacts of the decision to increase herd size offered the opportunity to distinguish between values and arguments that emphasized utility and those that gave priority to human rights (Thompson, 1996). The essay was due at the start of the next class meeting. During the next meeting, the instructor facilitated a class discussion of diverse student viewpoints about the moral dimensions and stakeholder viewpoints in the decision about dairy expansion.

**Faculty Audience.** In a faculty workshop about systemic change in academic programs in agricultural colleges, the decision case was used to challenge groups of participants to develop an integrative and systemic approach that graduates of their college could use for making the firm-level decision about expansion of the dairy.

### Evaluation

Student responses to questionnaires were used to evaluate the decision case in the agronomy and agricultural ethics courses. The survey results were expressed as the percentage of students who responded to each statement or question during the semesters in which the decision case was evaluated (Tables 1, 2, 3, and 4).

**Agronomy Course.** Student responses to evaluative statements were used to assess their perceptions and preferences during two semesters in which the decision case and project were assigned. At least 90% of the responding students thought the decision case was realistic, supported by adequate sources of information, and a useful part of the course (Table 1). Student responses to questions related to the expansion decision were used to survey student preferences for the decision and for information and criteria that could have been used in the decision. It was noteworthy that only 12% of the agronomy students who were surveyed during two semesters in 1997 supported the decision to expand the dairy (Table 2). Forty-two percent of the students chose criteria (nutrient balance and risk) (Question 2, Table 2) from methodologies that were discussed in class and applied in the decision case. Yet, risk assessment was not chosen to the exclusion of other options; 29 and 39% of the respondents chose risk from among the criteria that should or could be used to make the decision (Questions 2 and 3, Table 2). More students valued the authority of law and regulatory agencies, or public rights to a clean environment, than the owner's authority and rights in the decision to expand (Questions 1, 3, and 4, Table 2).

**Agricultural Ethics Course.** Similar to the agronomy students, 74% or more of agricultural ethics students thought that the decision case was realistic, adequately supported by information, and useful (Table 3). The portion of students who valued societal rights of access to a clean environment was comparable between the two courses, but a larger portion of agricultural ethics than agronomy students chose the value that respected individual freedoms of the owner (Question 4, Table 4). Unlike agronomy students, the percentage of agricultural ethics students who chose owners as ultimate authority for the expansion decision was two times greater than those choosing regulatory agencies on the

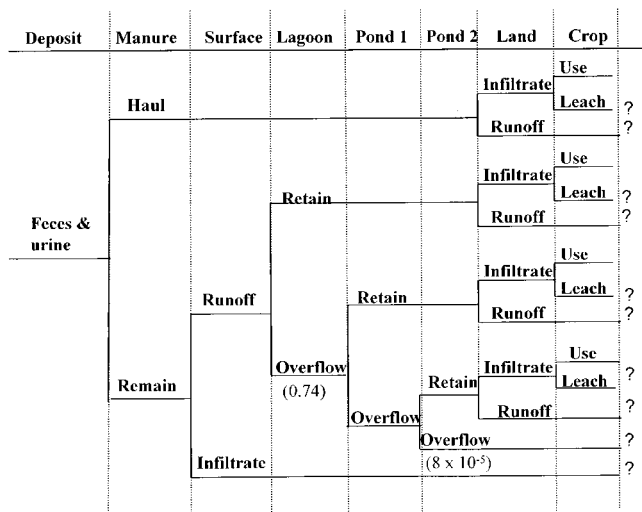


Fig. 1. An event tree illustrating the relationship among components of the manure and wastewater management system of Lynn's dairy. An initiating event, feces and urine deposition on the open lot, is connected to natural and management events within system components that represent successes or failures. Students were expected to fill in blanks on an incomplete event tree for this dairy's manure and wastewater system. Information about probability estimates for selected events was included in the decision case, but students were not expected to estimate probabilities of events in the tree.

**Table 1. Student responses to evaluative statements about a decision case and project that was assigned in an agronomy course during two semesters during 1997.**

Evaluative statement	% of Responding students			
	Strongly agree	Agree	Uncertain	Disagree
The decision case provided a realistic situation for applying the principles in this course.	27	65	4	4
Lecture, the decision case, readings, and handouts provided adequate information for the decision.	8	81	11	0
The decision case, semester assignment, and related class discussions are a useful part of this course.	19	73	4	4

**Table 2. Responses of agronomy students to questions about the decision to expand the UD-R-ALL dairy during two semesters of 1997.**

Question	% of Responding students	
	Pretest	Posttest
1. Who should have ultimate authority and responsibility for decision?		
• Owners of UD-R-ALL	26	
• Neighbors whose land surrounds UD-R-ALL	0	
• Expert who evaluates risk to environment	4	
• Official of state regulatory agency	57	
• Official of USEPA	9	
• All of the above	4	
2. What criterion should be used in deciding whether UD-R-ALL should expand?		
• Profit in dollars per 100 pounds of milk	21	
• State and federal regulations	4	
• Nutrient balance	13	
• Risk to environment	29	
• UD-R-ALL'S right to use property as long as no interference with others' rights	0	
• All of above	33	
3. If you were a downstream neighbor of UD-R-ALL, what information will you require before you concur with state decision to issue a permit for dairy expansion?		
• Economic benefit of dairy to community	0	
• Sierra Club's assessment of environmental impact	4	
• Farmer's compliance with state laws and dairy permit requirements	31	
• Risk assessment by consultant or expert	39	
• Assurance from owner that downstream air and water quality will be protected	9	
• All of the above	17	
4. What value will influence your recommendation concerning the dairy expansion?		
• Respect for individual freedoms of UD-R-ALL owner	4	
• Protect right of access to clean environment for all members of society	43	
• Protect consumers' right to wholesome and nutritious dairy products	0	
• Protect right of all citizens to due process under local, state, and federal law	31	
• Protect your <i>self</i> interests	4	
• All of the above	18	
5. Using your knowledge of UD-R-ALL and the views expressed in class discussion, will you recommend expansion of the herd to 700 milk cows?		
• Yes	12	
• No	88	

posttest (Table 4). Although data were presented during the oral presentation of the case to students that illustrated an excess of N amounts in manure over crop requirements at the increased herd size, >90% of agricultural ethics students recommended expansion of the dairy. The agricultural ethics students were not required to analyze nutrient budgets nor environmental risk. They appeared to accept that the dairy had made a good-faith effort to achieve regulatory compliance through expert advice, management of the existing facilities and land area, and export of nutrients from the dairy as manure.

**Table 3. Student responses to evaluative statements after the decision case and associated assignments and discussions were completed during two semesters of an agricultural ethics course.**

Evaluative statement	% of Responding students			
	Strongly agree	Agree	Uncertain	Disagree
The decision case provided a realistic situation for ethical judgements.	19	67	9	5
The information presented was adequate for the decision and ethical justifications.	14	60	16	10
The decision case, homework, and discussion were useful.	26	65	6	3

**Table 4. Student responses to questions in a pretest and posttest that was administered before and after students completed the decision case and associated requirements during one semester in an agricultural ethics course.**

Question	% of Responding students	
	Pretest	Posttest
1. Who should have ultimate authority and responsibility for deciding whether the dairy expands?		
• Owners		58
• Committee of neighbors who own land surrounding UD-R-ALL		2
• Expert who evaluates risk to environment		3
• Official of state regulatory agency		18
• Official of federal USEPA		5
• More than one of the above		14
2. What criterion should be used in deciding whether the dairy should expand?		
• Profit in dollars per 100 pounds of milk	22	16
• Provide greatest benefit to greatest number of people	28	16
• Protect the right of cows to humane treatment and care	6	3
• Right of owners to use property as desire if no interference with other's rights	22	40
• Protect environment for future generations	21	--
• Risk to environment	--	16
• More than one of the above	1	9
3. If you were a downstream neighbor of the dairy, what information will you require before you agree with the decision to issue a permit for expansion?		
• Economic benefit of dairy to community	3	0
• Environmental impact assessment by Sierra Club	19	5
• Farmer's compliance with laws and permit requirements	33	39
• Personal assurance from owner that downstream air and water are protected	38	24
• Nutrient budget for dairy	3	--
• Risk assessment by expert	--	26
• More than one of the above	4	6
4. What value will you use to decide whether to recommend expansion of the dairy?		
• Respect for owner's individual freedoms	18	27
• Protect society's right of access to clean environment	36	40
• Protect consumer right to nutritious supply of dairy products	22	4
• Protect right of citizens to due process under local, state, and federal law	16	14
• Protect your <i>self</i> interests	4	4
• More than one of the above	4	11
5. Given your current knowledge of UD-R-ALL and the views expressed in class discussion, will you recommend expansion to 700 milk cows?		
• Yes	79	91
• No	21	9

**Faculty Workshop.** A 3-page version of the decision case was distributed to participants and a 20-min, illustrated description of Lynn's dairy was presented at the start of a 3-h session of the workshop. Working groups were given 1.5 h to develop a systemic and integrative approach to making the decision and 1 h was devoted to reports from four groups and associated questions and discussion. Evaluation of the decision case in the context of the workshop was anecdotal,

but the decision case did illustrate how a real-world situation could stimulate interdisciplinary thought and discussion about a broad range of issues, including economies of scale, environmental quality, family farms, technology transfer, nutrient cycling, and sustainability of animal agriculture. It was noteworthy that each group of faculty developed and proposed a different approach for analyzing the situation and organizing information for the decision about expansion. One group modeled the dairy as a bounded system of connected components that could be analyzed and managed to optimize productivity and efficiency and to minimize environmental impacts. Two groups proposed linear, step-wise approaches in which constraints, costs, risks, and benefits were identified and could be quantified. The model of a fourth group could be described best as a system of human activities that fostered learning of participating stakeholders and supported firm-level decisions, including dairy expansion.

### CONCLUSION

The decision whether or not to increase the herd size to 700 milk cows stimulated learning and participation of three different audiences. The decision about expansion and associated assignments and exercises encouraged critical thinking about regulatory constraints and environmental consequences in an agronomy course, about the human values and ethics in an agricultural ethics course, and about learning models and methods in a faculty workshop. In the different contexts, the case illustrated the potential conflict between economies of scale that have driven structural change in animal agriculture and potential environmental impacts and opposition from nonfarm stakeholders in the situation. Student responses to surveys indicated the decision case was realistic, adequately supported by information, and a useful part of both the agronomy and agricultural ethics courses.

### ACKNOWLEDGMENTS

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# Hard White Wheat Variety Release: A Decision Case

Sara Schumacher,\* Michael A. Boland, George Ham, and Ronald L. Madl

## ABSTRACT

In the spring of 1998, the Kansas Agricultural Experiment Station announced that two new hard white wheat varieties (*Triticum aestivum* L., 'Betty' and 'Heyne') were available for possible release in Kansas. The varieties represented approximately a \$15 million investment by Kansas taxpayers. Approximately \$3.4 million of this investment had been paid by producer checkoff funds through the Kansas Wheat Commission. The major decision in this case was whether the varieties should be released immediately. If so, what was to be the appropriate method for the release procedures? The case summarizes four alternative options for variety release procedures, as well as both positive and negative positions of producers, producer organizations, and agribusiness firms on this decision case. The case provides the basis for discussing technology transfer and the appropriate role of a land-grant university in distributing crop varieties that have been funded by the public and private sector. Students should gain a greater understanding of how land-grant universities analyze decisions that have major implications for the structure of a state's agricultural industry.

THE Kansas Agricultural Experiment Station (KAES) announced in 1998 that two new hard white winter wheat varieties (*Triticum aestivum* L., 'Betty' and 'Heyne') were available for possible release in Kansas (K-State Research and Extension, 1998). A multidisciplinary committee (Hard White Winter Wheat Committee) within the College of Agriculture had been created to prepare a recommendation regarding release procedures (Exhibit 1). The committee's charge was to: (i) generate a release of high quality seed increase, (ii) release white wheat to the market in a way to keep red and white wheats separate to protect the value and orderly marketing of each class, and (iii) protect the research investment of Kansas taxpayers and the expense of wheat producers contributing to checkoff funds (M. Johnson, 1998, unpublished). White wheats rather than hard red wheats were increasingly in demand by domestic and international millers and bakers. A strategy of widespread adoption of white wheat by all producers was likely to be more effective than allowing only a small number of producers to market the white wheat varieties. However, there were few economic incentives for producers to switch from red wheats to white wheats. The successful adoption of white wheat varieties depended on the ability to keep the hard red wheat, which is the predominant wheat grown in Kansas, separate from the white wheat. Failure to segregate

these two classes would disrupt the marketing system and these new white varieties would likely not be adopted by producers. Lack of widespread adoption would not provide the greatest return to the Kansas taxpayer investment in the development of the varieties. The traditional method for crop variety release was a general release to enable access for all Kansas producers. This case considers alternative release procedures including two nontraditional methods that were both novel and controversial (Exhibit 2).

## THE CASE<sup>1</sup>

Kansas is the largest producer of hard red winter wheat in the USA. In response to an increasing demand for hard white wheat relative to hard red wheat, breeders at Kansas State University developed hard white wheat varieties adapted to Kansas (Paulsen, 1998). The first two varieties were available for possible release in Kansas in the fall of 1998 and represented 15 yr of research effort. Over \$12 million had been invested by the Kansas Agricultural Experiment Station (KAES) in the development of these varieties. Through a "check off" fee paid to the Kansas Wheat Commission (KWC), wheat growers had invested an additional \$3.4 million in their development. The goal was to maximize the market opportunities for Kansas hard white wheat, and provide Kansas wheat producers and taxpayers the highest return possible for their investment. A Kansas State University press release stated:

K-State has determined that release of these two varieties through conventional mechanisms may not result in the best return on investment for Kansas agriculture. The introduction of a new wheat class into an area dominated by hard red winter wheat must be done in a way that maximizes the potential for development of the white wheat industry with minimum disruption to the red wheat industry" (K-State Research and Extension, 1998).

The two new varieties were comparable to the recent hard red winter wheat varieties that had been released in Kansas for yield and baking characteristics. As expected, the white wheat varieties had a 1 to 2% improvement in milling yield over hard red wheat, since less bran could be extracted without affecting flour color. A KAES agronomist reported:

White grain can be milled at a slightly higher extraction rate to yield more flour than red grain, making each bushel more valuable. The higher extraction rate often increases the flour's content of protein, an essential component for bread making (Paulsen, 1998).

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<sup>1</sup> This journal uses SI units, according to the ASA-CSSA-SSSA style. Due to the circumstances of this case study, however, English units are used, either alone or along with SI units.

**Abbreviations:** KAES, Kansas Agricultural Experiment Station; KCIA, Kansas Crop Improvement Association; KWC, Kansas Wheat Commission; KCES, Kansas Cooperative Extension Service.

**Exhibit 1. The hard white winter wheat committee at Kansas State University.**

Individual	Department
Mike Boland	Assistant professor, Department of Agricultural Economics
Brendan Donnelly	Head and professor, Department of Grain Science and Industry
George Ham	Associate director, Kansas Agricultural Experiment Station
Tim Herrman	Extension grain specialist, Department of Grain Science and Industry
John Howard	Program administrator, International Grains Program
Don Kueltzow	Director, USDA-ARS Grain Marketing Research Lab
Ron Madl	Director, Wheat Research Center
Joe Martin	Professor, Department of Agronomy (Agricultural Research Center-Hays)
Rollie Sears	Distinguished professor, Department of Agronomy

Increased demand for soft and hard white wheats that could be used to make noodles had occurred in recent years, especially in Southeast Asia. U.S. wheat associates noted:

Asia is the fastest-growing market in the world, and noodles are its fastest-growing segment. Currently, Asian noodles utilize 405 million bushels of wheat and Middle Eastern Flatbreads account for another 400 million bushels. Without hard white wheat, the U.S. cannot compete with the Australians in this market (Reichenberger, 1998).

Market share for U.S. wheat exports had declined over the previous 10 yr (Exhibit 3). Meanwhile, other countries such as Australia had increased market share due, in part, to lower transportation costs and differentiated products (Exhibit 4). Australia produces only hard white wheat varieties and has differentiated their wheats by variety and quality characteristics. A spokesperson for a major U.S. grain company was quoted with reference to U.S. wheat producers:

You're (producers) being clubbed to death by the Australians on how their wheats yield more flour than U.S. hard red winter wheat (Ernst, 1998b).

The U.S. government had also used wheat as a policy instrument in recent years. For example, wheat exports to Pakistan were cut off due to the Pakistani government's testing of nuclear weapons. A spokesperson for the Washington Wheat Commission said:

If we lose this (Pakistan market), we're devastated (AgWeek, 1998).

Many believed that white wheat offered hope in regaining the U.S. share of the world wheat market. The vice-chair of the Kansas Wheat Commission said:

Hard white wheat is a tool we can use to regain our presence in the world wheat market. We can become competitors again, rather than suppliers of last resort (Reichenberger, 1998).

The question of whether the USA could become a major hard white wheat producing country was of interest to many different parties. Economists at the USDA framed the issue by asking the question,

Will HWW (hard white wheat) remain a niche product or will it become a major new class of wheat? (Lin and Vocke, 1998)

**Exhibit 2. Sample magazine editorial regarding the release options (Ernst, 1998a).**

"As Kansas Farmer Sees it: Red Letter Days for White Wheat" by Hank Ernst

Dear KSU White Wheat Release Team:

...K-State, you're in the catbird's seat. Preliminary interest, with few exceptions, is high in the two new hard white wheat varieties pending release. . . Your decision to offer the varieties, provided they meet muster, on a nonexclusive, identity preserved basis is shrewd. What, however, is nonexclusive means providing a proportionate share of the available foundation seed (production from 15 acres of each, far less than the more than 3000 bushels available in a typical hard red wheat release) to all who meet release criteria. Too few bushels per accepted entity? Then delay the release to increase the supply, even if it means challenging tasks of contract production and processing. The certified seed growers I know would certainly be up to the task.

Fully years ahead of the next closest state or private breeding program, you have an opportunity to go beyond the politically correct release model initially presented. While you cannot coerce players to join forces (some unexpected alliances may emerge regardless), you could craft a release scheme, which would provide a larger stake for farmers. The program's emphasis, as the predominant wheat produced shifts from hard red wheat to hard white wheat could be domestic markets, ones more readily monitored.

You already have a commitment from ABC Company to be a proactive player at any level. That's a refreshing development. Given the multinational company's status, connections, and capital base, an all-or-nothing position would not be out of the question. Should ABC Company or a firm of similar stature elect to submit a proposal and subsequently be selected as one of several recipients, they'll be stiff competition for others who also meet the requirements, but aren't as well grounded.

Make no mistake, participation by ABC Company could speed up the achievement of critical mass, a level of production that efficiently could meet the demands of the milling and baking industry. I recognize such a scenario may in time go a long-way to capture a lion's share of the world white wheat market-Middle Eastern style flat breads in Africa and noodles in Asia. Would it, however, better serve me and fellow farmers?

It's all in how you look at it. If hard red wheat is out of favor and the USA isn't a viable player in white wheats, then I won't be receiving the highest return from my farm. No, I don't think hard red wheats will go away over night, but with K-State's commitment to white wheat breeding, the reds will lag in production and agronomics. Without a value-added edge to my marketing, it will still be bushels in the bin that I've paid for, whether the wheat is white or red.

I wasn't around when Turkey Red was first seeded, but I don't intend to miss out on hard whites. I want to be involved in a producer-driven system, that, despite pitfalls beyond the farmgate, positions my further-processed products closer to the consumer. The model you develop could be used for future releases of grains for even more specialized traits. Consider your work a pioneering effort in an alternative risk management plan for farmers.

### Wheat Production

Wheat is divided by the USDA's Federal Grain Inspection Service into six classes: durum, hard red spring, hard red winter, soft red winter, hard white, and soft white. Wheat class, which was determined from the kernel shape and appearance, reflected the intended end-use of the flour. Wheat was grown in 42 states with almost 45% produced in the five states of Kansas, Oklahoma, Texas, Nebraska, and Colorado (Exhibit 5). These five states produce hard red winter wheat, the major type grown in the USA.

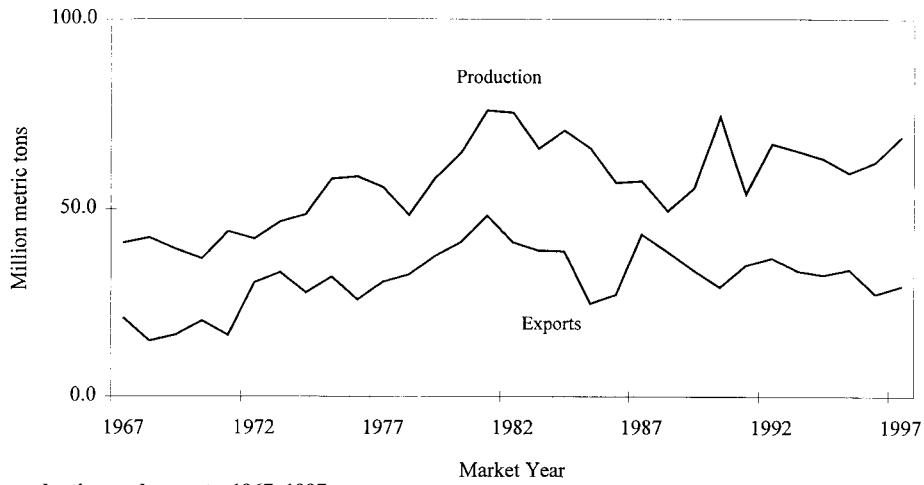


Exhibit 3. U.S. wheat production and exports, 1967–1997.

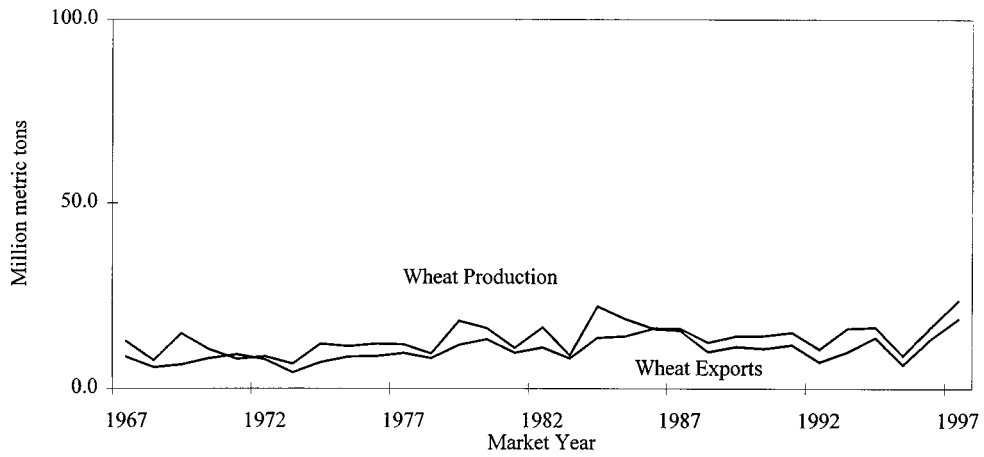


Exhibit 4. Australian wheat production and exports, 1967–1997.

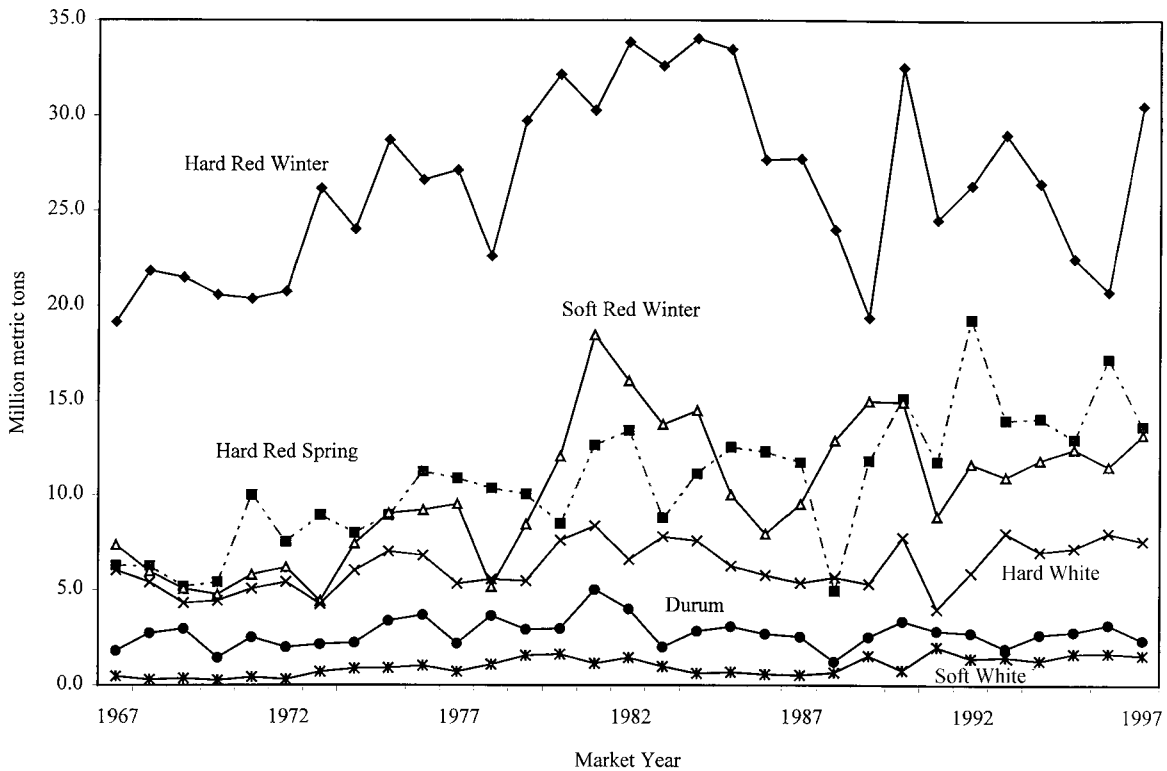


Exhibit 5. U.S. wheat production by class, 1967–1997.

Approximately 25% of the U.S. wheat (primarily hard red spring wheat) wheat production is grown in North Dakota, South Dakota, and Minnesota. Durum wheat is grown primarily in North Dakota and Montana, and white wheat was grown mainly in the Pacific Northwest. Soft red winter wheat is grown from Missouri to Ohio and in the Atlantic States (U.S. Congress Office of Technology, 1989).

The U.S. production and export of hard red winter wheat significantly declined from the early 1990s (Economic Research Service, 1998). Kansas produced more bushels of wheat than any other state in the USA, but production had been decreasing in the past decade (Kansas Agric. Statistics Service, 1998). The decline in wheat production was primarily due to low wheat prices and producers who took advantage of the 1996 FAIR Act to switch to potentially more profitable crops such as corn (*Zea mays* L.) and soybean [*Glycine max* (L.) Merr.].

The KAES had a vested interest in the hard white wheat's successful release. Due to climate and soil conditions, wheat is the primary crop grown in Kansas. Much of south central and western Kansas is relatively dry and it is not economically feasible to grow other crops. The successful introduction of a hard white wheat may provide an opportunity to expand the market for all Kansas wheat producers and this made it a KWC funding priority.

The two hard white wheat varieties released are adapted for central and western Kansas. They are comparable in performance to the most popular hard red winter wheat varieties. In addition, five new hard white lines had been advanced into elite and regional tests, and all had performance traits equal to or better than the two hard red winter wheat varieties with the greatest acreage being grown in Kansas. Three of these five new varieties were being increased on a preliminary basis for release consideration in 1999 or 2000 (Madl, 1998). This provided a short-term marketing opportunity for Kansas producers since other states were not anticipating hard white wheat varieties for several years.

### Wheat Quality Characteristics

The quality of wheat characteristics may be separated into three categories of properties: physical, sanitary, and intrinsic. Physical properties included test weight, kernel damage, shrunken or broken kernels, and foreign material. These properties used U.S. Wheat Standards to grade and market the majority of hard winter wheat. The sanitary properties were contaminants that may affect wheat such as insects and pesticide residue. These properties were also used to grade and market wheat.

The intrinsic properties determine the wheat's milling and bread-making (end-use) performance. These properties include flour protein content and quality, falling number, flour yield, ash content, flour color, dough mixing properties, texture, color, and loaf volume. The intrinsic qualities had not traditionally been used to market wheat, but buyers have conducted surveys to determine geographic regions where the desired wheat quality exists. Processors, due to the speed and precision at which mills and bakeries operate, were demanding consistent quality with certain intrinsic characteristics (Herrman et al., 1995).

The market channel for most wheat starts with the country elevator. Testing at country elevators only included measuring the wheat's physical, sanitary, and some intrinsic properties (protein content). However, many of the intrinsic characteristics were not known when it left the country elevator. Wheat was shipped from local country elevators to large central storage and distribution terminals or subterminal elevators. Wheat was blended to achieve grade and test weight uniformity, and to provide the desired protein content. The terminal's primary function is storing wheat and preserving its condition before shipping it to the final customer (CAST, 1996). The wheat was likely to be milled into flour. The current industry structure did not typically provide information regarding the intrinsic qualities of wheat (other than protein) until it was milled into flour.

### Traditional Release Procedures

The KAES releases wheat varieties through an alliance with the Kansas Crop Improvement Association (KCIA). The Kansas state foundation seed program director was provided seed (*breeder's seed*) after preliminary approval of a new wheat release. The foundation seed program planted approximately 100 to 200 acres (40–80 ha) of breeder's seed with the intention of producing 3000 to 5000 bushels of cleaned foundation seed.

This foundation seed was available for purchase when the KAES officially released the new variety. The KAES did not have enough land or facilities to increase seed production, which was why KCIA was used to expedite seed production. Category 1 seed growers, who were members of the KCIA, were the first to receive foundation seed. Category 1 growers must have successfully grown certified seed for a minimum of 3 yr. Because of supply limitations, foundation seed was not available to every Category 1 grower, and the foundation seed program director allocated seed quantities to the growers during the first year or two after release.

Foundation seed Category 1 growers produce registered seed that could be purchased by any producer in Kansas or neighboring states. The registered seed was planted to produce certified seed, which was available to any interested producer. Kansas Crop Improvement Association's role in this process was to inspect and ensure the integrity of all certified seed classes. Kansas State University retained control for a new variety during the first 2 yr of seed increase through breeder's and foundation seed production. Once foundation seed was distributed to Category 1 seed growers; the variety was considered released to Kansas seed growers. This standard release procedure made new crop varieties available to the general public beginning with certified seed growers and then to anyone in Kansas (Boland, 1999).

The potential problems with this method for these hard white wheat varieties were segregation and economic incentives. If the white wheat was mixed with red wheat, it was no longer classified as white wheat and lost its identity in the marketing system. To preserve the identity of the grain during the critical period of introduction, it was necessary to segregate it from red wheat. However, only a third of the storage in Kansas is on-farm relative to 75% in North Dakota (Dhuyvetter, 1999). Thus, country elevators would be responsible for class segregation in Kansas, which could

require some coordination between agribusinesses and producers.

It was thought that significant economic incentives did not exist for hard white wheats. Agribusiness firms believed that any hard white wheat premiums above the hard red wheat price were likely to be less than \$0.05 per bushel. Using Baker, Boland, and Herrman's (1998, unpublished) simulation model, Heischman (1998) found the cost of wheat segregation at country elevators to be \$0.02 to \$0.04 per bushel, depending on the number of drives, capacity, and pits. Producer adoption was likely to be based on economic incentives and the ability to rapidly segregate based on color at country elevators. This gave rise to the decision about how to introduce these two hard white wheat varieties. Should the release follow the same procedures as previous crop variety releases, or should an alternative method be used?

### **Kansas Crop Improvement Association**

The KCIA is the official seed-certifying agency in Kansas with membership made up of 10 members representing growers and seed dealers to serve on the KCIA board of directors. These elected directors, one director elected by the Kansas Seed Industry Association, the head of the Kansas State University Department of Agronomy, and the director of the Kansas Cooperative Extension Service (KCES) governed the KCIA. The executive director served under the board and managed the day-to-day operations of the KCIA. There were close relationships between the KCIA, KAES, and the KWC.

The Kansas Certification Law authorized Kansas State University to appoint an agency to carry out the necessary functions of seed certification in the state of Kansas. The university had annually reappointed KCIA as the official state seed-certifying agency since 1937. The mission of KCIA was to "plan, facilitate and document the orderly selection, distribution and increase of pure, unique and identifiable genetic plant materials from originator to consumer, to improve and enhance the economic, environmental or nutritional well-being of the people of Kansas and the world." The KCIA worked closely with KAES and KCES, and the Kansas Seed Industry Association.

The Kansas Agricultural Experiment Station and KCES annually tested new and currently grown varieties of wheat. These performance tests included agronomic information, disease ratings, and milling and baking quality. Performance tests were published annually and made available to Kansas producers. The objective was to provide Kansas producers with unbiased performance information on varieties and hybrids likely to become available in the state.

### **Previous Hard White Wheat Releases**

Hard white wheat was grown in Kansas by producers of the American White Wheat Producers Association (AWWPA). The AWWPA was a cooperative, chartered in 1988, which produced and marketed hard white winter wheat to markets in the Great Plains. They had hoped that producers could maximize their returns from white wheat production by forming a cooperative. The AWWPA controlled the production and marketing of an existing KAES

hard white wheat variety through an exclusive restricted release that was given to them in 1988. However, AWWPA had not managed to increase the market for hard white wheat. Wheat production had not increased beyond a few thousand acres (hectares). The main criticism of this release procedure was that economic benefits were given to relatively few producers rather than to all the wheat producers who had funded the variety's development.

To grow the hard white wheat varieties controlled by AWWPA, a producer became a member of the cooperative by purchasing common stock that cost \$100 per share. Each share of stock gave the producer the right to grow 100 acres (40 ha) of wheat. Each producer signed an agreement indicating that he or she would grow hard white wheat according to certain conditions and abide by a marketing agreement. All fields were inspected and growers were required to submit a 35-pound (15.75-kg) grain sample from each field after harvest. The AWWPA arranged for transportation of wheat that met quality specifications.

The AWWPA's goal of supplying a consistent, high quality, identity-preserved grain required additional testing costs. After wheat was harvested and stored, each lot of grain went through milling and baking tests assuring the wheat in storage was of high quality and would meet end users specifications. The AWWPA's strategy was to maximize economic benefits for its members who represented an unknown share of Kansas wheat production (Brester et al., 1996).

The number of acres (hectares) planted to hard white wheat had been growing rapidly, but total land area planted was small compared with the production of hard red winter wheat. One problem for AWWPA was matching supply with projected demand. Potential customers were reluctant to commit to hard white wheat due to lack of reliable supply assurance. Producers were reluctant to participate in contract wheat production, since they assumed more risk and relinquished some control over production. Given small economic incentives and the need to educate producers with respect to contract production, it was unclear if there was an opportunity to increase production sufficiently to assure potential customers of a reliable supply. However, AWWPA was undercapitalized and filed for bankruptcy in 1994. Their exact financial situation was unknown at the time of the varietal release decision.

A second Kansas wheat cooperative was the 21st Century Grain Processing Cooperative, which was formed in 1996. Producers purchased the right to deliver a minimum of 2850 bushels of wheat for \$5000. The cooperative used existing equity to purchase a New Mexico mill, which provided flour for the tortilla market. However, the cooperative was not yet fully capitalized.

Other wheat producer cooperatives had been successful in marketing identity-preserved wheat. Dakota Growers Pasta Company had started in 1992 through the sale of stock to producers who leveraged a \$12.5 million investment into becoming the largest private durum wheat marketing firm in North America. In January 1998, U.S. Spring Wheat Growers announced plans to build a mill in the southeastern USA after raising over \$20 million in equity. The marketing plans developed by each of these two cooperatives cost approximately \$250 000, respectively. Clearly, producers in



the northern Great Plains had experienced success with some producer-owned cooperatives. Other producer-owned cooperatives such as Harvest States Cooperatives (now Cenex Harvest States) had been profitable, but have a more diverse product line.

#### **Four Alternative Release Procedure Options**

The multidisciplinary Hard White Wheat Committee at Kansas State University had identified four options for releasing the new hard white wheat varieties: (i) use the current release program, (ii) implement a restricted release program, (iii) initiate a managed public release program, or (iv) delay the release for 1 yr so that KAES would increase seed production.

The current release program provided the most equitable allocation of economic incentives to producers in Kansas. However, the current method of public release did not consider impacts on the industry due to segregation. Identity-preserved production, segregation, and marketing of the hard white wheat was necessary to ensure that the hard white wheat benefits were achieved by Kansas producers. Producers favored this option because they had invested through wheat checkoff dollars, which are increasingly becoming more important in funding agricultural research at land-grant universities. It was unclear if a nonpublic release would jeopardize the KAES relationship with the KWC and KCIA. A spokesperson for KAES noted:

“...We feel that a public release may result in handling problems, mixtures, and dilution of the two new varieties and may lead to the demise of hard white wheat in Kansas... If we were going to do a public release we should probably increase these varieties another year to produce a greater quantity of seed. This would exceed the land and seed processing capacity of the K-State system (G. Ham, 1998, unpublished).

The second option, a restricted release program, involved awarding a firm exclusive rights to produce and market these two hard white wheat varieties. This firm would decide how to produce the seed for planting and how to market the grain to end-users, while meeting the requirements for preserving the wheat's identity and providing the best return to Kansas producers. This restricted release allowed identity-preserved production and marketing plans to be developed, and implemented over some period of time. There would be a transition to a general public release if the identity-preserved production and marketing proved successful, which would ensure maximum adoption by Kansas producers. However, this plan did not necessarily involve KCIA in certified seed production, although KAES expected that certified seed growers would be part of such a plan. The spokesperson for KAES also noted:

An alternate production and product delivery system for this new class of wheat seems appropriate. We anticipate an identity preserved, nonexclusive release arrangement that will encourage all of the seed production to enter into the hard white wheat marketing channels to allow a thorough evaluation of these varieties (G. Ham, 1998, unpublished).

At the present time, KAES and KCES had already established research and teaching partnerships with two large

agribusiness firms—Cargill and Farmland Industries. It was anticipated that these two competitors would be interested in obtaining rights to these hard white wheat varieties. The KCIA had also discussed forming a third Kansas cooperative (called AGvantage IP) to market the hard white wheat variety seed. Likewise, AWWPA and the 21st Century Grain Processing Cooperative were interested in the hard white wheat varieties. A release to any of these firms might antagonize their competitors who did not obtain the seed. However, none of these firms had provided funds to KAES for hard white wheat research. There were some relationships among KCIA, AWWPA, and 21st Century Grain Processing Cooperative in that some producers and leaders belonged to all three organizations. However, none of the three firms were believed to have access to export markets at the present time. The executive director of the KCIA said:

If white wheat is a preferred food, then the benefits ought to first accrue to U.S. consumers, the taxpayers. For a producer-based group, it's the most direct way to analyze the values of white wheat (Ernst, 1998b).

The third option, a managed public release program, would award the production and marketing tasks to two or more firms or partnerships. These firms were required to use the maximum practical number of Kansas producers to plant and grow certified seed. The KAES would retain rights to production and sale of foundation seed to eligible growers, and retain intellectual property ownership. This option would maximize the number of KCIA growers in the production of certified seed, while attempting to produce and market white wheat in an identity-preserved program when interfaced with a grain marketing firm. The attractiveness of the second and third option was the potential increase in export markets by utilizing those highest bidding firms with experience and contacts in export marketing.

Finally, the KAES could decide to keep the seed and delay release for a year. During that time, KAES would increase seed production at its experimental farms across Kansas. However, this would put a great strain on the KAES system due to increased logistics and the need to rent additional land. It would also place KAES with a large amount of risk if the crop was damaged because Kansas State University is self-insured. However, this option avoided some of the problems associated with a restricted or general release.

As part of the hard white wheat release procedures, the committee recommended that producers or firms must submit a seed production plan and a marketing plan to receive the hard white wheat varieties. Further, the committee indicated that firms could work together on joint proposals. For example, a producer cooperative with KCIA members might partner with an agribusiness firm.

#### **The Decision**

In the spring of 1998, the Kansas Agricultural Experiment Station (KAES) announced that it was anticipating releasing two new hard white wheat varieties. Four options had been identified to establish release guidelines. With few economic incentives to switch varieties, it was likely that hard white wheat variety adoption would be scat-

tered across Kansas unless a marketing plan was developed to ensure widespread adoption and minimum disruption in the marketing system. A producer cooperative had not succeeded in widespread hard white wheat adoption of earlier varieties, but some lessons had been learned through that process. Kansas grain elevators were not equipped to segregate grain on a large scale. The decision to switch producers from marketing hard red wheat to hard white wheat could have long-term payoffs to Kansas agriculture due to possible increased market share. Which alternative should KAES use to release the variety to Kansas producers?

### Teaching Note

Upon completion of this case, students should be able to:

1. Understand the role of producer organizations in assisting agricultural experiment stations with technology transfer and dissemination.
2. Describe the process by which crop varieties have been traditionally released to producers.
3. Describe the concerns in crop variety releases when you have multiple partners involved in funding the research.

### Use of the Case

This case can be used in at least three ways. First, the case could be used for introducing students in an undergraduate agricultural science course to the process whereby new crop varieties developed by agricultural experiment station plant breeders are released to the general public. Students could understand how the process works and discuss why it is advantageous to partner with organizations such as state crop improvement associations to increase seed production. Land-grant universities are constrained by resources and many times it is easier and less expensive to use the private sector to transfer technology or new varieties to the general public.

Second, the case could be used by agricultural economics or agribusiness students to introduce the role that economic incentives have in decision making. Students would be expected to recognize that individuals can change their behavior in response to economic incentives. However, the lack of economic incentives makes adoption more difficult. Land-grant universities can provide recommendations, but without incentives, enacting those recommendations may be difficult.

Third, the case could be used in a more advanced undergraduate seminar course where students discuss topics such as ethics, decision making processes by public institutions, or public policy choices. Students could discuss the increasing role that private industry (agribusiness firms, producer organizations, etc.) has in funding research. Upon completion of that research, land-grant universities may have different parties who believe that they solely are entitled to the benefits from that research.

### Approach

Extensive resources are available on the World Wide Web (a list of resources has been provided in the references). Students could work in teams whereby one individual is assigned to locate information on wheat marketing

and wheat value chain. A second student could find information on producer checkoff programs and agribusiness joint ventures, and what research is being funded. For example, in most producer organizations, funds may be used for costs such as equipment, student labor, and other variable costs. However, these funds do not pay for items such as clerical support, and other costs indirectly related to research. Kansas State University indicates that these costs comprise approximately 45% of total costs. Another student might obtain information on release procedures followed by other experiment stations.

Students could also be assigned to read the case and discuss it in class. Then the instructor could ask the students to choose a particular crop in their state. Students could be assigned to assume that the crop would be released in their own state and could prepare recommendations for release procedures. In doing so, students would be forced to find information on how crop variety research is funded in their state and how agribusiness firms or producer organizations are involved in that process.

### Possible Discussion Questions

**1. What role do commodity organizations and private industry have in setting the research agenda of a land-grant university?** Increasingly in recent years, commodity organizations and private firms have played larger roles in funding research at agricultural experiment stations. Significant declines in federal and state funding, coupled with increasingly expensive research programs, has led to increased funding from these two groups. Commodity organizations fund research through checkoff programs whereby producers contribute a certain percentage of the total value of their grain or livestock to fund education and research on that commodity. These dollars have become more important because they fund production-oriented research such as breeding programs, livestock nutrition, pest control, and other similar research. Consequently, scientists and administrators must work with these groups if they are to continue this type of research. In recent years, there has been a push in some states (e.g., North Dakota) for more direct involvement of commodity organizations in setting the research agenda through legislative action.

**2. Should private firms benefit from sharing the value obtained from research that has been funded by taxpayer and commodity organizations?** Clearly in this case, the role of private grain firms is important because they will have to maintain segregation of the wheat. Producers are not able to export wheat due to cost inefficiencies, market access, and other variables related to the wheat supply chain. The logical answer is that "yes, it is OK," if it can be shown that these firms can assist producers in obtaining that value. It is far too costly for firms to completely integrate into production agriculture. Consequently, that will force firms to provide economic incentives when purchasing the wheat.

**3. What are the major concerns that an Agricultural experiment station must address when releasing a new crop variety?** One concern is how to ensure that the seed production takes place so that the amount of seed available to the public increases, and every person can have access to

that seed. The use of crop improvement associations assists in getting this done. A second concern is that the release of a new variety must not disrupt existing marketing and supply channels. For example, with respect to hard white wheat, grain elevators will need at least two pits so both red and white wheat can be purchased. If elevators do not have the logistical capability to segregate varieties between elevators, the variety will not likely be adopted by producers.

**4. Why is the release of hard white wheat such an important decision in this case?** Hard red winter wheat is the principal crop grown in many areas of Kansas. Most of the wheat in Kansas is used immediately in milling or exported rather than stored for future use domestically. So producers do not store the wheat, which might allow them to take advantages of changes in price over time. Relative to feedgrains or oilseeds, there has been little development of *value-added* wheat products. Despite the few, if any, differences in production costs or tillage practices, producers will likely be resistant to switching from red to white wheat production, unless there are economic incentives. In this case, these economic incentives are estimated to be small. Thus, the release procedure is important to avoid disruption in the marketing and supply channels and to encourage producer adoption. Currently, food and agribusiness firms had indicated that they would not be able to segregate the wheat, and while supportive of the decision to release hard white wheat, these firms believed that the release must be managed in some form. Thus, the Kansas Agricultural Experiment Station had to ensure that the maximum return on its investment in breeding research could be realized without disrupting the marketing and supply channels.

**5. How was the case resolved?** After much discussion by the committee, a 30-d comment period was allowed regarding the alternative release procedures. Although the comments of more than 40 individuals, firms, and organizations were overwhelmingly positive, the committee decided that Option 3 (more than one firm would receive the seed) would be the ultimate method for release procedures, because it involved more than one competitor. However, KAES reserved the right to fall back on Option 4 if no suitable proposal could be found. Three major components were needed to obtain the seed. First, successful proposals must involve certified seed growers to increase seed production, and a seed production increase plan was required. Second, successful proposals must demonstrate that the firm(s) must have access to domestic and international markets and an explicit marketing plan was required. Third, successful proposals must involve as many producers as possible. Four proposals were received (Cargill in cooperation with Goertzen Seed; Farmland Industries in cooperation with the 21st Century Grain Processing Cooperative and HybriTech; AWWPA; and a new producer cooperative formed by KCIA called AGvantage IP). Only the first proposal satisfied the requirements of the Call for Proposals. One of the partners in the second proposal (21st Century Grain Processing Cooperative) wanted exclusive rights to the seed, which was not allowed according to the Call for Proposals. The AWWPA did not have access to international markets and was not adequately capitalized. The last proposal did not have any marketing plan, which did not meet the require-

ments. The net result was that only one proposal met all the requirements. However, providing the seed to only one firm also did not meet the requirements under Option 3 that more than one firm would be given the seed. Thus, the committee faced a stalemate. Some producers were upset that the two proposals from agribusiness firms were considered despite the inability of the producer groups to market the wheat. The two proposals from producers argued that because wheat checkoff dollars were used in the development of the varieties, agribusiness firms should not be considered, and that only certified seed growers should benefit. However, this failed to consider that taxpayers had also helped pay for the development of the varieties. The KAES did attempt to determine if there was a way that the producer groups could work out an agreement with the firms that had proven marketing plans. However, no such agreement could be reached and the committee did not provide a formal offer to anyone. After further consultations with these firms and other grain handling firms, the general consensus was that although segregation might delay rapid development of the hard white wheat industry in Kansas, segregation was not viewed as a limitation. Consequently, the wheat was released using a General Release (Option 1). Note that the actual outcome of the case may or may not be revealed to the class, depending on the instructor's intent. One motivation for including the information is that students could critique the committee's recommendation. This would be important if the instructor is not very familiar with the case. Not including the information allows students to focus on the decision-making process.

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# The Case of the Harmony Basin Grazing Allotment

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## ABSTRACT

The Harmony Basin Grazing Allotment, located in Wyoming, is administered by the U.S. Forest Service. In 1991, the USFS issued a Decision Notice for the allotment calling for a 50% cut in grazing and a conversion of high altitude pastures from cattle (*Bos taurus*) to sheep (*Ovis aries*) grazing after a 5-yr rest period. The changes were intended to remedy problems found by the USFS with rangelands, wildlife and fish habitat, riparian plant communities, and aspen (*Populus tremuloides* Michx.) stands within the basin. For the Moon, Pratt, and Sowers families—holders of grazing permits for the allotment—the cuts meant lost pasture for 989 cow–calf pairs over the summer grazing season. Citing misinterpretations of biological data and negative economic and social impacts, the grazing permit holders (permittees), led by the Sowers, appealed the Decision Notice to Sid Barnes, High Peaks National Forest supervisor. Barnes granted the stay of the decision and also committed the USFS to participate in a Coordinated Resource Management (CRM) group. The group's goals were to formulate grazing plans to ensure that standards and guidelines mandated in the High Peaks Land and Resource Management Plan of 1983 were met on the grazing allotment while minimizing negative economic and social impacts to the permittees and community. The CRM is an innovative approach to resolving natural resource management. This case serves to introduce the CRM method and gives students the opportunity to experience the CRM method as they discuss and attempt to solve a natural resource conflict.

NATURAL resource management, especially on public lands in the Rocky Mountain region, is continually besieged with controversy propagated by many groups (Lundburg, 1980; Ross, 1984; Cramer et al., 1993; Borman and Johnson, 1990). Emotions and personality issues often overshadow and supercede technical knowledge and natural resource management principles. In a number of cases, courts of law have eventually settled the disputes and mandated management plans, rarely to the satisfaction of anyone.

Within this climate of conflict, individuals from private, public, and special interest backgrounds have developed an innovative approach to resolving natural resource management conflicts for the benefit of all, including the resource. Called Coordinated Resource Management (CRM) in Wyoming, and by similar names in other Rocky Mountain states, this approach is a proven tool in allowing concerned individuals to work together to more effectively manage natural resources. This case provides insight into the social,

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economic, and scientific issues that influence the formulation of grazing management plans for public lands while providing the framework for learning consensus building skills through the CRM method.

## THE CASE<sup>1</sup> (ABRIDGED<sup>2</sup>)

### Background

Harmony Basin (Exhibit 1) has always been a land of raw, untamed beauty and rich natural resources. Reaching from the majestic steep sided canyons of lower Harmony Creek, to the snow covered, rocky ridges of Sheep Mountain, Harmony Basin encompasses >177 km<sup>2</sup> of the High Peaks National Forest in the Rocky Mountains of Wyoming.

Once the hunting ground of American Indians, the basin quickly became summer pasture for cattle and sheep as the first ranchers settled in Harmony Creek Valley during the 1880s. By the end of the 19th century, uncontrolled grazing had severely degraded pastures within Harmony Basin and other high country areas across the west. As a result of rangeland abuse, the USFS was established in 1905 and a forage allotment system was initiated (Holechek et al., 1989).

In Harmony Basin, the USFS forage allotment system resulted in grazing permits being issued to area ranches for 1400 cow–calf pairs and 3000 sheep with the grazing season running from 1 July to 10 October. Ranches receiving permits had to: (i) have base property in the area; (ii) show prior use of grazing in the area; and (iii) have feed resources available when livestock were not on USFS land.<sup>3</sup>

Edward J. Hampton and his cousin Joseph established the Round Top Ranch at the mouth of Harmony Creek Canyon in 1928. A USFS permit to graze 1000 cow–calf pairs in Harmony Basin accompanied the land they purchased. To expand operations, the Hamptons purchased an additional 3000-head sheep permit for Harmony Basin in 1938 from a neighboring ranch. When the grazing permit exchanged ownership, the USFS reduced the permit to 2000 head. Due to increasing losses of sheep to predation and the general unprofitability of the sheep business, the permit was converted to cattle at the rate of one cow for five sheep in 1973 (1:5, cow/sheep). At the same time, the USFS imposed a 20% reduction. After the conversion, the Hamptons were grazing a total of 1307 cow–calf pairs in the basin over the summer season.

<sup>1</sup> At the request of the parties involved names, places, and dates in this case have been disguised.

<sup>2</sup> This is an abridgement of the complete case. The complete case consists of 19 pages of text, 131 pages of exhibits, and a 5-page teaching note. Contact the corresponding author to request a copy of the complete case.

<sup>3</sup> For a discussion on the history of public land grazing, see Hage, 1994; Lundburg, 1980; and Ross, 1984.

**Abbreviations:** USFS, U.S. Forest Service; CRM, coordinated resource management; AUM, animal unit month; NEPA, National Environmental Policy Act; EA, environmental assessment; EIS, environmental impact study; BLM, Bureau of Land Management.

During the period after 1938, advances in range science and management had a positive impact in the basin, as the Hamptons, in cooperation with the USFS, constructed fences, developed water sites, and undertook other projects to enhance pasture management. Between 1950 and 1984, the Round Top Ranch spent approximately \$38 per animal unit month<sup>4</sup> (AUM) in the basin on range improvements. Improvements were so successful the Hamptons received range management awards from the Society for Range Management and the USFS.

The range improvements not only benefited livestock but also benefited wildlife, especially the elk (*Cervus elaphus*) population, which expanded tremendously during this period. Edward Hampton, Jr., an old man in 1973, remarked, "When I was a boy coming up into the basin, seeing an elk was an unusual sight. Now they run all over the place, especially before grazing season starts."

As years passed in the basin the rest of the USA experienced tremendous changes. The population grew and shifted from the farm and ranch to the city. Attitudes toward the land and its natural resources changed. People became concerned about air and water pollution, environmental quality, natural resource use, habitat protection, endangered species, public lands, and wilderness areas.

In the early 1960s, the rising national concern for the environment resulted in the Multiple Use–Sustained Yield Act being passed by Congress. This act put interests such as watershed protection, wildlife, fisheries, and recreation on an equal footing with grazing and timber production. In the late 1960s, the National Environmental Policy Act (NEPA) was passed; NEPA required government agencies to review the environmental impacts of any proposed action and make available to the public a written environmental assessment (EA) covering that review process. If the EA found significant impacts on the environment, NEPA required agencies to undertake an environmental impact study (EIS) documenting all environmental, economic, and social impacts of the proposed action, plus possible alternative actions, benefits, and costs. If the EA found no significant impacts, agencies were required to issue a Decision Notice and Finding of No Significant Impact outlining available alternatives and reasons for the agency's decision.

The first impact of these laws on Harmony Basin came in the late 1970s when the USFS began writing the *Land and Resource Management Plan for the High Peaks National Forest* (Exhibit 2). Released in 1983, the 2-inch (5-cm) thick document outlined objectives and goals for the forest over the following 10 to 15 yr and included monitoring procedures, rangeland utilization standards, and key area concepts.<sup>5</sup> The objectives and goals outlined in the forest plan followed multiple use concepts and, as required under NEPA, reflected public interests and priorities gathered from public meetings and written comments.

Livestock grazing systems and monitoring procedures were defined in the plan. Livestock were to graze under rest rotation, deferred grazing, or continuous grazing systems. Key monitoring areas were to be established in each allot-

ment pasture and to be given a classification based on range conditions and timing of use. Cattle were only allowed to graze in a pasture until the utilization standard (percentage of forage removed) for that classification was met within the key area. When utilization on key areas exceeded the seasonal allowable use criteria, the following year's grazing would be cut until goals were met.

The combined impacts of the Multiple Use-Sustained Yield Act, NEPA and the new forest plan finally hit like an earthquake in 1983 when the USFS released a new Allotment Management Plan (AMP) for the basin. Based on the utilization standards of the Forest Plan, the AMP imposed a 40% across-the-board reduction in grazing for a 6-yr trial period.

The 40% cut in grazing was incomprehensible to the Hamptons. In their minds the basin was part of the ranch, it belonged to them, and consequently they had always worked to maintain and improve the basin rangelands. The family asked the USFS, "Wasn't overall rangeland health improving? How could 50 years of good range management suddenly lead to a 40% cut? Hadn't they won range management awards?" Then as reality sank in the family asked, "How can we keep enough cows to survive and still meet the demands of government?"

Caught between the need to survive and the pressures to comply, under protest, the Hamptons agreed to the AMP. But, because they really believed basin rangelands were in excellent condition, the Hamptons made only the smallest possible reductions in their cowherd. Most of the Hamptons' efforts under the new AMP went into scattering livestock to better hide the cows and their impacts. Cows were pushed 5 to 10 at a time into small clearings scattered in the timber, or hung on the sides of mountains to take advantage of hidden grazing. In the broken terrain and timber of a 177 km<sup>2</sup> area, who could really tell if there were a few more cows than there should be?

While the ranch went about fighting its war for survival, the USFS undertook a 6-yr study to inventory resources and identify problem areas in the basin. In cooperation with the USFS, Chris Allison of the Wyoming Game and Fish Department also studied elk populations in the basin. Chris commented, "This is great opportunity to learn more about elk and elk habitat. I also want to make sure that elk don't get all the blame if problem areas are found."

During the study period, Tom West transferred into the area as USFS range conservationist for Harmony Basin. Upon his first visit to the basin in the fall of 1987, Tom said, "The devastation in the basin from cattle overgrazing is so widespread that, if it was up to me, all livestock grazing would stop for many years to come." Tom further commented that the USFS study underway at the time was a good first step toward documenting the definite downward trend in rangeland conditions across the basin.

The study, contained in the *Environmental Assessment–Harmony Basin Allotment Management Plan* (Exhibit 3), was released in interim form in 1988. The study reported that high altitude pastures were degraded and that upland aspen (*Populus tremuloides* Michx.) stands and riparian plant communities, especially willows (*Salix* sp.), failed to meet forest plan guidelines. The study also concluded basin streams showed severe impacts with wide, shallow channels

<sup>4</sup> An animal unit month is the amount of forage required to maintain a mature cow or equivalent for 1 mo.

<sup>5</sup> For a discussion on standards and key areas, see Hall and Lindenmuth, 1998; and Sanders, 1998.

and trampled, unstable stream banks. The study reported that elk use of the basin was well within allowed guidelines. In general, the allotment's livestock carrying capacity had previously been overestimated, with the result being a downward trend in resource condition. To reverse this trend, the study recommended complete rest of all pastures for 5 yr or, failing that, a 50% cut in cattle numbers and a 5-yr rest period for pastures above 2700 m (9000 ft) in altitude, followed by restocking with domestic sheep.

The USFS study gathered both praise and criticism. Praise came from within the USFS and environmental community as individuals touted the study as an excellent example of the thoroughness and professionalism of USFS in attempting to protect the environment. Criticism, on the other hand, came from outside the USFS as people like the Hamptons, local agricultural and business interests, and Wyoming state politicians disagreed with the study's methods and conclusions. These groups accused the USFS of carrying out the study to justify a perceived anticow bias.

In an attempt to deal with the criticism, the USFS asked Tim Pace and John O'Day, professors in the Department of Range Science at the University of Wyoming, to ride the allotment in late summer 1989 and view the areas the study was based on. The professors reviewed the methodology and conclusions of the study and found serious flaws based on what they had seen during the ride. Pace and O'Day reported that the USFS study presented unfounded problems with high-altitude pastures, exaggerated concerns in riparian areas, and assigned blame to cattle for damage that might have been caused by elk. The professors reported that rangeland conditions in the basin were on an upward trend and stocking rate reductions were not needed. The few problem areas that existed were isolated and could be easily fixed by small changes in current management practices.

Regardless of the criticism, the USFS wrote and released an *Environmental Assessment—Harmony Basin Allotment Management Plan* (EA) (Exhibit 3) in 1990 that was based on the controversial USFS study. The EA outlined the study results and presented five possible management alternatives. The alternatives were: (i) no action, leave the 1983 AMP in effect; (ii) reinstate pre-1983 cattle numbers and continue management under the current AMP; (iii) permanent 50% cut in AUMs to adjust the stocking rate, plus 5 yr rest above the 2700 m (9000 ft) elevation then restock with sheep; (iv) 70% cut to adjust stocking rate on entire allotment; and (v) convert entire allotment to sheep grazing, along with a 50% cut to adjust stocking rate.

Upon release of the EA, rumors began to fly that the USFS was going to recommend Alternative iii. Under this plan, the number of cattle grazing from 1 July to 10 October would decrease from 1707 to 718 head, and 1200 sheep would be allowed to graze for 45 d from 15 July to 1 September.

For the Hampton family, the rumored cuts were too much. A drought in 1988 had already forced a reduction in the ranch cow herd and they were tired of fighting the USFS. Instead of getting back into the sheep business and reducing their cow herd even further, the Hamptons put the ranch up for sale.

In early 1991, Martha and Jake Sowers became interested in purchasing the Round Top Ranch. The Sowers

inquired about the rumored grazing plan and were assured by Tom West of the USFS that although 50% cuts in grazing were possible, lesser cuts were more likely—especially if the Sowers would commit to proper management of their cattle in the basin.

Based on these assurances, the Sowers took possession of the Round Top Ranch, believing it to have a carrying capacity of 1500 cows. Shortly thereafter, the Sowers received from the USFS a *Decision Notice and Finding of No Significant Impact* (Exhibit 4) written by Tom West and signed by Lance Ferris, Harmony Basin district ranger. The notice outlined the alternatives available under the EA and specified Alternative iii as the preferred choice.

Upon receipt of the notice, the Sowers were very upset. Under Alternative iii they faced having summer pasture for only 518 cows instead of the 1307 cows they had planned for, and they faced being in the sheep business in 5 yr, something they knew nothing about. They also estimated that the carrying capacity of the Round Top Ranch would fall from 1500 to 1000 head of cattle, and since the value of a ranch was based on its carrying capacity, they stood to lose almost one-third of the real estate value.

While Martha and Jake Sowers were upset about the notice, the Pratt family, who had a permit for 300 cows in the basin, was in a state of shock. Their only source of income was the ranch's 300 cows and the only summer pasture they had was in the basin. The Pratt ranch, along with the neighboring Moon Ranch who had a basin permit for 100 cows, had been grazing cows in the basin for as long as the Round Top Ranch, but had escaped the earlier cuts. Under Alternative iii, they faced the same permanent 50% cut in summer grazing as the Round Top did. Unlike the larger Round Top Ranch and Moon Ranch, the Pratt Ranch only had 300 cows and was already as small as a ranch could get and still support a family.

After researching the issues and talking to the Moons, the Pratts, and Tim Pace and John O'Day, Martha felt the USFS was committing a grave injustice against the ranches. Martha asked, "How is it possible that 50 yr of management, all under the direction of the Forest Service, could suddenly be so wrong that a 50% cut is required?" She also asked, "Why is it that the opinions of two men, both experts in range management, differ so much from Forest Service opinions?" Martha said, "If I thought the Forest Service was really right about range conditions on the allotment I would be happy to cut cattle numbers for a while, but I don't know who to believe and I certainly don't think any permanent cuts are warranted."

Determined to slow down implementation of Alternative iii until her questions could be answered, Martha found that her first legal recourse was through the USFS's internal appeals process with Sid Barnes, the High Peaks National Forest supervisor, as reviewing officer. On behalf of the Harmony Basin permittees, Martha hired a lawyer and appealed the USFS decision before Sid Barnes. Martha said, "I think grazing permits across the west are being cut because of an anticow political agenda of individuals within the Forest Service and because most small ranches don't have the resources needed to fight back against a giant government bureaucracy like the Forest Service. I do have the resources, and I am going to fight, and I will fight on behalf

of all those who can't. I consider it a worthwhile contribution to cattle ranching in Wyoming."

After receiving the *Notice of Permittees Appeal and Statement of Reasons* (Exhibit 5), outlining the permittees' arguments, Sid Barnes granted a stay of the decision. At the permittees' request, Sid Barnes committed the USFS to participate in a Coordinated Resource Management (CRM) group as directed under a Memorandum of Understanding that had been entered into in 1982 with the Bureau of Land Management, the Natural Resource Conservation Service, and the Wyoming Cooperative Extension Service. The memorandum had made CRM the preferred natural resource planning process in Wyoming for the agencies involved.

The CRM group was charged with formulating a long-term grazing management plan for the basin that would: (i) remedy problems and ensure that the allotment met the standards and guidelines mandated in the *Land and Resource Management Plan for the High Peaks National Forest* (Exhibit 2), and (ii) minimize the negative economic and social impacts outlined by the permittees. These plans would then be used by the USFS to help write an AMP for Harmony Basin.

Once agreement had been reached to form the CRM group, invitations were sent to groups and individuals who might have an interest in participating, including environmental groups and federal and state government agencies. After allowing time for everyone to reply, the Harmony Basin CRM committee was formed with the members listed in Appendix 1.

### The Conflict

As preparations were being made for the first Harmony Basin CRM meeting, participants were very vocal about their positions and concerns on a variety of different issues. One position they all seemed to hold centered on protecting the environment within the basin. Each individual, in their own way, said they wanted to conserve and sustain healthy rangelands, forests, and streams in the basin for multiple uses. They personally enjoyed the beauty and natural wonders of the basin through participation in a variety of recreational activities like viewing wildlife, fishing and hunting, summer backpacking, or horse-packing trips and photography.

All future participants, however, did take different positions on what protecting the environment meant and how that protection could best be achieved. The positions, concerns, and personalities of these individuals are portrayed in Exhibit 7. The widest difference in positions, though, was between the permittees, led by Martha Sowers, and the USFS represented by Tom West and Lance Ferris.

Tom West made it clear that his position was absolutely for a reduction in grazing and the conversion of high altitude pastures to sheep as outlined in Alternative iii. Tom said, "I have been convinced from my first visit to the basin back in the fall of 1987 that overall range conditions were declining rapidly and that only drastic measures could reverse the trend. Further visits since that time have only reinforced my original impression. In fact, I still think the best route would be to eliminate all livestock grazing for a 5 or 10-year period." Tom West was also heard to say, "I grew up on a

Wyoming ranch so I have a personal interest in ranching, but my family survived without government subsidized grazing on Forest Service land, so these ranches should be able to do the same." Tom added that he didn't really want every single cow off of the forest, he just thought that ranching interests should be subordinate to the needs and interests of the national forest as the USFS defined them. "After all," Tom said, "when it comes to the Harmony Basin Grazing Allotment, I and my colleagues are the only real experts involved."

The permittees, on the other hand, took the position that the pre-1983 grazing plan for Harmony Basin (including allotment and pasture boundaries, grazing seasons, fencing, water developments, and permitted numbers of cows) was a proven, successful, balanced, and sustainable system based on >50 yr of experience. According to the permittees, this plan balanced all parts of the ecosystem [national forest lands, private pastures, irrigated hay meadows, Bureau of Land Management (BLM) desert grazing allotments, climate, plant and animal communities, and watersheds] as well as the social and economic structures<sup>6</sup> of the Harmony Basin area. Changing the grazing system, according to the permittees, would result in tremendous negative economic and social impacts on them, on the value of their ranches and on area residents and communities, all with no appreciable gains in rangeland conditions in Harmony Basin.

Martha Sowers added this comment, "The grazing system in effect up to 1983 worked and that hasn't changed. The only thing that has changed is the political agenda of the Forest Service." Martha also said, "I love the Round Top Ranch and don't want any damage to the environment in the basin. If I thought the Forest Service's decision was based on sound grazing management principles, I wouldn't protest. At every turn it seems that the Forest Service has bent data to fit its agenda, lied about its motives, and allowed local employees to make decisions based merely on their personal opinions." Martha finished by saying, "I have come to see this fight as a battle against government tyranny and intrusion into my life and the lives of all ranchers in the Rocky Mountains."

When asked where he stood, Lance Ferris said, "In my opinion the Forest Service is the only entity involved in the Harmony Basin that is capable of making an informed, rational decision concerning management of the basin. Local and state interests have shown too much of a willingness to sell out the future for the chance of making a dollar today. And besides that," Lance added, "since the Forest Service is the only legally responsible party involved with Harmony Basin, we will make all the decisions in the end—not necessarily because we want to, but because we have to."

Behind the rhetoric, positions were based on technical issues relating to the establishment of key areas and the application of utilization standards as outlined in the *Land and Resource Management Plan for the High Peaks National Forest* (Exhibit 3). The USFS insisted utilization standards were not being met in key areas. Tom West said, "The goal is to have all basin rangeland in 'satisfactory'

<sup>6</sup> For a discussion on the economic impacts of public grazing policy, see Fletcher et al., 1998; VanTassell and Richardson, 1998; and VanTassell et al., 1997.



condition by the year 2000. We always try to locate key areas so our measurements will monitor each pasture where cattle make the greatest impacts.”

The permittees took the position that the standards were already being met in most pastures and the problems that existed could be easily handled with small changes in current pasture management practices. In their opinion, the utilization standards applied to average range conditions within each pasture. Key areas, therefore, should be in average use areas to measure average use. Darren Younger, the Round Top Ranch manager, explained, “This is mountain country. Cattle have to move from pasture to pasture, and even within pastures, by trails to get through the rocks and trees. If you set up and take your measurements close to a trail, you always get excessive use. There’s no way around it. We’ve tried moving gates and trails in order to move the cattle in different patterns. But when we do, the Forest Service moves their key area so they can measure close to the new trail.”

Another concerning technical issue dealt with elk. Chris Allison, of the Wyoming Game and Fish Department, joined the USFS in taking the position that elk grazing should not be an issue. According to Chris, elk population counts and monitoring measurements showed that elk numbers were at allowable levels and use of available forage was <10%. Their monitoring also showed that the use of forage by elk in the spring had not exceeded the 25% allowed under agreements between the USFS and the Wyoming Game and Fish Department.

The permittees did not just take a position against the population numbers quoted by the USFS, but were concerned with the methods used to report elk forage use. Jason Sills, who was the range conservationist for the Round Top Ranch said, “It’s interesting that the Forest Service insists on measuring the worst cattle impacts, but then will turn around and only report average elk forage use.” Jason added, “The fact is, elk will camp out on the best parts of a pasture just like cows, and when they do the impacts look the same, only the hoof prints are different.” Darren Younger commented, “The Forest Service doesn’t want to accurately measure elk forage use anyway, because if they did, they would have to admit that there are a lot more elk running around these hills than allowed under their own regulations.”

### Finding a Solution

Following the public airing of positions, the Harmony Basin CRM group was scheduled to meet and formulate long-term grazing management plans for the Harmony Basin Grazing Allotment. These plans would serve as the basis for future Harmony Basin AMPs.

### CASE EXHIBITS

Many of the exhibits are several pages in length and may be assigned as reading material at the instructor’s discretion, depending on the background of the students and intent of the learning exercise.

**Exhibit 1: Allotment Description (8 pages).** This exhibit contains a description written by the USFS of the geographical and biological characteristics of the Harmony

Basin Grazing Allotment and includes pasture names and descriptions.

**Exhibit 2: Land and Resource Management Plan for the High Peaks National Forest (9 pages).** This exhibit contains an abridged copy of the 1983 Forest Plan for the High Peaks National Forest. The plan establishes management direction, goals, and objectives for the High Peaks National Forest and specifies standards and guidelines as well as the approximate timing and vicinity of practices necessary to achieve goals and objectives. It also establishes monitoring and evaluation requirements needed to measure the effectiveness of all efforts carried out under the plan.

**Exhibit 3: Environmental Assessment—Harmony Basin Allotment Management Plan (27 pages).** This exhibit contains a copy of the Environmental Assessment published by the USFS in 1990. This document presents alternative management plans considered by the USFS to bring management of grazing in the basin into compliance with the Forest Plan and the impacts of these revisions.

**Exhibit 4: Decision Notice and Finding of No Significant Impact (10 pages).** This exhibit contains a copy of the Decision Notice issued by the USFS in 1991 announcing the USFS’s decision on an Allotment Management Plan for the Harmony Basin Grazing Allotment. The document also reviews the alternative plans considered in the Environmental Assessment and the reasoning behind the choice made.

**Exhibit 5: Notice of Permittees Appeal and Statement of Reasons (6 pages).** This exhibit contains a copy of the appeal written by Martha Sowers’ attorneys and submitted to Sid Barnes, supervisor of the High Peaks National Forest in protest of the 1991 Decision Notice. The document outlines Martha’s arguments against letting the Decision Notice stand.

**Exhibit 6: Report Pertaining to the Ride on the Allotment, 17–18 Aug. 1989 (15 pages).** This exhibit contains a copy of the report submitted to the USFS at their request by Tim Pace and John O’Day, professors in the Department of Range Management, University of Wyoming. This report contains the concerns and criticisms of Pace and O’Day pertaining to the 6-yr study (1983–1989) carried out by the USFS that served as the basis for both the Environmental Assessment published in 1990 and the Decision Notice issued in 1991.

**Exhibit 7: Personality Profiles of the Harmony Basin CRM Group (22 pages).** This exhibit contains basic personal profiles of all members of the Harmony Basin Coordinated Resource Management Group as listed in Appendix 1. These personal profiles can be used for an in-class role-play where students can discuss the case as if they were actual participants with a personal interest in the case.

**Exhibit 8: Wyoming CRM: Enhancing Our Environment (18 pages).** This exhibit is a brochure written by Scott E. Cotton and Ann C. Cotton for the Wyoming Department of Agriculture. The brochure contains an introduction and history of CRM, examples of CRM groups in Wyoming, a discussion of the value of CRM, a summary of CRM, and a copy of CRM guidelines.

## INTERPRETIVE NOTE

### Case Objectives

Through the deliberation and discussion of this case, participants will:

- Gain insight into the varied interest groups, individuals, and positions that underlie this and similar natural resource conflicts.
- Experience the problems and frustrations involved in solving natural resource conflicts.
- Learn fundamental elements of the CRM process and guidelines, and have an opportunity to discover the need for—along with the advantages and disadvantages—of the CRM process.
- Have the opportunity to discuss the economic and social impacts that changes in USFS management of a grazing allotment can have on local ranch families, on the value of their ranches, on area residents, and on area communities.
- Understand the need for using well conceived methods of collecting range management information.
- Gain experience with the type of documents used by the USFS in managing a grazing allotment.
- Have the opportunity to improve their communication and decision making skills.

### Use of the Case

This case was originally developed for use in interdisciplinary capstone courses for senior-level range management, agricultural economics, and animal science students, but will also be of value to extension educators, professionals, and others concerned with learning about and discussing natural resource conflicts in the Rocky Mountains.

While valuable as a decision case for in-class discussions, the case was designed to be used for an in-class role play where students take on the identity, interests, and personality of individuals participating in the Harmony Basin CRM group. Through the role-play, students have the opportunity to personally experience the frustrations and triumphs of solving a natural resource conflict.

The case has been used once in class as a role-play. Three periods were dedicated to the case. During the first period, the CRM process was introduced and students received the roles they would play. During the second and third periods, students played out their roles while participating in a CRM meeting with a facilitator trained in the CRM process. During the second period, students argued issues while exploring their roles. They were then led in a consensus and team building exercise by the CRM facilitator. In the third period, the students attempted to deal with issues while trying to develop a management plan for the basin. During the last part of the third period, students were asked to fill out a short survey covering their impressions of the case and the role-play format.

Student comments about the strengths of the case ranged from, “Showed how CRM works” and “great role playing” to “This is the only day of lab/class that I have wanted to go to.” When asked how the case could be more effective and useful, students wrote, “More time should be allowed to actually hammer out solutions...” and, “More background information. More preparation time.” During class students

showed a wider range of reactions ranging from frustration with the lack of information (it was also obvious that some students had not read the information that was available) and anger at being told, “Use your imagination and play the role the way you want.” Many students welcomed the chance to defend their character’s position.

Given student comments and the high level of class participation, the case objectives appeared to be met. Students were more aware of the issues and frustrations involved in natural resource conflicts. They had learned about the CRM process and, most importantly, come to realize why CRM is needed. They become familiar with USFS documents, discussed economic and social impacts, and internalized the need for sound methodology.

### Discussion Questions

The questions that follow are examples of questions that could be used to stimulate discussion of issues in the case.

#### **1. Who do you think are the main antagonists in this case? Why is the conflict so intense between these antagonists?**

The major conflict exists between Martha and Jake Sowers (permittees) and Tom West (USFS). The conflict becomes intense because of their strong personalities and commitment to their individual causes.

#### **2. What do you think is the main point of conflict in this case? What are the secondary points of conflict?**

In a technical sense, the main point of conflict is over the general trend in range conditions. The USFS is convinced that overall range conditions in the basin are declining rapidly and only drastic measures—such as the 50% cut in grazing—can reverse the trend. The permittees are convinced that the general trend is up and that forest goals can be reached using historic cattle numbers and seasons with only small changes in present grazing practices. But, as it is with many public land issues, the actual conflict is of a political nature. The USFS claims their job is to set the rules, establish study procedures, gather data, make the judgments, decide final outcomes, and if arguments arise, act as judge and jury in the appeals process. The permittees, on the other hand, argue that USFS actions cannot be arbitrary and capricious (i.e., based on personal opinions and political agendas) but must hold up to public review. Secondary points of conflict are:

- Technical issues relating to the establishment of key areas and monitoring of grazing impacts.
- Wildlife vs. livestock on public lands and the effects of high wildlife populations.
- Local vs. federal decision making on public lands.
- Deciding who pays for improving rangeland conditions, the rancher or the public.
- Private property rights associated with holding federal grazing permits and the taking of private property for public use without just compensation under the Fifth Amendment to the U.S. Constitution in regard to economic losses claimed by the permittees.

#### **3. Are there any issues that members of the CRM agree on? Why is it important to recognize these points of agreement?**

All CRM participants want to protect and preserve rangelands within the basin. Points of agreement are important because they serve as a foundation where people can begin to communicate. The CRM process begins by finding points of agreement, then builds consensus while focusing on needs instead of positions.

**4. With all the monitoring and study that has occurred on this allotment, why do you think there is still a conflict over grazing management in the basin?**

The basic conflict is still present because the overall trend in basin range conditions has never been clearly determined. The USFS just assumed that the trend was down, while the permittees just assumed that the trend was up. The monitoring and study that has occurred started with one assumption or the other, leaving the basic question relating to trend, unanswered. In addition, conflict is still present because of disagreements over the definition and use of key areas where utilization measurements are taken and the forage elk are consuming. If elk are a significant contributing factor, then even with the complete removal of cattle, utilization standards won't be met.

**5. How do you think individual perspectives and values impact this conflict?**

Tom West's beliefs toward rangeland trend, livestock on public lands, subsidized grazing for ranchers, and wildlife impact this case by narrowing the problem and solutions he is willing to consider. Martha Sowers' beliefs about the USFS and government, in general, were the motivating force behind her to appeal of the decisions made by the USFS and her impetus in pursuing the CRM process.

**6. What do you see in the CRM method for resolving disputes such as Harmony Basin?**

The CRM method, as outlined in Appendix 2, changes the focus of attention from conflict to common goals. This encourages communication, builds trust and understanding, and ultimately leads to winning solutions for all involved, especially for the natural resource in question.

**APPENDIX 1**

**Harmony Basin Coordinated Resource Management Committee Members**

<b>Committee member</b>	<b>Association or position</b>
Martha Sowers	Owner, Round Top Ranch
Jake Sowers	Owner, Round Top Ranch
Tom West	Harmony Basin Range Conservationist, USFS
Lance Ferris	Harmony Basin District Ranger, USFS
Bob Thayer	Range Conservationist, Natural Resource Conservation Service
Sharon Rogers	Range Conservationist, Bureau of Land Management
Chris Allison	Wildlife Biologist, Wyoming Game & Fish Department
Kelly Buck	Biology Teacher, Harmony Community College
Lloyd Moon	Owner, Moon Ranch
Mike and Sue Pratt	Owners, Pratt Ranch
Chuck Overman	University of Wyoming Cooperative Extension Service Agent, Harmony County
John Jackson	Professor, University of Wyoming Range Department
Darren Younger	Ranch Manager, Round Top Ranch
Jason Sills	Range Conservationist, Round Top Ranch

**APPENDIX 2**

**Coordinated Resource Management (CRM)**

First conceived in the early 1950s, CRM has become the method of choice in bringing together dedicated people from private, public, and special interest backgrounds to effectively manage natural resources. Officially recognized in 1982 as the natural resource planning process for Wyoming, CRM operates with the following guidelines (Cotton and Cotton, 1995).

1. CRM is strictly a **voluntary** program.
2. It should be **landowner** initiated with landowner leadership.
3. All interested agencies, organizations, and interest groups must be **involved**.
4. The CRM committee should be **facilitated** by a knowledgeable neutral party.
5. **Ground rules** establishing rules of behavior and conduct need to be set.
6. **Common goals** must be developed at the very beginning of the CRM process.
7. All members must have the **authority** to make decisions for their respective entities.
8. CRM operates under **management by consensus**.
9. Focus is on **needs vs. position**.
10. Create a **team** by developing understanding and trust among committee members.
11. All members must be **committed** to the process.
12. **Management objectives** must be developed and prioritized.
13. **Monitor** for baseline data, and for data showing successes or failures of new management practices, to facilitate adjustments that will achieve management objectives.
14. A CRM plan must have **flexibility** built in to allow for changing conditions.

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# Beaver Stadium: A Decision Case in Football Field Management

A. J. Turgeon\*

## ABSTRACT

Difficult decisions are not unusual for sports turf managers whose work requires them to sustain high quality levels despite tight scheduling, heavy traffic, and damaging play. During a football game against Rutgers in the fall of 1993, Bob Hudzik wondered what he would do to deal with the disaster evident on the Penn State University playing field. The sod planted 2 mo earlier was being torn and lifted with each play in the soaking rain and the field was becoming a muddy mess. The underlying problem, which required periodic resodding, was the poor internal drainage due to the presence of a gravel blanket 45 to 53 cm below the surface of the silt loam soil installed during the field's establishment in 1959. This case focuses on Bob's decision regarding what action to take to address the immediate problem of restoring the field to a playable condition while solving the internal drainage problem as well. Objectives of the case are for students to identify, analyze, and discuss these issues and to propose and defend a course of action for Bob Hudzik. The case has been used successfully in a senior-level capstone course in turfgrass management.

PENN STATE UNIVERSITY'S BEAVER STADIUM has a reputation as one of the finest football fields in the nation. This largely reflects the competency of its field manager, Bob Hudzik, who earned his certificate in turfgrass management at Penn State. Bob developed a reputation for producing and maintaining consistently high quality turf at Beaver Stadium. Notwithstanding his long-term success, Bob knew that, given the internal drainage problems of the field dating back to its construction several decades earlier, there was a disaster waiting to happen. In the fall of 1993 during the annual football game with Rutgers, the long-awaited disaster finally occurred. This case was developed to provide students with insight into complex drainage problems and to the thought processes and perspectives of a respected athletic-field manager as he considers a particularly difficult problem.

## THE CASE

During Penn State University's game with Rutgers in 1993, Bob Hudzik wondered how he would cope with the disaster occurring before his eyes. It was raining hard and the field looked like it was exploding. The sod laid 2 mo earlier was lifting and forming convoluted piles wherever there was play. Obviously, there were no roots to anchor the sod. With the saturated condition of the turf, the physical stresses of play easily cleaved the sod from the underlying soil. While football players can be expected to slip on a wet field, this field was unplayable. It was also embarrassing—despite

having one of the world's premiere turfgrass programs, Penn State's football field was now in the worst imaginable condition. Bob wondered if he would still have a job at the end of the day. And, if so, what he would do to correct this mess.

## The Field Manager

Bob Hudzik graduated from Penn State's technical program in turfgrass management in 1976. Despite having completed 2 yr as an undergraduate agronomy major, he switched to the 36-wk technical program because he believed it would better prepare him for a professional career as a turfgrass manager. Shortly after graduation, he secured a position with Penn State's Office of Physical Plant in campus turf maintenance. The following year, his responsibilities expanded to include athletic fields. His job changed again in 1978 when he was promoted to superintendent of all university golf courses and athletic fields, a position he held for the next 13 yr. Then in 1991, Bob chose to solely manage the athletic fields and buildings, an 80-ha complex, which included Beaver Stadium.

## The Administration

The administrative structure of the Athletic Department in the early 1990s included the athletic director and three associate directors: one for men's sports, a second for women's sports, and a third for sports information. The associate director for men's sports also had responsibility for all campus sports facilities and served as Bob's direct supervisor. An assistant director supported each associate director, and all of the coaches within the Athletic Department reported to one of the two assistant directors for either men's or women's sports.

The coaches oversee a wide variety of sports, most of which are played on Bob's turf. In addition to football, the athletic fields support baseball, softball, lacrosse, soccer, track and field, and a variety of club sports including rugby, cricket, and field hockey. Bob always felt that satisfying the coaches was one of his greatest challenges. His challenge was finding the resources to do what they wanted. For example, because of poor drainage, some fields didn't play well for days following a heavy rain. And because many of the fields didn't have irrigation, he was not able to sustain vigorous turfgrass growth during dry periods and provide the resiliency desired for optimum playing conditions. The demand for the resources needed to address these needs far exceeded the financial resources, and turf improvement had never been high on the priority list.

Bob's communication with the football coach was usually through intermediaries. The exception was when the coach was dissatisfied with the field at Beaver Stadium and would directly and forcefully communicate his concerns. Bob usually accepted these comments and concerns without verbal response. At the Rutgers game in the fall of 1993, the coach was not happy. Bob knew this even before the coach walked over to voice his complaints.

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## Field Construction and Conditions

Personnel from Penn State's Office of Physical Plant oversaw the construction of the football field at Beaver Stadium by an outside contractor in 1959. After excavating down to the subsoil, a coarse gravel blanket 15 cm thick was installed containing drain tiles spaced 1.8 m apart (Fig. 1). A 45- to 53-cm layer of silt loam soil was placed on top of the gravel, fine graded, fertilized, and limed in preparation for sodding (Harper, 1969). Strips of 'Merion' Kentucky bluegrass (*Poa pratensis* L.) sod measuring 45 by 180 cm were planted. Additional soil was worked into the cracks separating sod strips to minimize the potential for desiccation at the edges. An irrigation program was initiated to promote rooting and sustain shoot growth. By the time the new turf was fully established, however, a serious internal drainage problem was evident (Fig. 2). The field would remain saturated for extended periods and water would stand in depressed areas along the sidelines after each rain.

In 1960 a portion of the sod was removed, additional soil was added, and the sod was replaced, to provide a 25-cm crown down the center of the field. Catch basins were added to carry standing water along the sidelines to drain pipes located in the gravel layer. These changes were made to accelerate surface drainage and subsequent removal of



Fig. 1. Installation of gravel blanket during construction in 1959.



Fig. 2. Surface water along sideline, indicating poor internal drainage in 1960.

standing water. While these measures did not provide an entirely satisfactory solution to the internal drainage problem, they did reduce its severity.

Another approach to deal with the drainage problem was to minimize the traffic on the field. In the late summer and fall, traffic was limited to six practice scrimmages and the six intercollegiate games that were typically scheduled at home each year. In spring, traffic was limited to the annual intersquad game and six practice scrimmages preceding it. No other events were permitted on the field. To the consternation of the director of the band, their practices were prohibited as well. When visitors arrived at the stadium, they were cautioned to restrict their activities to the sidelines and stay off the playing field. Otherwise, the only traffic allowed on the field was the array of operations associated with its maintenance.

## Field Maintenance

Field maintenance included measures to carefully manage the amount of water entering the turf. This involved the installation of canvas tarps on the field whenever rainfall was expected for several days preceding a game or practice session (Fig. 3). The tarps were stored in large rolls along the sides of the field for easy access. The full- and part-time members of the maintenance crew—working at the stadium or involved in maintenance operations at any of the numerous practice and playing fields under the control of the Athletic Department—were the personnel needed to pull the tarps in place. Also, since the primary avenue by which water left the soil after infiltration was through evapotranspiration (Kneebone et al., 1992), irrigation was carefully monitored and controlled to limit the amount of water infiltrating the turf. A large travelling sprinkler with an adjustable speed control was used for irrigation. Based on the amount of moisture in the soil, the control was adjusted to set the speed at which the sprinkler traveled across the field. Given the flow rate of water through the nozzles of the sprinkler, controlling the sprinkler's rate of movement across the field controlled the amount of water applied to the turf. Through the combination of tarping and irrigation management, the turf's moisture requirements were met and a firm playing surface was maintained during the playing season.



Fig. 3. Grounds-crew members installing canvas tarps on the field in anticipation of rainfall.

Mowing was also an important component of the program for maintaining proper playing conditions. Since a football turf should provide a firm and resilient surface for secure footing, but also permit fast running speeds, close mowing heights are typically employed (Turgeon, 1999). Mowing too closely, however, could reduce turfgrass recuperative capacity and lead to pest problems. At Beaver Stadium, the turf had been mowed at 24 mm for many years. While higher than many coaches normally preferred, Bob mowed more frequently to produce a turf of high density that *looks* like it is mowed lower.

A multifaceted cultivation program was employed each spring immediately following the intersquad game. This involved scalping (mowing at 16 mm), vertically mowing to remove excess thatch, coring with 19-mm diameter tines at a 5- by 10-cm spacing, and matting to reincorporate the cores into the turf (Turgeon, 1999). Usually, an overseeding with perennial ryegrass (*Lolium perenne* L.) was included just after coring but before matting.

Fertilization practices were followed to sustain healthy growth while avoiding the soft and succulent growth that often results from excessive N use and to maximize wear tolerance (Turgeon, 1999). This usually involved the application of a complete fertilizer in May, immediately following the cultivation program, including 73 kg ha<sup>-1</sup> from a combination of quickly available and slowly available N carriers. Using these same carriers, an additional 73 kg of N were applied in mid-August, followed by 10-kg applications every 2 wk during the early part of the football season to sustain healthy growth. Finally, an additional 98 kg ha<sup>-1</sup> of slowly available N were applied in late October to promote fall color and root growth, and early spring green-up the next year.

In addition to cultural operations, maintenance activities also included lining the field. This involved usually two applications of an exterior latex paint before each game, and several additional applications in spring just before the intersquad game and in mid-August just before the start of the football season. At 230 L of paint per application and \$1.35 L<sup>-1</sup>, lining the field constitutes a significant component of Bob's maintenance budget.

Regardless of the care taken to control soil water, aeration, and fertility—and protect the turf from paint-induced phytotoxicity—the turf gradually deteriorated. Annual bluegrass (*Poa annua* L.) and creeping bentgrass (*Agrostis stolonifera* L.), whose presence is often indicative of poor drainage and excessive soil compaction (Turgeon, 1999), eventually invaded. As a consequence, the field had to be resodded several times since the time it was originally established to obtain acceptable turf quality. The last resodding was in the summer of 1993.

### The 1993 Season

Following the intersquad game in May 1993, all sod was cut from the field with a sod cutter and removed. The soil was deeply tilled with a chisel plow to open the compacted soil, then disked, harrowed, and graded to break up severely compacted clods. Sod that had been ordered early in the year was scheduled to arrive in early June; however, due to

a severe drought lasting through the spring, the sod was not suitable for harvesting. Finally, after several false starts, replacement sod was obtained from another producer. Crews were ready to do the installation when the sod arrived 1 July. By the time the first load arrived, it was 0830 h (8:30 a.m.) and the temperature within the stadium had already exceeded 24°C; by midday, it was 41°C. It took a day and a half to complete the job. Large, tractor-mounted rolls of washed sod measuring 1.2 m across and 9.2 m long were unrolled and placed onto the carefully prepared planting bed. By midafternoon of the second day, all of the sod was in place and the entire field hand watered. Initially the results of the sodding operation appeared favorable. Rooting was proceeding as expected and the new turf was holding up well, despite the above-average temperatures and droughty conditions persisting through midsummer. On Friday, 13 August, just 8 d before the first scheduled game, however, it was obvious to nearly everyone that there was a problem. Even under light traffic, sections of sod were easily dislodged. What roots had developed earlier in the summer were now gone; the culprit was later identified by Penn State's Disease Diagnostic Lab as *Magnaporthe poae*, the causal organism of summer patch disease (Vargas, 1994, p. 76–79).

Bob was frantic. All of the experts consulted on possible courses of action said essentially the same thing: control desiccation while keeping the turf as dry as possible, be patient and wait for cool nighttime temperatures to stimulate new root growth, and, especially, avoid playing on the field during rainy or very wet conditions. The weather stayed dry up to and during the first two games. While numerous pieces of sod were dislodged from the soil by play, the extent of the damage was not severe and grounds-crew members repaired what they could during breaks in the games. The Rutgers game was third on the schedule. It began raining on the Thursday afternoon before game day. Tarps were placed on the field to direct all rainfall to the sidelines. The rain persisted all day Friday and into Saturday morning. Finally, just before the initiation of activities on the field at noon on Saturday, the tarps were removed. During the game, it rained constantly; sod was being pulled up by play at an accelerating rate as the game proceeded. By the end of the game, hardly a piece of sod remained where it had been before. Television and radio commentators wondered aloud why this was happening at an institution with a "world-class turfgrass program." But Bob Hudzik's communications were not limited to media people. The athletic director, the football coach, and the players all wanted to know how this could have happened and, more importantly, what he was going to do about it *before the next home game*.

## INTERPRETIVE NOTE

### Case Objectives

Upon completing the case, students should have:

1. Wrestled with the long-term feasibility of sustaining acceptable turf quality and playability under the constraints imposed by the lack of internal drainage in the field.

2. Considered better ways to improve surface drainage to reduce the impact of poor internal drainage on the turf.
3. Explored the feasibility of developing and pursuing the goal of field reconstruction with the coaches and administrators of the Athletic Department.
4. Considered innovative approaches to addressing the internal drainage problem, given the nature of the soil and the presence of a gravel blanket 45 to 53 cm below the surface.

### Use of the Case

This case was developed for use in a capstone course in turfgrass science, but may be suited for both formal and nonformal instruction in athletic-field turfgrass management. The case can serve to stimulate discussion of principles of soil physics, weed management, and sports turf culture. To prepare for dealing with the technical aspects of the problems presented in this case, students are encouraged to review relevant sections of a general turfgrass text (e.g., soil physics, p. 130–139; weed control, p. 234–245; and athletic fields, p. 347–351, in Turgeon, 1999). Students can also gain appreciation from the case for the social processes involved in dealing with complex problematic situations in large, bureaucratic institutions.

This case has been classroom tested several times with excellent results. Senior undergraduate turfgrass science majors in the Case Studies in Turfgrass Management course have responded well to the discussion questions. Following is an approach patterned after Bouda et al. (1996) that can be used for teaching this case:

- Students are assigned the case several days or weeks before it is to be discussed in class and are asked to review the case.
- Study questions; additional research topics; or outside readings on soil physics, weed management, and cultural operations specific to athletic fields might also be assigned to help students prepare for the in-class discussion of the case.
- The instructor may wish to begin the in-class discussion of the case by dividing the class into small groups (four to six students per group) and assigning an introductory question (such as Question 1) for discussion within the groups. This can serve to start a productive discussion by focusing on a key point in the case.
- When the small-group discussions are proceeding well and the discussion is lively, the instructor can intervene and initiate a whole-class discussion using questions such as Questions 1 through 5.
- The instructor may conclude the discussion by pressing for a consensus decision during the class. As an alternative, the instructor may suspend the discussion and ask the students to prepare a written or oral report stating their decision and the rationale for this decision. This written or oral report could also include: a detailed analysis of the situation presented in the case, an identification of the issues emerging from the analysis, a comprehensive list of decision options for addressing the issues, and an action plan for implementing the decision option selected by the individual or group.

### Discussion Questions and Issues in the Case

**1. Given the existence of a gravel blanket 45 to 53 cm below the surface, could anything be done to take advantage of this feature?** This question requires students to think creatively about the possibility of turning a liability into an asset. If holes or slit trenches extending from the surface to the gravel blanket could be dug and backfilled with sand, these would significantly enhance surface drainage. Normally, openings to these channels would be threatened as fine-textured particles and turfgrass roots fill the pores near the surface; however, a sand blanket, created at the surface with the installation of sand-grown sod, could protect these openings, provide greater access to them by infiltrating water, and serve as a more favorable medium for turfgrass growth (as long as moisture and nutrient requirements were satisfied through the irrigation and fertilization programs). The increasing popularity of *drill-and-fill* (e.g., Floyd-McKay) systems should make most students aware of this possibility. An alternative would be to rebuild the field in accordance with USGA specifications that call for a predominantly sand medium underlain by a gravel blanket (Green Section Staff, 1993).

**2. How feasible would it have been to simply plant conventional sod after the Rutgers game and continue to maintain the field as in the past?** This question will challenge students to think about factors influencing the resistance of newly planted sod to cleavage from the physical stresses associated with football play. The sod would have to be sufficiently thick and heavy to remain in place under play until a substantial root system developed. And, given the poor internal drainage in this system and the likelihood of a perched water table forming above the gravel blanket, students would have to determine if the deterioration in turf quality, requiring periodic resodding in the past, would be inevitable or if it could actually be prevented through various cultural interventions.

**3. Could Bob have intensified the cultivation program sufficiently to provide a better medium for sustaining healthier and more vigorous root and shoot growth?** This question requires students to consider the specific effects of various turf cultivation operations. Given the availability of new hollow-tine and solid-tine (as well as drill) cultivators that can now reach well beyond the surface 8 to 10 cm of soil, modern cultivation methods may be more effective than earlier methods in alleviating soil compaction and its effects on turfgrass growth. However, students must recognize the limitations of these methods: they cannot improve internal drainage in a soil that has none (into the gravel blanket), and they cannot enhance evapotranspiration from the turf to an extent adequate to compensate for an internal drainage problem of this severity. Also, students must appreciate the fact that any measures directed at improving internal drainage (while allowing sufficient time for turfgrass recuperation) would be constrained by the short window of favorable growing conditions between the intersquad game in April and the initiation of summer stress in late June or early July.

**4. What were Bob's options?** It is important to impress on the students that the selection of a decision option may not be entirely within Bob's authority, given the resource

limitations under which he (and most turfgrass managers) must operate and the time frames he has available to implement specific courses of action. Clearly, one option would be to rebuild the field. This might involve removing the soil and underlying gravel blanket, and modifying or replacing the existing soil with a more-suitable growth medium. An alternative might be to remove the soil but leave the gravel blanket, and install a sand medium selected to conform to USGA specifications (Green Section Staff, 1993). While these would be expensive options requiring the approval of the athletic director, they would not be suitable for restoring the field to a playable condition in time for the next game. Over the short term, the sod would have to be replaced with new sod cut sufficiently thick to remain in place despite the physical forces associated with football play. Only after the conclusion of the football season would rebuilding or major renovations be feasible.

Following resodding the field, less-expensive alternatives for improving drainage would include the drill-and-fill option (discussed under Question 1), and the intensive cultivation option (discussed under Question 3).

**5. What did Bob Hudzik do to solve the problem?** The instructor may choose to avoid this question because it may suggest that only one *correct* answer exists. An alternative would be for the instructor to share the actual decision with the students, given their curiosity about the outcome of the case.

Immediately following the Rutgers game, all of the sod was removed from the field. A supply of sand-grown sod was located and planted. Sand-grown sod was selected for its heavier weight so that it would remain in place after planting, despite the lack of a root system for anchoring it to the underlying soil. After planting, a heavy roller was used to create a smooth surface for play. Rooting was evident within 1 wk and the sod remained in place throughout the remainder of the football season.

At the end of the football season, the maintenance crew began drilling 32-mm diameter holes into the turf extending down to the gravel blanket. The holes were backfilled with sand and all excavated soil was removed. This slow process continued throughout the 1994 season and into 1995, until a total of 102 000 holes had been drilled and filled. The sand selected for filling the holes was selected to match the sand contained in the sod. This same sand was used for topdressing the field in May 1994. Immediately following the intersquad game, the field was scalped to a height of 16 mm and core cultivated to a depth of 89 mm with 25-mm diameter hollow tines at a 5- by 10-cm spacing. A core harvester removed the cores as soon as they were extracted from the turf to avoid creating a fine-textured soil layer above the sand or clogging up the sand blanket with soil particles. A

13-mm thick layer of sand was then applied and matted into the turf to expand the sand blanket. While some of the sand used for topdressing filled the holes created by core cultivation, much of it expanded the sand blanket from its original thickness of approximately 50 mm by more than 6 mm. This procedure has been repeated each spring since 1994.

Because the sod planted after the Rutgers game was sand grown, the silt loam soil in the field was now sandwiched between a sand blanket at the surface and a gravel blanket below. Backfilling the drill holes with sand created multiple columns connecting the sand and gravel blankets to form a unique bypass drainage system. Water infiltrating the turf first percolated through the sand blanket, accumulated at the sand-soil interface, migrated to the nearest sand column and proceeded down the column to the gravel blanket. A perched water table formed at the sand-gravel interface until a hydraulic head of sufficient volume accumulated to force the water across the interface and into the gravel where it could migrate to the drain tiles. Thus, despite the desorption resistance of the silt loam soil, the field now drained excess water for the first time.

A significant challenge was to sustain healthy turfgrass growth and quality in the relatively thin sand blanket above the silt loam soil. Changes in the fertilization program were made to compensate for the limited nutrient holding capacity of the sand. Micronutrients were added to the other fertilizer nutrients used in the program and applications of all nutrients were made at a frequency sufficient to ensure that turfgrass growth would not be seriously limited. Tarps are still used, but only during a week in which a game is scheduled and only for moderate to heavy rainfalls. Since 1994, the turf and playing quality of the field have been excellent.

#### ACKNOWLEDGMENT

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# Nutrient Management for Organic Farming: A Case Study

Robert L. Mikkelsen\*

## ABSTRACT

There is increasing interest from farmers and consumers in food grown without the use of synthetic pesticides and inorganic fertilizers. This case highlights the history of one farmer in the Coastal Plain of North Carolina who has grown vegetables for 12 yr using only composted turkey (*Meleagris gallopavo*) litter for a nutrient source. Since he began production, the concentration of several plant nutrients has increased as much as fivefold in the soil. Although there were no apparent problems with the soil, the certification board that oversees his production practices questioned this rapid change in nutrient status and the implications for the future. In presenting this case, students were shown a video recording of the farmer discussing his operations and his concerns for the future. The students were then asked to make practical management recommendations to deal with the current trends of nutrient accumulation, to determine the conditions where excessively high nutrient concentrations may become a problem, and to construct a whole-farm nutrient budget that considers the initial sources of nutrients entering the farm and their ultimate fate. A follow-up session allowed the students to discuss their ideas and critique each other using the available information.

THE production of organically grown crops has been expanding in recent years. Many consumers are willing to pay a premium for food products that are grown without the use of synthetic pesticides and inorganic fertilizers. This case highlights the nutrient management concerns of an individual vegetable grower who uses organic materials and composts as his sole source of nutrients. The data for this case were gathered from 12 yr of soil analysis, historical production data, and personal interviews.

## THE CASE

Stefan Hermann grew up in Germany and studied agricultural sciences at the University of Cologne. After graduation, Stefan decided that he would like to apply the theoretical knowledge he had learned in school to real-life production agriculture. As a self-proclaimed city kid, he had never lived on a farm, but was attracted to the idea of managing some land that belonged to the family in North Carolina. Stefan and his wife felt strongly that agricultural production should be self-sufficient and not rely on off-farm inputs of chemicals and nonrenewable resources for operation.

With these goals in mind, they moved to a small community in eastern North Carolina and began to implement their plan. The farm was located in Sampson County, on the Coastal Plain where the soils are predominantly Entisols that receive between 1000 and 1100 mm of rainfall annually (Table 1). At

some earlier time, the farm had been used for grain and tobacco (*Nicotiana tabacum* L.) production, but the land had been overgrown with brush and weeds for many years. Stefan decided early on that he would use no inorganic fertilizers or synthetic pesticides on this farm, thereby allowing his vegetables to be certified as organically grown. He remembered that his neighbors were highly skeptical of this newcomer who was trying to raise vegetables in what Stefan termed "the pest capital of the world."

Stefan found that he had easy access to a huge supply of nearby poultry litter and swine (*Sus scrofa*) manure (Table 2). He recalled that when he first began, most animal producers were rather careless with their waste management and viewed manure primarily as a material that required disposal. Stefan learned that turkeys in North Carolina are generally raised in large barns with a floor covering of wood shavings that serves to absorb moisture and cushion the birds while they are lying down. For turkeys, the amount of shavings used varied from 2 to 6 Mg/1000 birds produced. The mixture of turkey manure and wood shavings, termed *litter*, is periodically removed from the barn and applied to surrounding cropland. He made arrangements with a local turkey grower to obtain all of the litter that he wanted. Swine manure was less attractive as a nutrient source since it is primarily flushed from the barns as a dilute liquid (effluent) and then treated in open anaerobic lagoons. For Stefan to utilize swine manure on his farm, it would have required the transportation of considerable water or the acquisition of a solid separator, neither of which was immediately practical for him.

Sampson County (245 000 ha) has an abundance of animal agriculture. More than 2 million swine, 11 million turkeys, and 5 million broiler chickens (*Gallus gallus*) are raised each year in this one county alone (NCAS, 1998). Surrounding counties have similar levels of livestock production. The high intensity of animal production has resulted in a regional surplus of nutrients compared with available agricultural land in this region (Barker and Zublena, 1996). Despite this regional excess of manure-derived nutrients, more than 7000 Mg of N, 800 Mg of P, and 5000 Mg of K as inorganic fertilizer are sold annually in this county alone (NCDA, 1997). There was considerable pressure on livestock producers by state regulators to utilize the manure-derived nutrients in an acceptable and environmentally sensitive way and to follow strict nutrient management plans.

Stefan composted the fresh turkey litter in open windrows before application to his fields (Table 3). The litter was periodically turned with a tractor and aged for approximately 1 yr before being added to the fields. He felt that the composting process helped to stabilize the nutrients and made the N less vulnerable to leaching on these sandy-textured soils. During the compost process, a 20 to 30% loss of volume was anticipated.

Stefan followed a 4- to 5-yr rotation for crop production on his fields. He began the sequence with high-value crops such as tomato (*Lycopersicon esculentum* Mill.) and eggplant

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**Table 1. Soil profile description of Chipley sand (Aquic Quartzipsamments) found predominantly in Mr. Hermann's fields.**

Horizon	Depth	Description
	cm	
Ap	0-15	Dark grayish brown, sand, single grained, strongly acid
Bw	15-35	Yellowish brown, sand, single grained, strongly acid
C1	35-90	Pale brown, sand, few distinct mottles, very strongly acid

**Table 2. Amount of excreta produced by livestock.**

Type of livestock†	Body wt.	Moisture content	Typical volume	Typical manure wt. (wet)
	kg	%	L/d	kg/d
Dairy cow	450-650	90	57	50
Beef cow	200-450	90	27	20
Pig	45-75	90	4	5
Sheep	25-45	89	4	1
1000 laying hens	2000	70	115	130
1000 broilers + litter	1000	30	36	19
1000 turkeys + litter	5000	30	124	50

† Cow, *Bos taurus*; pig, *Sus scrofa*; sheep, *Ovis aries*; chicken, *Gallus gallus*; turkey, *Meleagris gallopavo*.

**Table 3. Typical chemical composition of fresh and composted turkey litter used as a nutrient source by Mr. Hermann and swine waste in anaerobic swine lagoons.**

Type†	pH	Total N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu
		kg/Mg						g/Mg			
Stockpiled litter‡	8.6	30	17	14	21	4	5	650	325	320	250
Composted litter‡	7.8	221	18	16	30	6	6	1740	580	560	700
		mg/L									
Anaerobic swine effluent	7.8	600	100	500	110	37	44	10	2	7	2

† C/N ratio of the materials are: stockpiled litter, 25:1; composted litter, 17:1; pine shavings alone, 700:1, swine lagoon effluent, 3.5:1.

‡ Litter concentrations calculated on wet wt. basis with 33% moisture.

(*Solanum melongena* L.). Cucumber (*Cucumis sativas* L.) or squash (*Cucurbita* spp.) were next in the rotation, followed by a leafy vegetable such as lettuce (*Lactuca sativa* L.). The last crops in the rotation are generally garlic or potato. A relatively heavy application of compost began the 5-yr rotation and then a lesser amount of supplemental compost was applied as needed to the following crops (the exact application rates are not known).

The use of cover crops had not fit especially well with his production schedule. Plowing cover crops into the soil before planting in the spring occasionally caused problems with achieving uniform seed germination and subsequent seedling establishment. Many vegetable crops have a small seed size and required a well-prepared seedbed to obtain good germination and the desired plant population. Additionally, to avoid problems with disease and drought, it was frequently necessary for Stefan to plant early in the spring before there was substantial growth of winter cover crops. However, Stefan always left strips of rye (*Secale cereale* L.), clover (*Trifolium pratense* L.), or vetch (*Vicia monantha* Retz.) in the field throughout the year as protective habitat for beneficial insects in the area. He hoped to bring additional land into production in the future and use longer rotations that would allow certain fields to be devoted to cover crop production for several years and

**Table 4. Chemical analysis of soil from Stefan Hermann's farm.†**

Year	HM	CEC	BS	pH	P	K	Mn	Zn	Cu
	%	cmol/kg	%			kg/ha			
<b>Field 1</b>									
1987	1.9	6.8	71	5.9	>400	415	24	17	4
1988	1.6	7.1	77	5.7	>400	280	23	26	5
1989	1.9	7.9	80	6.1	>400	385	21	30	7
1990	1.5	7.8	84	6.3	>400	360	20	29	
1991	1.3	7.8	90	6.6	>400	345	23	23	7
1992	1.3	8.4	86	6.3	>400	475	12	29	9
1993	1.3	7.5	79	6.0	>400	615	23	23	9
1994	1.1	8.3	86	6.1	>400	625	34	60	23
1995	2.5	9.8	88	6.0	>400	565	30	51	19
1996	2.1	10.8	84	5.9	2040	655	33	52	23
1997	1.8	9.2	81	5.8	1675	455	29	44	15
1998	1.7	9.0	83	5.9	1740	510	31	47	17
No crop response when nutrient concentration is in excess of					120	195	16	4	2
<b>Field 2</b>									
1990	1.3	4.2	14	4.5	>400	47	20	3	1
1991	1.1	5.2	55	5.1	>400	116	22	11	5
1992	0.9	6.4	75	5.5	>400	203	15	19	8
1993	0.8	6.9	77	6.0	>400	275	24	29	13
1994	0.8	7.0	77	5.8	>400	265	25	45	17
1995	1.1	8.7	86	6.0	>400	405	33	56	22
1996	0.8	12.4	92	6.2	2285	473	43	78	30
1997	0.9	10.3	89	6.2	1970	240	32	62	23
1998	1.0	10.1	83	6.0	1995	251	34	66	24
No crop response when nutrient concentration is in excess of					120	195	16	4	2

† HM is a measure of chemically reactive humic matter in the soil. BS is the proportion of the cation exchange sites that are occupied by Ca, Mg, and K. Soil nutrients extracted with Mehlich-3 solution. Nutrient recommendations from Tucker et al., 1996.

perhaps provide some additional income from organically produced hay harvested from these fields.

Stefan first began selling his produce from a stand at a local farmers market to get experience with consumers and their preferences. However, with the heavy time demands associated with operating a farmer's market stand, he realized that he could not successfully raise the crops himself and then sit at a retail outlet all day. He switched to selling his produce through an organic farmers' cooperative that offered on-farm pick up twice each week during the growing season and then distributed the food to grocery stores, restaurants, and organic wholesalers throughout the state. He also began a *community-supported agriculture program* where individuals contracted directly with him to receive a certain amount of produce each week during the growing season. The contracts (also known as *subscriptions*) were paid each spring and provided him with valuable financial support during the time when planting and fieldwork are just beginning.

Insects were a major challenge when Stefan began his operation and he recalled losing entire crops to insect damage. Since then, he had learned to stagger planting dates, avoid pest-sensitive crops, and carefully scout fields to minimize insect damage. He had observed that insect damage decreased steadily through the years, which he attributed to an increased population of beneficial insects. When necessary, predatory insects and organically certified pest control materials were used in the fields. Weeds were another major challenge to successful vegetable production for Stefan. Cultivation and hand hoeing had been the primary methods of weed control.

Stefan had been careful to take soil samples from his primary production fields each year (Table 4). He tried to follow

**Table 5. Relative tolerance of selected horticultural crops to high concentrations of Cu (adapted from Jones, 1998).**

Very sensitive	Moderately sensitive	Insensitive
Asparagus ( <i>Asparagus officinalis</i> L.)	Apple ( <i>Malus sylvestris</i> Mill.)	Carrot ( <i>Daucus carota</i> L.)
Bean ( <i>Phaseolus vulgaris</i> L.)	Broccoli [ <i>Brassica oleracea</i> (Botrytis Group)]	Dill ( <i>Anethum graveolens</i> L.)
Pea ( <i>Pisum sativum</i> L.)	Cabbage [ <i>Brassica oleracea</i> (Capitata Group)]	Lettuce ( <i>Lactuca sativa</i> L.)
Peanut ( <i>Arachis hypogaea</i> L.)	Celery ( <i>Daucus carota</i> L.)	Onion ( <i>Allium cepa</i> L.)
Soybean [ <i>Glycine max</i> (L.) Merr.]	Cucumber ( <i>Cucumis sativus</i> L.)	Spinach ( <i>Spinacia oleracea</i> L.)
Potato ( <i>Solanum tuberosum</i> L.)	Radish ( <i>Raphanus sativus</i> L.)	Beet ( <i>Beta vulgaris</i> L.)
Mint ( <i>Mentha</i> spp.)	Strawberry ( <i>Fragaria X ananassa</i> Duch.)	
	Swiss chard ( <i>Beta vulgaris</i> L.)	
	Tomato ( <i>Lycopersicon esculentum</i> Mill.)	

the nutrient recommendations provided by the soil testing laboratory operated by the North Carolina Department of Agriculture as much as possible. He became concerned when a steady increase in the concentrations of certain elements was noted. He recognized that although these nutrients were essential for plant growth, they could eventually accumulate in soil to concentrations that could become problematic. As a grower of organic produce, the health of the soil was an especially important concern for Stefan and for his customers. An increase in the concentration of extractable P was not apparent until 1995 when the state soil testing laboratory began reporting actual soil P concentrations. Before 1995, the laboratory reported only that the P concentrations were not limiting to plant growth (>400 kg P/ha). After this time, they began to report actual P concentrations, although it was in excess of agronomic needs.

Stefan discovered that essential elements are routinely added to animal feed for the normal functioning of biochemical processes and to accelerate animal growth. However, there were few, if any, restrictions regarding the concentration of minerals in the animal waste since most land application plans are based solely on the N concentration of the waste. While some of the metals and nutrients are naturally occurring in the basic feed grain components {primarily corn (*Zea mays* L.) and soybean [*Glycine max* (L.) Merr.]}, the elevated concentrations are generally due to mineral supplements added to feed. For example, the recommended concentrations of trace minerals for turkey feed ranges from 40 to 70 mg Zn/kg and 4 to 8 mg Cu/kg (NRC, 1994). Zinc is commonly added to poultry feed as ZnSO<sub>4</sub> or ZnO, although ZnO is only half as effective at supplying bioavailable Zn to poultry (Wedekind and Baker, 1990). Copper is typically added to feed as either CuSO<sub>4</sub> or CuO; however, the bioavailability of CuO has been reported to be very low (Ledoux et al., 1991). Although low concentrations of Cu are required for proper nutrition, Cu is usually fed commercially at much higher pharmacological levels (100–300 mg/kg) because of its growth-promoting properties (Fisher, 1973). Underwood (1981) reported that mineral supplements in animal feed frequently contain an unnecessarily wide margin of safety to ensure against deficiency; these additions in excess of animal need may be economically wasteful and potentially harmful.

The high concentration of P in animal feeds has received attention due to potential environmental concerns related to manure application. For example, in the Netherlands, manure application rates are limited by the amount of P added to the land and the quantity of P removed in the harvested portion of the crop. The majority of P in cereal grains is in the form of phytate (also known as *phytic acid* or as *inositol*), which is largely indigestible by monoruminant animals (such as poultry, swine, and humans [*Homo sapiens*]). Phytate-bound P must be enzymatically hydrolyzed before becoming available for animal nutrition. As a consequence of the presence of nonnutritional P, supplemental inorganic sources, such as deflourinated rock P, dicalcium phosphate, or bone-meal, are routinely added to feed. Between 70 and 90% of the added P is typically excreted in the manure (Mikkelsen, 1996).

Stefan underwent a recertification process every 5 yr to verify that his farm and his operations meet the criteria set by the Carolina Farm Stewardship Association, the regional organic certification agency. Because of potential impacts on soil health, he was concerned about the consequences of the continued accumulation of nutrients in the soil (Table 5). He was warned that if the current trends continue, he might ultimately lose his certification. However, there were very few alternative organic nutrient sources located in his area and no organic animal producers in the proximity. After many years of hard work, Stefan finally had the farm in the condition and at level of production he wanted, and he felt that an ecological balance had been established. He was uncertain about how to keep the nutrient concentrations from further escalation and to avoid potential problems, while maintaining current yields.

## TEACHING NOTE

### Case Objectives

This case should be used to teach students about concepts such as soil fertility, cropping practices, waste management, soil chemistry, soil health, and concepts related to nutrient cycling on a large regional scale. Students should use the case to learn about complex production and philosophical issues that may appear to conflict. It appears that the current intensive practices cannot be sustained indefinitely without excessive nutrient accumulation and potential degradation of the soil resource. However, the magnitude of the problem is not easily defined and many alternative solutions may be proposed.

When the students have completed an analysis of the case, they should be able to:

1. Synthesize multidisciplinary information from a variety of sources regarding nutrient management and use within an organic vegetable production system.
2. Be able to understand the potential environmental concerns associated with excessive accumulation of nutrients in soil and potential management options.
3. Understand the original and intermediary sources of nutrients entering a farm that uses strictly *organic* materials in production and the eventual fate of these nutrients.
4. Appreciate the interdependence of agroecological systems within a region (e.g., how animal feed formulations impact organic vegetable production).

## Use of the Case

### Stimulant Questions

1. Is it possible to achieve a balance between nutrient inputs and harvested material on an individual farm or within a geographic region? Would this balance be easier to accomplish with organic nutrient sources or inorganic fertilizers?
2. What potential threat does accumulation of nutrients pose to the environment? How can Stefan minimize the problems associated with this accumulation while continuing to produce high-quality vegetables in a profitable way?
3. What nutrient sources do you feel should be classified as organic? What value is placed on organically grown vegetables?
4. What role should the Organic Certification groups and government agencies have in maintaining soil quality on farms?
5. What responsibilities should the turkey producers assume in the utilization of the litter? What responsibilities should the consumers of Stefan's vegetables assume in this situation?

### Author's Analysis and Interpretation

This case illustrates the difficulty associated with managing organic nutrient sources on a long-term basis on any farm. The ratio and quantity of nutrients present in organic materials is rarely in balance with the plant requirement and the amount removed in the harvested portion of the plant. This accumulation of nutrients has been noted in most regions where long-term applications of animal manures, composts, or biosolids are made. Several states have attempted to regulate the accumulation of P (e.g., Delaware, Maryland, Virginia) or Cu and Zn (e.g., North Carolina) for environmental purposes, largely resulting from long-term use of organic nutrient sources.

The N in the turkey litter largely derives from the protein present in the feed grains. The majority of animal feed used in North Carolina is imported from out of state. The importation of nutrients from a large area of the country and the eventual concentration in a relatively small area (e.g., Sampson County) presents serious long-term challenges. The principles of nutrient movement and transport should be applied to the student's local condition to make the concept more meaningful.

The nutrient removal in the harvested portions of most plants cannot equal the accumulation that occurs when manure or compost is added at a rate to supply sufficient N. After the students examine the quantity of nutrients added to the soil during production and the amount ultimately removed, the imbalance will become apparent. For example, assuming plant-available N (PAN) of 30%, approximately 17 Mg of compost would be required to supply 150 kg N/ha to a tomato crop. In this 17 Mg compost application, approximately 290 kg P also will be applied. In the harvested portion of the fruit (assuming 30 000 kg fruit/ha), only 5 to 10 kg P/ha will be removed. Compost application rates in subsequent years may be less, as a portion of the residual N becomes plant available. Similar calculations can be made for other potential crops and nutrients.

This soil could remain in production for many years without further P fertilization due to the high residual nutrient levels. Excessive P accumulation is generally not a concern for

crop production; however, there are serious environmental issues that may result from this practice. Loss of P from soils occurs primarily via runoff and erosion. When concentrations of P become elevated in surface water, the ecological system is disrupted with a degradation of water quality. Phosphorus management options to reduce losses that are appropriate for Stefan and for the student's local conditions should be discussed.

The students have the opportunity to consider the source of the nutrients entering the vegetable farm in the turkey litter. Mr. Hermann is adamant about using only organic nutrient sources for his vegetable production. However, when the students consider that the P added to the turkey feed is identical to fertilizer (e.g., dicalcium phosphate) and passes through the bird largely unchanged and undigested, they can discuss the basis for calling it *organic* P. Similarly, the Zn and Cu are added as inorganic salts that pass through the bird into the manure. The decision to label one nutrient source as organic and another as inorganic is not always simple.

The practice of adding excessively high amounts of mineral supplement to animal feed is a major concern for waste management. Although there appears to be only limited justification for the high degree of supplementation, the practice continues to be standard for much of the animal feed industry. The adoption of more modern feed technology could easily allow the concentration of metals to be reduced and P excretion to be substantially minimized. Improved P utilization could be accomplished through addition of phytase enzyme to improve feed P digestibility or the use of low-phytic acid corn, which contains less indigestible P.

The chemistry of Cu and Zn in soils should be reviewed, with an emphasis on forms in soil, phytoavailability, and potential corrective measures for toxic concentrations. The concepts of risk assessment can also be introduced at this time with potential pathways of exposure. The pharmacological benefits derived from high concentrations of Cu can be used as a discussion point regarding the routine addition of antibiotics to poultry feed and the rise of antibiotic-resistant bacteria (Levy, 1998).

The importance of soil pH needs to be stressed in the management of these metals. Copper and Zn both become increasing insoluble and unavailable for plant uptake as the soil pH increases from the acid range. These same issues of metal availability are dealt with in management plans where municipal biosolids are applied to land. The students should discuss the long-term implications of high Cu and Zn. For example, can the landowner guarantee that the proper pH will always be maintained or that metal-sensitive crops will never be grown on these fields? Crop tolerance to high concentrations of these metals will vary among species. For example, peanut (*Arachis hypogaea* L.) plants are commonly grown in this region and have a low tolerance to high metal concentrations, while bermudagrass [*Cynodon dactylon* (L.) Pers.] has a high tolerance to these conditions.

The ethical issues involved with appropriate soil sampling can also be addressed with this case. When the possibility of regulatory action exists based on soil analysis, a landowner may be inclined to sample the portions of the field that will provide the desired results. For example, the nutrient concentrations in both Field 1 and Field 2 declined between the 1996 sampling and the 1997 sampling. This apparent anom-

aly is explained by the fact that the fields were plowed 2 to 3 cm deeper than in previous years. This resulted in dilution of the nutrient concentration in the *plow layer* without reducing the total quantity of nutrients present. How can a regulator determine the *true* nutrient concentration in a field when a grower may be inclined to conceal these results?

The students will benefit from a discussion about the organic certification process. What does a consumer expect from organically grown food? What is the role of organically grown food in the global marketplace? These issues can be discussed and referenced using the USDA National Organic Program Web site (<http://www.ams.usda.gov:80/nop/>).

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# Whose Watershed is This? A Decision Case Study of Agricultural Drainage in the Midwestern USA<sup>1</sup>

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## ABSTRACT

Every day, individuals make local land management decisions, involving a few hectares or a few square kilometers. These decisions may enhance or degrade local environments, and often are reflected in downstream surface water quality. This case focuses on management decision making in an agricultural watershed in southern Minnesota, USA, and engages participants in making environmental decisions in the context of conflicting values. The case exemplifies a process that is occurring worldwide: people are demanding more local-scale decision making, which often conflicts with broader community and societal goals for integrated management. In using the case, participants are presented with background from the perspective of a local farmer who believed he was making a wise management decision on behalf of his family and his community. He was surprised by the presence and strength of opposition and needed to make difficult decisions about his land and future. There was a well-understood, potential financial gain; he had trouble predicting both the costs (e.g., legal fees) and the probability of success. Participants are presented with the dilemma, asked to make a decision, and then to evaluate their results and process in light of decisions eventually made by the farmer.

**D**RAINAGE of agricultural land using subsurface tiles and open surface ditches is a common management practice in the midwestern USA (Fig. 1). Its purpose is to remove water from low-lying areas and poorly drained soils to promote higher crop yields. In the early part of the century, many wetlands in Minnesota were drained to make agricultural production possible. As a result, <20% of estimated presettlement wetlands now remain in southern Minnesota (Mulla, 1996). Currently, landowners and managers in the state rarely drain additional wetlands; however, they do maintain and improve existing drainage systems. Drainage offers clear economic benefits to farmers, but there has been growing public concern about its environmental impacts. In this decision case, a group of farmers in southern Minnesota proposes to improve the ditch and tile system on their land, but are met with strong opposition from neighbors and environmental groups. The focus of the case is on the decision of one farmer who weighed the benefits of improved drainage against potential legal fees and impacts on the downstream environment.

## THE CASE

Glen Steele's family had been farming on land near Fairfield, MN, for about 35 yr. In recent years, it had become ap-

parent that the old tile drainage system on their land needed to be replaced. The drainage system was installed in 1915 and its pipes were deteriorating. Neighboring farmers with similar problems had suffered substantial crop loss due to excess water on their fields. Glen understood the scale of the potential losses and the need for change. It had been estimated that inadequate drainage could reduce crop yields in southern Minnesota by 2.8 Mg/ha (45 bushels/acre) of corn (*Zea mays* L.) or 1.0 Mg/ha (15 bushels/acre) of soybean [*Glycine max* (L.) Merr.], resulting in a decrease in expected income of \$225 to \$260/ha (\$90 to \$104/acre) of cropland (Hachfeld and Theisse, 1997). In addition to removing surface water and increasing crop yield, improved drainage could reduce the time needed to till, plant, and harvest crops. Farmers could plant earlier in the growing season on well-drained land, which allowed crops to mature more completely before harvest, reducing the cost of artificially drying crops.

Glen Steele began talking to his neighbors about the need for better drainage; many agreed that something had to be done to ensure the future viability of croplands in their watershed. They organized meetings to discuss the issue, and decided to hire an engineer to design a drainage improvement project. The project would upgrade the old tile system's hydraulic capacity and drainage ability. This would minimize the drainage problems the landowners were currently facing and almost certainly would result in increased average income per hectare.

In Minnesota, most actions to change drainage procedures begin with a petition to the county board. A minimum percentage of property owners affected by a proposed project must sign a petition before it can be submitted to the board. For the improvement project proposed by Glen Steele and his neighbors, at least 26% of the affected property owners needed to sign. Steele and 11 neighbors (46% of those affected) agreed on a proposal and signed a petition that was approved by the Northland county board in November 1997. The new system was projected to cost about \$830 000. This cost was to be divided among all property owners in the watershed. The 14 property owners who did not sign would be assessed a portion of the cost relative to the benefit they would receive from drainage improvements. Glen saw the project as fairly routine, the type that is typically approved and constructed without a problem. He felt he had made a positive investment in the future of his farm and his community. To his surprise, an organized and determined opposition to the project quickly arose.

## Opposition is Voiced

The first opposition to the project came from Linda and Rick Krause, who were assessed a portion of the project cost

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<sup>1</sup> While this case represents an actual situation, all names of people have been changed.

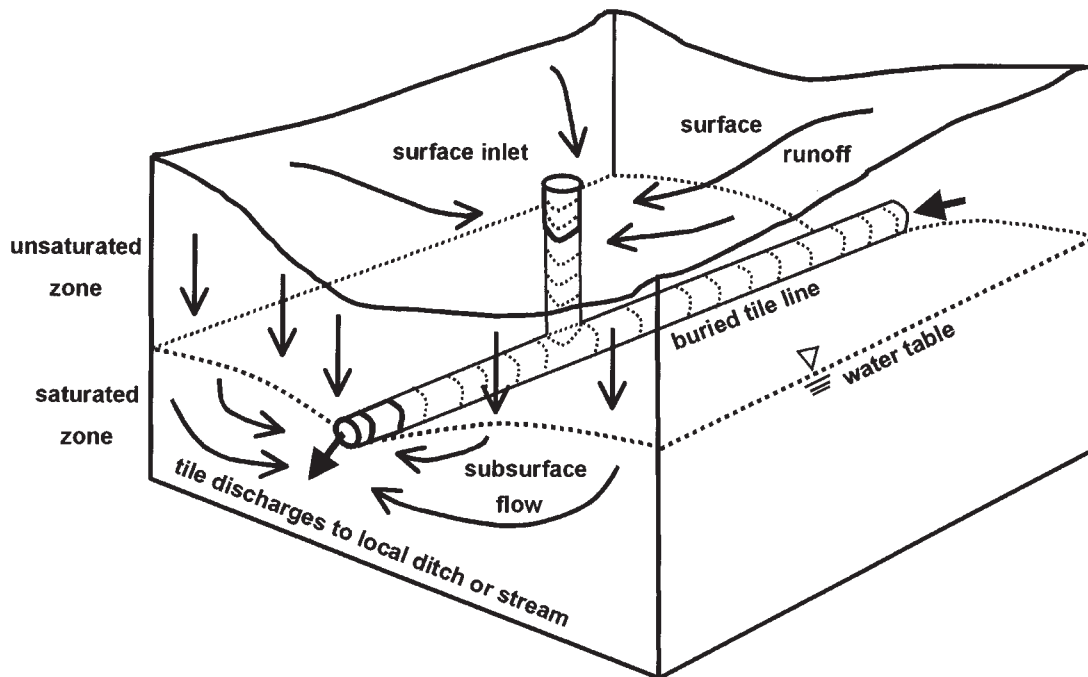


Fig. 1. Schematic diagram of surface and subsurface flow to tile lines in agricultural areas of the midwestern USA (adapted from Magdalene and Alexander, 1993).

although they did not sign the petition. They claimed that the project threatened to damage a wetland on their property. The Krauses and their two small children had recently moved into a house on land in the watershed. The house overlooked a small wetland that attracted birds and wildlife to the property. Linda's grandmother owned the land, and to Linda it was a familiar place. "That slough has been there since I was a child," she said, "To me, it's home." The Krause family did not want to cause conflict with their neighbors, but they were worried that the drainage project would damage the wetland, and they decided to file an appeal in district court.

The Krauses contacted lawyers at Minnesota's Future Environment (MFE), a nonprofit law firm based in Minneapolis, and the firm began to look further into the case. In addition to the wetland issue, MFE discovered that the new system's outlet was directly upstream of a trout stream that was protected by the Minnesota Department of Natural Resources (DNR) and the change in drainage would increase flows to the stream significantly. Higher peak flows would potentially increase bank erosion, sedimentation, temperature fluctuation, and nutrient inputs to the trout stream, which would degrade its fish habitat and biological integrity. The MFE was concerned about these potential impacts, and before Glen knew it, they had orchestrated a lawsuit to stop the project.

Glen felt that the lawsuit was baseless and unsupportable. "What we did was follow every rule to a 'T,'" he said, "We got the project ready to go, and then somebody steps in and tries to stop us on it." Glen and the other petitioners had already invested a great deal of time and money into the project, and they had not anticipated the challenges that were now facing them. "The only way the environmentalists could get in was to go piggyback on the Krauses," said Glen. "The Krauses were pretty much trying to protect their own land; that's all they were doing. They enjoy wetlands and wildlife,

which all of us do, and that was...well, we underestimated them a little bit."

Regardless of the Krauses' reasons for becoming involved in the lawsuit, Glen was now facing important decisions. What had begun as a necessary action to maintain his farm's drainage system and improve the value of his land was now a financially risky situation. Under Minnesota drainage law, if a project is approved but fails to be constructed, each petitioner is liable for all costs incurred, including engineering fees, attorney's fees, and county auditor's fees.

As word of the lawsuit spread, public opposition to the project gained momentum. Local and regional environmental groups including Trout Unlimited, Mankato Area Environmentalists, New Ulm Sport Fishermen, and the Coalition for a Clean Minnesota River all voiced opposition. Dennis Coleman, the engineer who designed the drainage project, said it would improve farmland without endangering any wetlands. "The only way that dewatering of a wetland area could occur is if an individual chose to install tiles there, and that could be punishable by law," he said. But Linda Reister believed that tile drainage could affect a wetland even if tiles did not go directly through it. Coleman agreed, but said that the Natural Resources Conservation Service had established setback distances to guard against such problems. Drainage improvement projects are required to comply with local, state, and federal guidelines intended to protect the state's wetlands and downstream property owners who may be affected by modifications to an existing system (Assoc. of Minnesota Counties, 1997). Coleman argued that the project was in compliance with all legal guidelines and thought the suit should be dropped. Even after hearing Coleman's arguments, the Krauses were insistent. They wanted legal documents ensuring the safety of the wetland, and were determined to fight the drainage project in court if necessary.



Fig. 2. The Minnesota River Basin.

### The Trout Stream

The MFE focused their case on the fact that the planned outlet of the drainage project was upstream of the designated trout stream. The stream was designated for protection because it was spring-fed and had trout-supporting habitat. Glen Steele pointed out, however, that the stream did not currently support a trout population. "There's never been a trout in the stream," he said. When MFE demanded that the petitioners modify the project to avoid increased flows to the trout stream, Glen said, "Most farmers are pretty practical people, and we looked at that and said you know... [Why should we] concede that to them for something that was never gonna be." He did not believe that the stream had potential for restoration and did not agree that the drainage project would damage the stream.

The MFE reviewed the engineer's report of the proposed project, and found that it would involve the construction of nearly 5 km of new open ditch and five new branch lines, which would outlet through a 1.2-m diameter pipe into a ravine approximately 3000 m upstream of the trout stream. The DNR did not have the authority to prevent the project's construction, because the outlet did not discharge directly into the trout stream. This raised the concerns of officials in the DNR Division of Waters. Leo Griggs, an area hydrologist with the DNR, wrote to the deputy administrator of Northland County saying he thought it would be reasonable to require that the project be designed to ensure that runoff did not exceed the current peak stream flow and velocity at the outlet. If that was not possible, then Griggs thought the petition should be denied so that all landowners were treated equitably. "As a society, we can no longer ignore the consequences of our actions with respect to the treatment of water," he wrote.

"Our responsibility must extend to all landowners, both present and future."

While the petitioners saw the project as a local, community-based issue, people who opposed the project thought it deserved large-scale public concern. Kenneth May, a petitioner and farmer, was disappointed to see outside groups intervening. "The neighbors are the ones being impacted," he said, "and it's their money that's being used. If we were asking for public dollars it would be another story." Glen Steele felt that the rights of rural people were being trampled upon. "You can't expect a farmer," he said, "on land he's paying taxes on, to totally fund what urban people want." But the opposition saw this drainage project as one of the many county- and local-level land use decisions that cumulatively cause larger environmental problems.

### The Conflict in a Larger Context

The project watershed is nested within the Minnesota River Basin, a rich agricultural region stretching across most of southern Minnesota (Fig. 2). In 1997, the Minnesota River was named one of the "Twenty Most Threatened Rivers in the United States" (American Rivers, 2000). In recent decades, pollution of the river from agricultural runoff, leaky septic systems, and inadequate treatment of municipal wastewater had caused water quality in the river to decline to levels society was unwilling to accept. In 1989, federal, state, and local agencies undertook the Minnesota River Assessment Project (MnRAP), a comprehensive 4-yr study of pollution in the Minnesota River Basin. The MnRAP showed that agricultural runoff was contributing sediment and phosphorus that damaged water quality and fish habitat, and that ditching and sed-



imentation were the most significant factors impairing stream biological communities (Minnesota Pollution Control Agency, 1994).

On a larger scale, the cumulative effects of local-level land use decisions in the Minnesota River Basin determine the sediment and nutrient loading at the mouth of the river, where it meets the Mississippi River, which in turn flows to the Gulf of Mexico. In recent years there have been periods of *hypoxia* in the Gulf of Mexico, in which a lack of oxygen in the water creates a *dead zone*. Excess nutrients carried in the Mississippi allow prolific growths of algae that consume oxygen as they die and decompose, resulting in oxygen levels too low to support aquatic life in the Gulf. A major cause of hypoxia is the input of nutrients contained in fertilizers and animal manure from thousands of agricultural fields in the Midwest.

The lawyers at MFE believed that the drainage project had the potential to impact downstream environments on a local scale (through direct effects on trout habitat). They also argued that effects were evident at the regional and national scales, through contributions to cumulative water quality impacts in the Minnesota River Basin, the Mississippi River, and the Gulf of Mexico. The lawyers saw the county's approval of this drainage project as an example of poor environmental management, and were determined to set a precedent in the way drainage decisions are made. Leo Griggs, DNR hydrologist, supported their stance. He wrote to Dennis Coleman, engineer, saying, "Despite our lack of direct jurisdiction with respect to this project, I still have several misgivings concerning the potential for increased erosion, loss of wetlands, and increased flows...As you know, a great amount of effort and expense is being invested toward improving the quality and hydrology of the Minnesota River Basin. The cumulative effects of projects such as this clearly run counter to those efforts."

### Historical Context

When asked why he thought the project was singled out for public scrutiny, Glen Steele said, "We're just coming to a time now when the hog (*Sus scrofa*) lots have really been picked on, and all the environmental stuff is coming to the forefront now, and a lot of circumstances came together." He expressed worry about farmers' future livelihood and said that many believe a time will come when no new drainage will be allowed. He also noted how people's views had changed in his own community. "The interesting part of the Krauses," he pointed out, "is that back in 1915 when this was put in, their dad was the original petitioner to get the drainage system in. So their dad wanted this drainage, and now these people are the ones who are trying to put a stop to it."

Changing attitudes toward drainage have been reflected in Minnesota's state drainage policies. In the early part of this century, state policy encouraged the conversion of wetlands to agriculturally productive land through tile drainage. Drainage systems were installed on millions of square kilometers of state land, and the Minnesota River Basin grew into a prosperous farming region that is today a vital limb of the state's economy. By the late 1960s, however, attitudes toward drainage had begun to shift toward concern for the effects of drainage on the environment and natural resources. Scientists and the public began recognizing that wetlands provide valuable services including water storage, fish and

wildlife habitat, and water quality improvement. Policies were implemented to discourage, rather than promote agricultural drainage, and in 1991, Minnesota passed the Wetland Conservation Act, establishing a "no-net-loss" policy to help preserve the state's existing wetlands.

Many of the old tile systems in the Minnesota River Basin are breaking down, and are not big enough to carry the water flowing to them. Farmers like Glen Steele know that maintaining or improving drainage systems helps guarantee their economic survival in an era when many small farms have been forced out of business. Farmers have spent millions of dollars implementing best management practices to decrease the amount of sediment and nutrients that enter streams. State and federal programs have helped some farmers take erodible or agriculturally marginal lands out of production, but farmers often feel that they are being assessed more than their share of the burden of improving water quality.

### Difficult Decisions

Glen Steele and the other petitioners were forced to make a series of important and potentially costly decisions. They hired a lawyer and were determined to defend their case in court. Attorney David Johnson of MFE specified the conditions under which his law firm would agree to a settlement of the case. He said that the project would need to be modified so that it did not drain or otherwise damage any wetlands, did not hurt the designated trout stream, and did not increase the flow of surface water into the Minnesota River. In a letter to Bill Wilkinson, the lawyer representing the petitioners, he wrote, "MFE's objectives could possibly be met if water was drained at a slower rate over a greater length of time, using an outlet control structure to limit the discharge rate, combined with water storage basins to store excess water until it can be released. Further, if the water storage basins were designed as wetlands, away from the main course of the ditch and the tiling, this could address MFE's water quality concerns."

At this point, Glen and the other petitioners were facing estimated costs of approximately \$50 000 in lawyers' fees, \$22 000 in court time, and the possibility of \$20 000 to \$40 000 in costs to make changes to the system that would suit MFE's demands. These costs (\$92 000–\$112 000) were in addition to the original \$830 000 estimated cost of the project. If they canceled the project at this point, they would lose \$72 000 plus engineer's fees, and would still be left with inadequate drainage. Potential benefits to the farmers if the project were constructed could vary widely, but most research has shown that on average, tile drainage projects will pay for themselves in 3 to 10 yr (Eidman, 1997). Thus, the petitioners faced sure losses by canceling, and increased income after 3 to 10 yr if the project were successful. When he went looking for help and advice, Glen said, "We found out it was a pretty lonely deal and not too many people want to help you. We went to groups that we help fund, like the corn growers and soybean growers. We were really put out that absolutely nobody really seemed to care about helping us a whole lot."

Some petitioners wanted to fight MFE and some wanted to settle quickly and cut their losses. They asked Glen to lead the group in their decision. There were no guarantees if the case went to court, the direct costs were approaching \$930 000, and there were concerns about being a good neigh-

bor as well as potential damage to the local environment. However, the petitioners feared that the loss of this drainage project could eventually put them out of business as farmers. Glen Steele needed to decide how to proceed.

## TEACHING NOTE

### Case Objectives

Upon completion of this case, students will have:

- An increased ability to understand and make complex decisions; the case increases decision making capability,
- A better understanding of the variety of issues involved as an individual farmer makes decisions regarding land and water management,
- An understanding of the way environmental policies reflect and influence the values of different sectors of society.

Depending on how the case is taught (i.e., the background reading and writing involved), students may develop an understanding of the environmental (especially water quality) and economic issues of agricultural drainage in the midwestern USA.

### Uses of the Case

This case was developed for use in upper level undergraduate or graduate classes in agricultural or natural resource management and is particularly suitable for classes in water quality or water resource management. Before reading the case, students should be introduced to the basic principles of watershed management and agricultural issues related to wetlands and water quality. In addition, students will benefit from an introduction to tile-drainage systems.

We have used the case as a basis for an in-class role-playing exercise. Students were asked to read the case in advance and develop supporting material defending a specific perspective. In advance, each student was assigned to play the role of one of the following characters:

- Glen Steele, farmer and principle decision-maker
- Dennis Coleman, engineer who designed the drainage project
- Linda Krause, landowner defending wetland
- Leo Griggs, hydrologist and environmentalist
- Bill Wilkinson, lawyer representing petitioners
- David Johnson, lawyer representing MFE

We found that this presentation was strongest when the entire scenario (i.e., each of the steps to be followed in teaching the case) was clearly explained to students at least 1 wk in advance. Students were given the case materials and assigned one of the roles to play at that time. We found that having students write a one-page paper before class encouraged them to read and think about the material in advance. We required students to develop a paper that cited a minimum of five outside sources and defended the position of the role they were to play. Students were told that they would work in groups of six (i.e., one for each role), and their final product at the end of the in-class exercise would be a statement describing Glen Steele's decision on how to proceed. We explained that the statements would be evaluated on the degree to which each person's role was represented. We weighted the grading such

that the maximum possible grade was received for a consensus; however, we did allow for dissenting positions, and all grades were based on the degree to which positions were defended rather than simply stated.

In teaching this case in a typical 50- to 90-min class, we begin by restating the issues and clarifying the process (approximately 5 min). We then have the students meet for approximately 10 min in groups where all individuals represent the same role. In a large class (>60 students), we further divide those single-role groups such that each role has two sections. This decreases small group size to approximately 5 and increases interaction. In this forum, students discuss their character's perspective and refine their position by sharing information based on each person's background paper. Their goal at this stage is for each person to feel comfortable discussing and defending the role they have been assigned to play.

The class is then rearranged into groups of six, with one student representing each character in the case. They work in that group for 25 to 45 min. In that forum, each person makes a 2- to 5-min statement presenting the perspective of their character and specifying the action or statement they propose the whole group adopt. The group then negotiates toward a consensus. Their final product from this step is a decision Glen Steele should make and a series of bullet phrases defending that position. Finally, the whole class engages in a 10- to 30-min discussion of the product. We often call upon representatives of various groups to present Glen's decision and give an overview of their debate. Then we ask other groups to comment on how their decision and defense differed.

In summary, the in-class exercise is structured as follows:

Activity	Duration of activity, min	
	50-min class	90-min class
Introduction, clarification of process	5	5
Meeting of people playing the same role	10	10
Meeting of groups for debate, discussion, and development of consensus statements	25	45
Whole-class discussion, comment on product and process, reflection	10	30

We also lead a debriefing of the process involved, which may take place on the day of the in-class exercise if time allows, or at the next class meeting. This debriefing is an explicit guided reflection in which we discuss the development of the background paper, the initial discussion of character perspective, and the larger negotiation. We find this reflective step to be a critical part of the exercise. It allows students to better understand the pedagogy involved. Also, it allows them to vent about the fact that they had to adopt a position with which they did not agree. That, in turn, can lead to a productive discussion about the role of advocacy and decision-making, or can simply result in students realizing that they now have a greater appreciation for the other side of the argument.

### Discussion Questions and Issues in the Case

1. What are some of the environmental, economic, and social issues raised in this decision case?
2. What other options might the petitioners consider that were not explicitly mentioned in the case? What other options might be considered by those opposed to the petition?

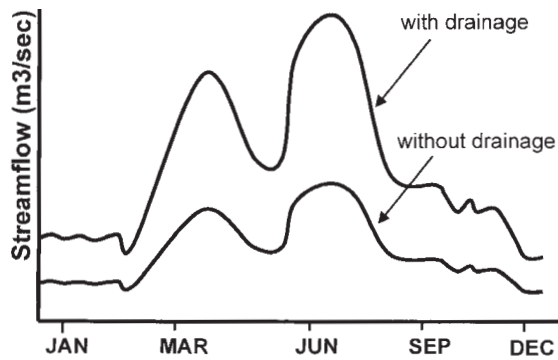


Fig. 3. Change in streamflow due to construction or expansion of tile drainage.

3. Environmental decision-makers, especially watershed managers, are currently facing a dilemma: we increasingly see the need to manage whole ecosystems and river basins to protect the integrity of our environment, but there is a simultaneous trend toward decision-making at smaller and more local scales. How do you think the case illustrates this dilemma?

4. What policy alternatives could you frame that would help guarantee the economic and cultural survival of farmers while still addressing environmental problems at the scale of the river basin?

5. What should Glen Steele do? In what way could he and the other petitioners have avoided this conflict in the first place?

### Technical Background: Understanding the Effects of Tile Drainage and Channelization on Water Quality, Habitat, and Stream Organisms

Tile drainage and channelization of streams in agricultural landscapes result in increased peak stream flow, habitat degradation, and increased streambank erosion. The combination of increased flows, habitat loss, and associated water quality degradation leads to a loss of biological integrity in local and downstream areas.

Tributaries receiving tile-drainage runoff have higher average streamflow volumes and exhibit greater peakflow after rain events. The difference in flow due to construction or expansion of tile drainage systems can be modeled in an annual hydrograph (Fig. 3). In addition to flow differences, natural (unmodified) and channelized streams differ in water quality and available habitat for stream-dwelling organisms (Fig. 4). Surface runoff to local drainage ditches carries sediment and sediment-bound phosphorus from agricultural fields; subsurface flow through tile drains often carries high loads of nitrogen and pesticides. Some tile drainage systems have open inlets that allow excess surface water to drain vertically from the field into a pipe, then flow laterally through that tile to the local stream. In these situations, tile drains often carry additional loads of sediment and phosphorus. Channelized tributaries are often located upstream of natural stream reaches (e.g., in the present case study, runoff and streamflow from Glen Steele's watershed drains to a downstream tributary with protected trout habitat). Thus, water is exported from

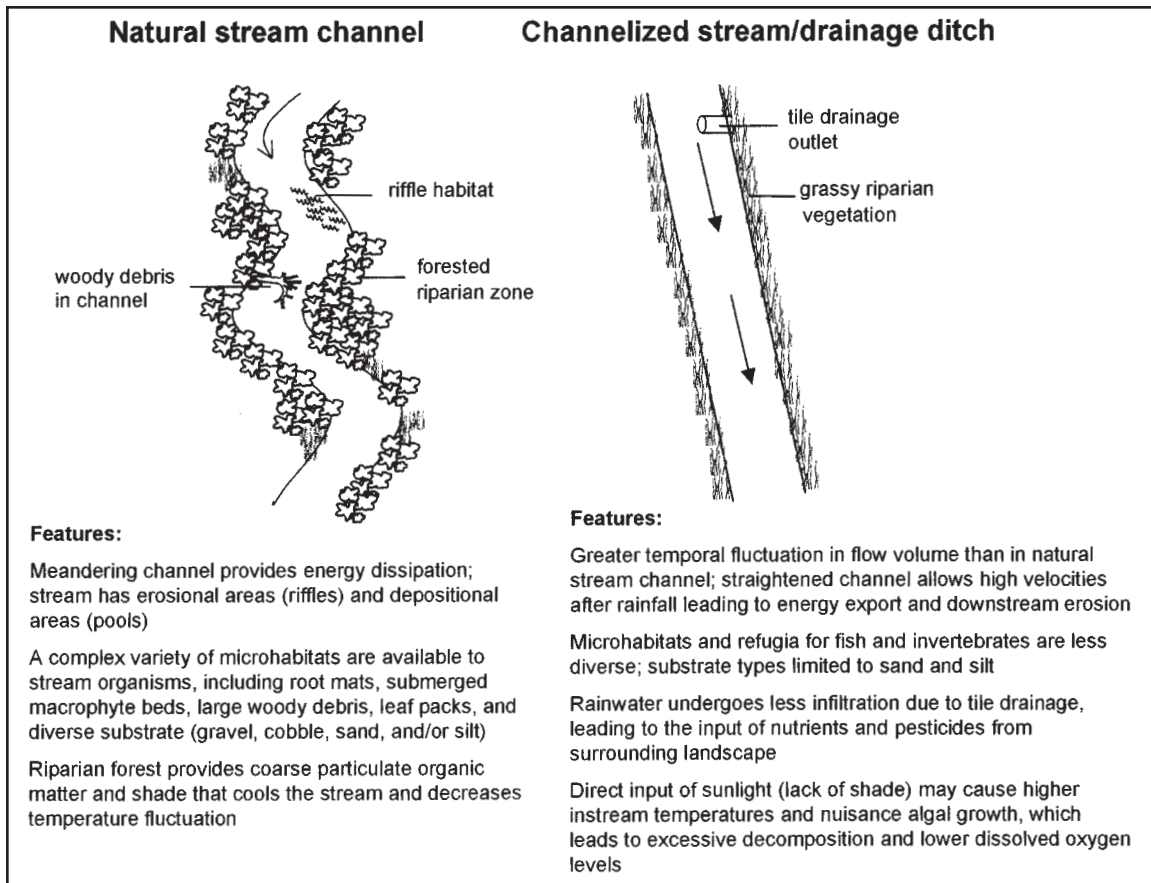


Fig. 4. Comparison of water quality and available habitat for stream-dwelling organisms in natural (unmodified) and channelized streams.

channelized streams (drainage ditches) and contributes to the degradation of downstream habitats.

Sediment has a wide range of effects in the receiving stream, including smothering plants and animals and clogging the gills of fish. Higher and less variable water temperatures deprive stream organisms of the thermal cues needed to trigger events such as spawning or emergence to the adult phase. Phosphorus draining from agricultural fields usually is associated with sediments, but can enter the dissolved phase once in the stream. Increases in dissolved or bioavailable phosphorus stimulates nuisance algal growth, which can then cause oxygen depletion in the stream.

Nitrates are a form of nitrogen that is oxidized and dissolved in water. In high concentrations (e.g., >10 mg/L), nitrates can be toxic to mammals; they are especially dangerous to young animals such as calves (*Bos taurus*) or piglets. Nitrates rarely have a direct effect on plant growth in freshwaters in the temperate zone; however, in marine systems they stimulate large growths of algae that eventually die and decompose. The decomposition process consumes oxygen; the lack of oxygen (i.e., hypoxia) can cause massive fish kills in areas such as the Gulf of Mexico.

### Analysis

This case places participants in the role of a local level decision maker (a farmer) who faces a complex decision. The case simulates a common situation, one students and instructors can find in their local communities, and thus it is relevant to their lives. The students become engaged in the case and that stimulates active learning; there is structure in the way they divide and re-divide into groups in the classroom exercise, and we have found that the discussions become heated as students adopt various roles. The issues in the case require a depth of thought in decision making; there are clearly supported arguments that oppose one another. Some of the substantive issues addressed, which might be worthy of further depth of discussion as time allows include:

- Economics of small scale agriculture (e.g., asking a student what he or she would need to know to judge Glen Steele's decision on economic terms).
- Water quality management (e.g., discussing the anticipated quality of water leaving a tile drain and its probable impact on a trout stream, or hypoxia in the Gulf of Mexico and the potential contribution to that problem by Upper Midwest agriculture).
- Regional and local environmental policy (e.g., contrasting local values versus the values of an adjacent urban population, and questions about cumulative effects).

### ACKNOWLEDGMENTS

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# Wastewater Management along the Mediterranean Coast: A Treatment Application Decision Case Study

M. El-Fadel\* and S. Sadek

## ABSTRACT

The Council for Development and Reconstruction, which needed to make decisions regarding the development of a wastewater management plan for the City of Beirut, was in the process of selecting a final site location and a treatment alternative for a facility along the Mediterranean coast. Environmental, technical, and socio-economic considerations constituted the basic issues to be addressed in the decision-making process. In this respect, proponents of the new wastewater treatment plant stated that it would provide many environmental and economic benefits to the area, particularly in terms of job creation and elimination of health hazards. Opponents of the plant, however, stressed that there was no need for the plant and argued that the wastewater should continue to be directly discharged into the Mediterranean Sea. They claimed that the dilution and treatment potential of seawater is adequate as a wastewater management approach and questioned the economic priority of constructing new treatment facilities in the country because of more urgent needs in other sectors, particularly since treatment facilities were being financed through international loans. Despite some public opposition, environmental concerns and international pressure led the Council to adopt a management plan that required wastewater treatment prior to final discharge. The council however, needed to decide on criteria for locating treatment facilities, determine the level of treatment, and select the final discharge media.

UNTREATED WASTEWATER usually contains numerous pathogenic microorganisms and toxic compounds that can cause various diseases, as well as nutrients that can stimulate the growth of aquatic plants. Historically, wastewater collected from communities was ultimately discharged to receiving waters (water bodies such as rivers, lakes, and oceans) or land. Continuous population growth, particularly in urban areas, led to serious deterioration of water resources and consequently, effluent discharge standards were developed and are being adopted on a global scale. Therefore, proper wastewater management is now being increasingly required to ensure a sustainable environment through protecting public health, maintaining aquatic ecosystems, and improving and protecting drinking water resources. The questions of how wastewater should be managed and to what extent it should be treated before discharge must be answered, taking into consideration local conditions and applicable regulation, while applying scientific knowledge and judgement based on past experience.

In Lebanon, as in many developing countries, nuisance, health conditions, and public pressure brought about an in-

creasing demand for more effective means of wastewater management, particularly in large metropolitan areas along the Mediterranean Sea. This paper considers the decision of the Lebanese Council for Development and Reconstruction (CDR) on criteria for locating a treatment facility for the city of Beirut, determining the level of treatment, and selecting the final discharge media. This council coordinates major infrastructure and developmental projects with various ministries and municipalities across the country. It reports directly to the Council of Ministers, the highest executive branch in the country.

The case was developed for use in senior undergraduate and graduate level courses in environmental engineering and science. Besides the stress on the technical component of wastewater treatment alternatives, the case can serve to discuss wastewater management in light of social perceptions in general, and limited economic resources in particular. Finally, an important aspect of the case study approach is to encourage students to seek additional information, data, or references that are needed to reach an informed scientific decision, thus allowing the simulation of real-time decision-making, which has to often be made in the absence of data due to economic or technical constraints.

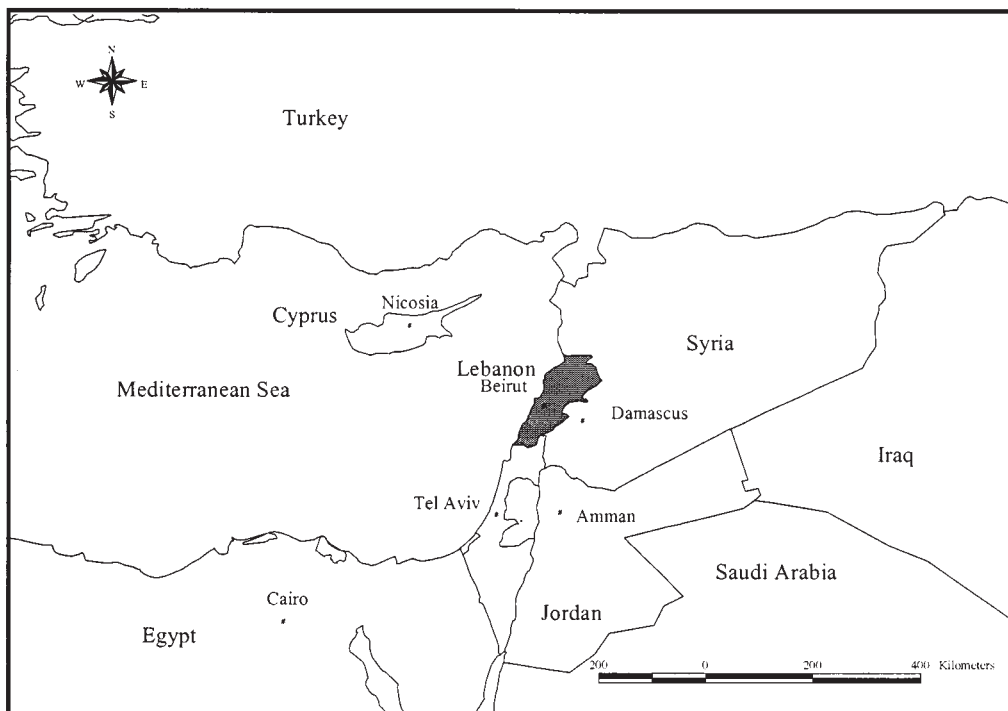
## THE CASE

Lebanon is located along the eastern shore of the Mediterranean sea (Exhibit 1) extending about 225 km long and possessing jurisdiction over about 20 km territorial limit of oceanic waters. Being a signatory of several international conventions for the protection of the Mediterranean from environmental pollution, Lebanon has the responsibility, in part, for the manner in which it uses this zone. Years of civil unrest accompanied with major demographic changes, unplanned development, and inadequate institutional support have hindered Lebanon from developing environmental management and control procedures to comply with its commitments. As such, domestic wastewater in Lebanon was discharged into the Mediterranean Sea with no treatment prior to disposal. Environmental impacts associated with open sea disposal of untreated wastewater had raised international as well as local concerns in recent years particularly with the continuously increasing population of major cities along the coastline. Environmental concerns and population increase coupled with pressure to comply with international treaties, as well as the anticipation of economic growth, had placed severe pressure on the government to undertake immediate remedial action and long-term planning, particularly regarding the need for renovating existing wastewater collection and disposal systems, and constructing new treatment facilities.

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**Abbreviations:** CDR, Council for Development and Reconstruction; BOD, biochemical oxygen demand; COD, chemical oxygen demand; SS, suspended solids; TDS, total dissolved solids; DDT, dichloro diphenyl trichloroethane; PCB, polychlorinated biphenyls.



**Exhibit 1. Lebanon location in the Middle East.**

Although CDR was initially conceived in the early 1970s as a policy planning entity, its role has progressed with time to develop, supervise, and implement policies and major projects. It consists of several departments responsible for various economic sectors including transportation, energy, industry, agriculture, and waste management. Its highest authority consists of a board of four members that are the ultimate decision makers who make decisions by majority. Their decisions can be over-ruled only by the president of the CDR and/or the Council of Ministers. Each board member is directly supported by technical and administrative personnel or can draw on the expertise of the various departments of the council.

### **Existing Wastewater Systems**

Damage assessment reports following years of civil unrest revealed that many wastewater collection systems had deteriorated to a degree that remedial action was needed to render them serviceable (Dar Al-Handasah and International Bechtel, 1991). In fact, not a single wastewater treatment plant in the country was operational. Damage assessment reports provided evidence suggesting that disposal systems, whether on-lot or community-based, presented an environmental hazard to the local townspeople either through direct exposure or indirectly through contamination of water resources, coastal recreation areas, and agricultural lands. As postwar rehabilitation and resettlement proceeded, new sewerage systems or extensions of existing systems, were being planned and installed. In many cases, accessible treatment facilities did not exist and provisions were not included for package plants or other temporary facilities. Environmental contamination unavoidably occurred around and downstream of discharge points.

### **Adverse Health and Environmental Impacts**

Data on the quality of Lebanese coastal waters were relatively limited, but marine pollution of the Mediterranean was well-documented (World Bank, 1989). Discharge of untreated sewage into coastal waters had been the common practice (Exhibits 2 and 3). Other sources of marine pollution included solid and industrial waste disposal, chronic release of petroleum wastes or products including oil tanker accidents, as well as excessive levels of nutrients that were generated from agricultural areas where nitrates and phosphorus were washed away from agricultural land and were carried by wastewater collection systems into the sea.

Although the effect of this direct discharge had not been adequately characterized, several local studies reported the presence of metals (mercury 10–250 µg/kg, copper 120–900 µg/kg, cadmium 2–25 µg/kg) and pesticides (DDT 3–150 µg/kg and PCB 0–90 µg/kg) in several types of fish (Keyomjian and Safa, 1993). Chemical analysis of sea water samples revealed the presence of concentrations of several nutrients (phosphates, nitrates, and nitrites) and elevated total coliform (30–11 000 colonies per 100 mL, depending on the sampling location). The solution to potentially adverse effects associated with the presence of these chemicals in fish and seawater samples lay in the construction of sewage treatment plants for cities with population >100 000 (World Bank, 1989). In some cases, this solution was technologically and economically burdensome, particularly in countries with limited financial resources.

### **Marine Protection Requirements**

The government of Lebanon, being a signatory to the Convention for the Protection of the Mediterranean Sea against



Exhibit 2. Culvert carrying untreated wastewater to an offshore outfall.



Exhibit 3. Land dried sludge due to an outfall overflow of untreated wastewater.

Pollution and its three associated protocols (1975–1989), was committed to adopting these protocols and associated guidelines and standards that relate to marine water quality. The objective of these protocols was the protection of bathing beaches, which required that toxic and nonbiodegradable substances be excluded from wastewater discharges and that a suitable combination of treatment and offshore dilution be provided.

### Existing Water Wells

During the period of civil unrest, the extensive need for water along with the inability of the government to act effectively encouraged the residents to drill private water wells. Such privately owned and operated wells were scattered throughout the country. In Beirut alone, because of lack of control and inadequate public water supply, some 10 000 privately owned wells supplemented the water systems managed by the official water authorities. The excessively high extraction rate of ground water from these densely situated wells had approached a crisis state, and had actually surpassed the natural recharge rate and a significant proportion of these cases resulted in serious salt water intrusion problems (Akkar, 1992; Acra, 1992). Many wells had also been a source of public health hazards because of inadequate maintenance and operation.

Exhibit 4. Current annual water balance (El-Fadel and Zeinati, 2000).

Description	Yearly avg flows	
	— 10 <sup>6</sup> m <sup>3</sup> —	
Precipitation		8600
Surface water evapotranspiration losses (assumed to be 50% of precipitation)		–4300
Surface water flows to neighboring countries		
Flow to Syria	Orontes River	–415
	Al-Kabir River	–95
Flow to Israel	Hasbani River	–160
Subtotal		–670
Ground water flow		
Unexploitable ground water or losses to the sea		–880
Losses to neighboring countries		–150
Subtotal		–1030
Net potential surface and ground water available		2600
Net exploitable surface and ground water		2000

Exhibit 5. Estimation of future water demands.

Source	Projection year	Water demand			
		Domestic	Industrial	Irrigation	Total
		— 10 <sup>6</sup> m <sup>3</sup> /yr —			
ERM, 1995	2010	310	440	1540	2290
Fawwaz, 1992	2010	900	240	2160	3300
Jaber, 1994	2015	900	240	1300	2440
Al Hajar, 1997	2020	850	250	1500	2600
Amhaz et al., 1992	2030	720	491	1700	2911
El-Fadel and Zeinati, 2000	2010	460	445	1000	1905
	2015	570	516	1200	2286
	2020	660	598	1350	2608
	2025	876	693	1500	3069

### National Water Balance

Planning for future consumption of fresh water was of vital importance because the available supply was finite and needed to be apportioned to various uses in proportion to their economic and social importance. A water balance was used to project current and future water demands and to devise plans to reach the estimated future water demands. Estimates of the current and future water balance for Lebanon are presented in Exhibits 4 and 5. These forecast a serious deficit in the water balance in the future, as further emphasized in Exhibit 6.

Considering that water resources in Lebanon are limited, it is imperative that all available water resources be considered as a source for domestic water supply or agricultural use. In the case of aquifer recharge, it is of utmost importance that effluent criteria comprise prescribed minimization of pathogenic and organic contamination with compliance to potable drinking water standards for nondegradable constituents.

### The Need for Wastewater Treatment

Despite the adverse environmental impacts associated with wastewater disposal into the sea, several interest groups opposed the construction of a new wastewater treatment plant for various reasons, including site location, economic, and political issues. Their argument was that the government was seeking to finance the construction of treatment facilities through international loans and under international pressure. The CDR that was responsible for making the final decision regarding the development of a wastewater management plan for the city of Beirut was under public scrutiny. The problem was whether or not to construct a new wastewater treatment

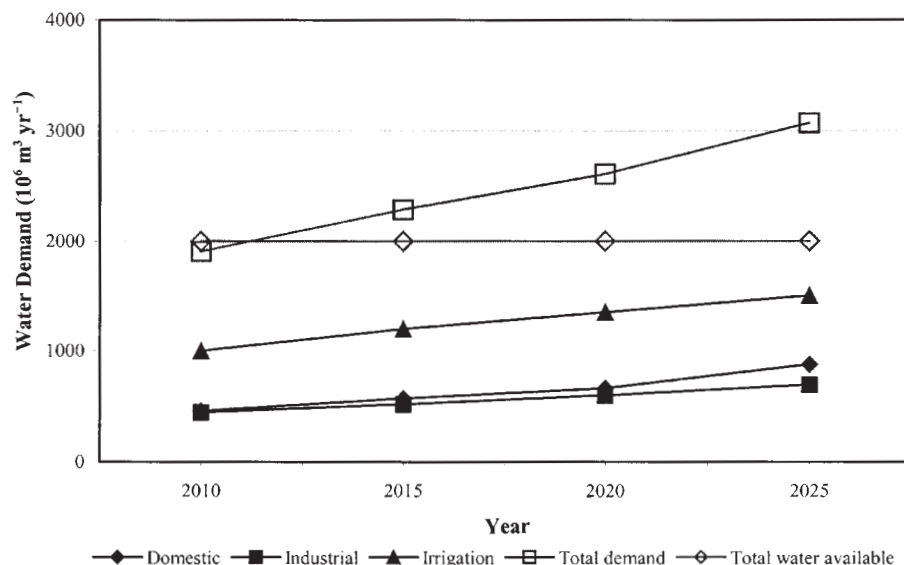


Exhibit 6. Comparison of future water demand and deficit.

facility, and if so, to select a site location and treatment alternative.

### WASTEWATER TREATMENT ALTERNATIVES

Planners faced the problem of developing appropriate wastewater treatment alternatives, which in the case of Beirut are highly dependent on the site location. Land availability along the Beirut coast was limited and, when available, the cost was prohibitively expensive, which in turn would affect the treatment process and the extent of wastewater treatment before final discharge. Wastewater quantity and characteristics, as well as effluent discharge standards, were essential parameters for the selection and design of a treatment process.

#### Wastewater Quantity

Prior to the design of wastewater treatment facilities, it was necessary to determine the quantities of wastewater generated that will be treated at the proposed facility. Then, wastewater facilities could be designed to treat and discharge projected future flows, which were directly proportional to water consumption.

Exhibit 7. Average annual water consumption for Beirut (Khatib and Alami, 1994).

Year	Population	Average demand	Annual demand
	10 <sup>6</sup>	L/capita per d	10 <sup>6</sup> m <sup>3</sup>
1990	1.25	165	75
2000	1.70	215	133
2015	2.30	260	218

Exhibit 8. Beirut wastewater characteristics (Khatib and Alami, 1994).

Parameter	Average	Range
	m	g/L
BOD	128†	30–230
COD	630	250–820
SS	130	60–230
TDS	1400	300–2900
Phosphorus	9	2–25
Nitrate	100	30–160

† Relatively low because of stormwater input.

sumption. In this respect, the national water balance was useful to some extent; however, additional data on population estimates and average water consumption per capita were typically needed. These data for Beirut are presented in Exhibit 7. Methods of wastewater treatment to be adopted varied with the wastewater characteristics and the end use of the product water, and consequently with the level of treatment required.

#### Wastewater Characteristics

Wastewater is typically characterized in terms of several parameters such as: biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS), and total dissolved solids (TDS). Determining the concentrations of other parameters such as nutrients (phosphorus, nitrate) and toxic metals also prove helpful in evaluating the methods of treatment, effluent disposal, and sludge management. Exhibit 8 summarizes available information on wastewater characteristics for Beirut.

#### Effluent Discharge Standards

The Ministry of Environment had proposed standards related to the disposal of wastewater in the Mediterranean (Exhibit 9). These standards dictated the level of treatment re-

Exhibit 9. Proposed Lebanese marine wastewater discharge standards (MOE, 1996).†

Parameter	Limiting value	Parameter	Limiting value	Parameter	Limiting value
BOD	60	Aluminum	3	Zinc	5
COD	100	Ammonium	3	Silver	0.1
TDS	200	Mercury	0.005	Barium	2
TSS	60	Lead	0.5	Cobalt	2
Sulfur	1	Cadmium	0.05	Pesticides	0.2
Grease	15	Arsenic	0.05	Cyanide	0.1
Hydrocarbons	0.5	Chromium	1	Temperature, °C	35
Phosphate	5	Copper	1.5	pH, unit	6–9
Nitrate	40	Nickel	0.1	Turbidity, NTU	50
Phenols	1	Iron	1.5		
Fluorides	1.5	Manganese	1		

† All units in mg/L unless specified otherwise.



quired and influence the treatment alternative to be implemented.

## THE DECISION

Taking social, environmental, technical, and economic factors into consideration, the Council of Development and Reconstruction needed to decide on criteria for locating a treatment facility for the city of Beirut, determine the level of treatment, and select the final discharge media for the treated water. All those elements are part of a wastewater management plan for Beirut. What decision should the CDR make?

## TEACHING NOTE

### Case Objectives

Upon completion of this case, students should be able to:

1. Discuss environmental impacts of uncontrolled offshore disposal of wastewater.
2. Identify site selection criteria for locating a wastewater treatment plan.
3. Define and evaluate alternatives in wastewater treatment and discharge.
4. Define and assess priority design and planning criteria in wastewater management.
5. Select and develop a design for wastewater treatment processes.

### Uses of the Case

This case study is intended for senior undergraduate and graduate level students in environmental engineering and science. Design questions are intended for students with the appropriate technical background, particularly in wastewater treatment processes. Students will use decision-making skills to integrate primarily the scientific and social components of the case. The case, based on country-specific data and events, provides students an opportunity to conduct a preliminary evaluation of a wastewater management plan in a developing and high-growth coastal city, even though there may be insufficient data. Therefore, students often misunderstand that the case will provide them with all the needed information—this belief should be diffused early by stressing the need to search for additional information from various literature sources, local firms, or even field surveys to collect their own data. In evaluating the information, students should learn to evaluate the reliability of the data and their sources. The importance of social and political considerations in deciding community issues are emphasized in the fact that even in the presence of public opposition for certain developmental projects, governments may find themselves forced to comply with international obligations, particularly when economic factors are at stake.

### Implementation of the Case

The case was successfully tested in a senior-level undergraduate course on wastewater treatment processes at the American University of Beirut. The class was composed primarily of civil engineering students. Invariably, the feedback of students was positive and in fact, their reports were used to improve on the case and refine certain questions. While case

studies can be implemented in a variety of ways in a classroom setting (Herreid, 1994), the implementation should be appropriate to the background of the students and the objectives of the course. The case can be assigned as outside reading followed by a general class discussion of the case issues and the decision that needs to be reached with the corresponding justification. Written reports could be required for grading purposes. After instructors respond to these reports, students' answers can be discussed in class in the context of actual events and the final decision that has been planned or was implemented. Another approach is to have the case read in class (only for a 3-h class that is offered once a week, otherwise the case would be too long for a 1-h session) followed by either small group or whole class discussion of all or selected questions. While the latter approach requires the least amount of class time, it also provides the least chance for students to reflect on the issues of the case. Some socially oriented questions lend themselves to role-play, whereby students assume the role of the opposing or supporting views of the community. Role playing offers the advantage of practicing public speaking and increased awareness of socio-economic constraints and hidden agendas. Other questions can actually be asked in an examination to stress to students that they may often be faced with situations where they have to address certain issues in real-time. Note that some questions can be eliminated from the case study if the course is not intended to teach students about design of wastewater treatment facilities. Examples of wastewater treatment textbooks that might be used in conjunction with this case include Metcalf and Eddy (1991) and Crites and Tchobanoglous (1998).

## DISCUSSION QUESTIONS AND ANSWERS

**1. Identify the potential adverse environmental impacts associated with open-sea disposal of untreated wastewater.** Seawater is typically in a state of ecological balance providing a harmony between plant and animal life with considerable interdependence among various life forms (Exhibit 10). The introduction of excessive quantities of pollutants may disturb this balance and result in toxic concentration levels for specific life forms.

Excessive quantities of organic material might also result in rapid bacterial growth, which leads to the depletion of dissolved oxygen resources (<2 mg/L compared with 5–7 mg/L for healthy conditions) and results in the death of fish and plants. In addition, direct discharge of wastewater into the sea would result in excess suspended solids on the seawater surface and sedimentation on the sea floor. Suspended solids at the surface block out energy from the sun, thus affecting the carbon dioxide–oxygen conversion processes (photosynthesis), which is vital to the ecological cycle. Long-term sedimentation of the sea floor hinders navigation near the shoreline and may require frequent dredging. Last but not least, discharge of untreated wastewater presents a serious health hazard through direct exposure (bathing) or consumption of fish, not to mention its effects on recreational activities (aesthetics, offensive odors).

**2. Identify a set of priority design/planning criteria in wastewater management.** Selection of the appropriate technology for treatment and disposal of wastewater requires an in-depth evaluation of the objectives that are to be achieved.

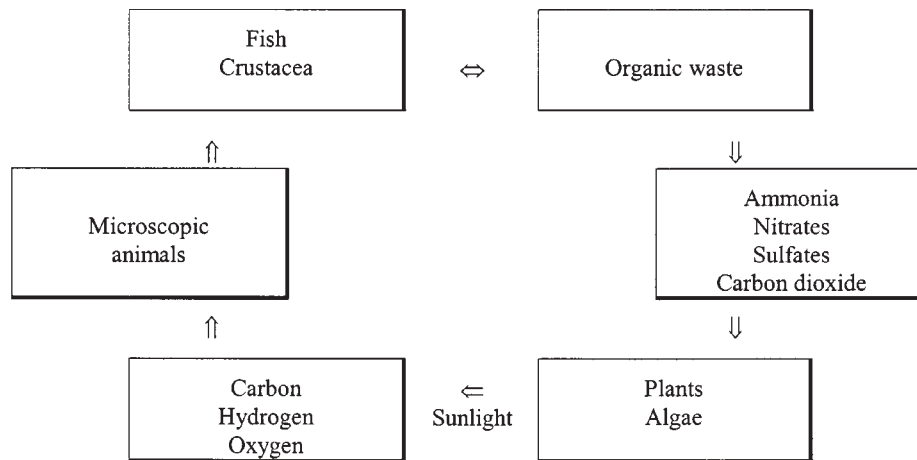


Exhibit 10. Natural cycle in marine environment.

Subject to technical and economical constraints to be considered in the evaluation of alternatives, the general objectives outlined below could be regarded as guidelines set for process selection:

- Domestic water sources—aquifers, springs, wells, or surface water—should be protected against contamination by wastewater.
- Irrigation of agricultural lands by wastewater reuse and utilization of treated sludge as a soil conditioner should be promoted where cost-effective, but only when pathogens have been effectively removed; pollution of irrigation supply sources by inadequately treated wastewater should be prevented.
- Conditions for water-based recreation (swimming, boating, and fishing) will be enhanced by improvements in water quality and control of marine discharges.
- Water conservation by means of irrigation reuse, aquifer recharge, or industrial reuse of treated effluent should be practiced where it is cost-effective and water resources are otherwise inadequate.
- Compliance with the Mediterranean Pollution Commitments.

**3. Identify criteria through which you can consider existing offshore outfall as an adequate treatment option.** A suitably designed outfall should ensure effective dilution at a distance away from the shore to:

- Comply with set criteria for bacterial concentration in recreational waters and shellfish growing areas.
- Prevent any sensory offensive conditions and identifiable waste materials from being present at waters used for recreational purposes.
- Maintain a dissolved oxygen level of  $\geq 5$  mg/L outside of the zone in which the sewage plume undergoes initial dilution.
- Prevent the presence of persistent, toxic compounds by controlling them at the source.
- Prevent accumulation of solids on the sea and prevent anaerobic conditions from prevailing.
- Prevent the presence of high concentrations of nutrients.

**4. Discuss the different levels of wastewater treatment and effluent discharge alternatives with corresponding advantages and disadvantages.** In coastal areas, the ultimate

disposal of treated wastewater is primarily to the sea. Pre-treatment of wastewater before discharge into the marine environment through ocean outfalls could be performed with different degrees of complexity (preliminary, primary, secondary, or tertiary). Aquifer recharge is a possibility, which can be considered to alleviate the problem of seawater intrusion into coastal aquifers resulting from indiscriminate tapping into these aquifers. Wastewater reclamation and usage for irrigation of agricultural land is another possibility for effluent management. Thus, the various alternatives that can be considered for wastewater treatment and disposal alternatives include:

1. Maintain the same offshore disposal method.
2. Preliminary treatment and offshore disposal.
3. Primary treatment and offshore disposal.
4. Secondary treatment and offshore disposal.
5. Secondary treatment and land irrigation.
6. Secondary treatment and aquifer recharge.
7. Tertiary treatment and aquifer recharge.
8. Tertiary treatment and municipal reuse.

Each alternative is associated with a series of advantages and disadvantages as presented in Exhibit 11, which also provides a description of the various treatment options.

**5. What is the general feasibility of these alternatives?**

As a general rule, it could be stated that the more complex the treatment the shorter the outfall. However, this is not always true. The level of required treatment, the availability of suitable onshore and offshore conditions, the magnitude of the works and, most important, the economics are all factors that will have to be considered in evaluating the various alternatives. In Lebanon, a number of constraints, such as difficulty in finding suitable sites with ample areas for secondary treatment and limited financial resources available for initial investment as well as for operation and maintenance, basically narrow down the alternatives to no more than secondary treatment, all while minimizing the amount of surface area required.

**6. What is a common problem with various treatment alternatives and how is it handled?** Irrespective of the treatment alternative selected, sludge generation will remain a problem. Sewage sludge may be expected to contain, to some

**Exhibit 11. Assessment of wastewater treatment and disposal alternatives.**

Alternative	Treatment description	Advantages	Disadvantages
Maintain the same offshore disposal method	None	<ul style="list-style-type: none"> <li>• Cheapest</li> </ul>	<ul style="list-style-type: none"> <li>• Significant environmental impacts as discussed in Discussion Question 1</li> </ul>
Preliminary treatment and offshore disposal	Includes measurement and regulation of incoming flow and removal of large floating solids, grit, and perhaps grease. Typical utilities used at this stage include coarse screens, comminutors, grit and grease removal tanks (skimming or vacuum flotation tanks), pre-aeration and equalization tanks.	<ul style="list-style-type: none"> <li>• Lower cost and complexity of construction and operation</li> <li>• Provides a first step in reducing sea and coastline pollution problems particularly from large size solids</li> </ul>	<ul style="list-style-type: none"> <li>• Quality of effluent still does not meet discharge criteria and will continue to cause adverse environmental problems</li> </ul>
Primary treatment and offshore disposal	Includes the removal of suspended solids. In addition to the preliminary utilities, it consists of clarifiers with mechanical sludge removal. It also includes chemical coagulation to remove finer and dissolved solids such as phosphorus.	<ul style="list-style-type: none"> <li>• Cost remains low compared with later treatment processes</li> <li>• Improved quality of effluent</li> </ul>	<ul style="list-style-type: none"> <li>• Requires large areas for clarifiers</li> <li>• Requires mechanical equipment that need regular maintenance</li> <li>• Produces a larger volume of sludge</li> </ul>
Secondary treatment and offshore disposal	Known as biological treatment and intended for the removal of soluble and colloidal organic matter, which remains after primary treatment. This treatment alternative is designed to maintain a large mass of bacteria within the system confined to biodegrade soluble and colloidal organic material. There are two main techniques to carry out this process namely the attached (sand or trickling filters, rotating biological contactors) or suspended (activated sludge) growth process.	<ul style="list-style-type: none"> <li>• High quality effluent that can be safely disposed of at sea</li> <li>• Removal of organic material resulting in a permanent solution for coastal pollution</li> </ul>	<ul style="list-style-type: none"> <li>• Expensive</li> <li>• Requires even larger areas for clarifiers and biological reactors</li> <li>• Produces even a greater volume of sludge</li> <li>• Relatively difficult to construct near residential areas because of potential odors</li> <li>• Requires skilled personnel for operation</li> </ul>
Secondary treatment and land irrigation	Same as above	<ul style="list-style-type: none"> <li>• Same as above</li> <li>• Effluents through the soil is very clean (almost equivalent to tertiary treatment depending on soil characteristics)</li> </ul>	<ul style="list-style-type: none"> <li>• Requires the use of large agricultural areas</li> <li>• May result in nutrients deposits in the soil, which may accumulate with time (phosphorus, nitrates, and heavy metals)</li> </ul>
Secondary treatment and aquifer recharge	Same as above	<ul style="list-style-type: none"> <li>• Same as above</li> <li>• May reverse the problem of seawater intrusion</li> <li>• Prevents the water table from dropping during drought months</li> </ul>	<ul style="list-style-type: none"> <li>• Requires pumping to recharge zones</li> <li>• Increased cost for injection wells</li> </ul>
Tertiary treatment and aquifer recharge	Typically performed if the effluent is intended for domestic reuse instead of disposal. May include the addition of chemicals or complex biological activities and advanced treatment systems such as activated carbon and reverse osmosis. Removes excess nutrients and heavy metals.	<ul style="list-style-type: none"> <li>• Produces high quality effluent which can be safely disposed of at sea, on land, or in ground water</li> </ul>	<ul style="list-style-type: none"> <li>• Most expensive</li> <li>• Requires large areas for construction</li> <li>• Produces large amounts of sludge</li> <li>• Requires the use of large amounts of chemicals</li> </ul>
Tertiary treatment and municipal reuse	Same as above	<ul style="list-style-type: none"> <li>• Same as above</li> <li>• Effluent can be used to make for predicted future deficit in water demand</li> </ul>	<ul style="list-style-type: none"> <li>• Requires large storage tanks</li> <li>• Sociocultural barriers to domestic wastewater reuse</li> </ul>

degree, all the types of contaminants present in the raw waste. Many of these are toxic and some of them are concentrated in the solid fraction. Sludge treatment, besides its complexity, is a costly operation. Sludge handling techniques are directed toward reducing the moisture content and thereby the volume of the sludge. Methods of sludge handling include:

- Landfilling without any pretreatment
- Thickening (water content reduction)
- Dewatering and stabilization (biological digestion)
- Reduction (via open bed drying, burning, composting)
- Disposal (sea or land after treatment)

**7. Select one alternative (justify your selection) and develop a preliminary design of the various components of the corresponding treatment facility (only for advanced students in the proper field).** This question is suitable for senior-level civil engineering (or related field) students who have taken or are taking a design course in waste treatment processes. The process of selecting the most suitable alternatives must include a comparison of advantages and disadvantages (see Exhibit 11), an economic and feasibility comparative evaluation between the various alternatives, and the physical and resource constraints at the location of the planned

facility. After the selection of an alternative, typical design, parameters that should be defined include:

- Design life
- Projected population served
- Per capita water consumption rate
- Wastewater characteristics
- Effluent characteristics

The preliminary design should present a layout of the plant showing its different components (Exhibit 12) and calculations should be made to define the geometry (width, length, depth, diameter) of these components as well as their design parameters (hydraulic and solid retention times, removal efficiency of selected environmental indicators listed in Exhibit 9, quantity of sludge produced at the various system components).

**8. What factors should the council consider in selecting the final solution?** Economic feasibility and least amount of disturbance to the surrounding community to ensure public support are major factors that should be considered in selecting the final solution. Other factors include international agreements and potential pressure from international donors

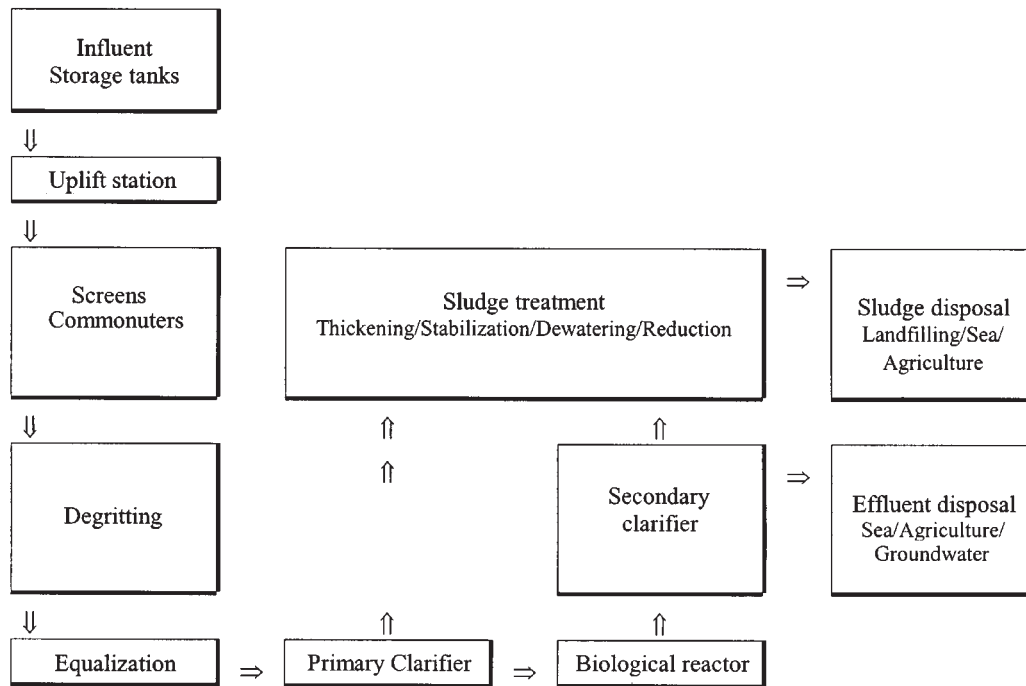


Exhibit 12. Typical treatment plant layout.

in other economic sectors, ease of implementation, potential for expansion, and operation and maintenance.

**9. Discuss the potential opinion of a community located along a coastal area with respect to encouraging the construction of a wastewater treatment facility.** The answer to this question may vary among students depending on socio-economic status of the student and the community. Students living in developing areas would likely agree with the view of the opponents to the facility that their community is more in need of hospitals, schools, and roads than a treatment facility. It is expected that they will be resistant to any international pressure and will perceive a right in continuing to discharge into the sea until the country can afford treatment plants. In more affluent communities, the perception will likely be the opposite, particularly for those who use the coast for leisure and tourism. Irrespective of their social background, many might be resistant because of international pressure, particularly when the latter is conceived as an obstacle toward industrial development and economic growth.

**10. Who do you think should be responsible for deciding whether a treatment plant is needed, and if so, who should decide on the level of treatment or effluent discharge standards?** While various entities may be identified including academicians, the government, citizens, or the industry, the discussion should be directed to examine why any group is more suitable than others and how they may differ in their opinions.

**11. What did the Council decide?** It is natural that in a class setting students will expect to hear the actual, final decision that may be considered the *correct* answer. In reality, there are often several solutions, particularly to a design case study. This latter aspect must be emphasized by the instructor to ensure maintaining the broadness of the discussion and avoid ignoring all but one solution, which may not even be the

most appropriate. Upon the recommendation of several consultants, the council adopted the concept of secondary treatment and offshore disposal with the installation of a pair of such facilities, one just north and the other just south of the city. A hybrid system of aerobic and anaerobic treatment was selected to accomplish secondary treatment and manage the sludge component.

#### ACKNOWLEDGMENTS

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# The Normandy Landfill: A Case Study in Solid Waste Management

S. Sadek\* and M. El-Fadel

## ABSTRACT

**The Normandy Landfill is a by-product of the Lebanese civil strife (1975–1990). During those years, the city of Beirut discarded about 1090 Mg/d (1.200 t/d) of its municipal waste in the Normandy Bay along the Mediterranean coast. After the civil war, the general area of the fill became popular real estate because of its location at the historic and economic center of Beirut. Economic incentives pushed planners of the reconstruction effort to envisage reclaiming the fill area and develop it as an extension of the central business district. This decision was controversial from the outset and was not met with great enthusiasm in many quarters, particularly given its socio-political implications. Proponents of development stated that it would provide many environmental and economic benefits to the area in terms of job creation and elimination of health hazards associated with the existing landfill. Opponents argued that the historic coastline of Beirut should be rehabilitated to its original status, and that the cost of the newly reclaimed real estate would be prohibitive and would only result in the creation of a wealthy enclave, which would be inaccessible to the majority of the population. Despite opposition, the Council for Development and Reconstruction, the final decision maker regarding the development of the Central Business District of Beirut, adopted a policy aiming to reclaim and expand the fill area. The council was to decide the best reclamation alternative for the landfill, taking into consideration socio-economic factors as well as technical aspects.**

**I**N LEBANON, as in most developing countries, municipal solid waste (MSW) disposal has been a chronic problem, particularly in areas with high population density, high production of refuse, and scarcity of land adequate for landfills. In such settings, uncontrolled waste dumping along the seashore has been an unfortunate, yet common practice for solid waste disposal in major urban centers. These practices along the Mediterranean coast resulted in serious sea pollution problems. Recently, efforts were made to rehabilitate and reclaim uncontrolled dumps and landfills, turning them in some instances into parks, recreational facilities such as drive-in theaters, or even service centers (Stearns and Petoyan, 1984).

This paper considers the decision of the Lebanese Council for Development and Reconstruction (CDR) regarding alternatives to remediate a waste disposal facility along the Mediterranean. The CDR coordinates major infrastructure and developmental projects with various ministries and municipalities across the country. It reports directly to the Council of Ministers, the highest executive branch in the country. While the CDR was initially conceived in the early 1970s as a policy planning entity, its role has progressed with time to develop, supervise, and implement policies and major projects.

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It consists of several departments responsible for various economic sectors including transportation, energy, industry, agriculture, and waste management. Its highest authority consists of a board of four members that are the ultimate decision makers who reach their decisions by majority votes. Their decisions can be overruled only by the president of the CDR and/or the Council of Ministers. At the end of the civil war in Lebanon, a private real estate holding company (SOLIDERE) was established to manage and implement the redevelopment of the Beirut downtown, which had suffered extreme levels of destruction. The seashore dump was included as part of the real estate portfolio of the newly created company. The CDR had final authority and constant supervision responsibilities for overseeing the work of SOLIDERE.

While the case presented in this paper was developed for use in senior and graduate level courses in environmental engineering and science, it is also suitable for students in related fields such as natural resource management if the design aspects are minimized. Besides the stress on the technical component of facility remediation alternatives, the case can serve to discuss solid waste management in the light of social perceptions in general, and limited economic resources in particular. Finally, an important aspect of the case study approach is to encourage students to seek additional information, data, or references that are needed to reach an educated scientific decision, thus allowing the simulation of real-time decision-making that has to often be made in the absence of some data due to economic or time constraints.

## THE CASE

As years of civil unrest in the city of Beirut came to an end in the early 1990s, reconstruction and rehabilitation efforts were launched to remediate the impacts of nearly two decades of conflict. At the heart of the reconstruction area lay the historical and business center of the capital, which was in effect, the demarcation line during years of civil strife. A private company, SOLIDERE, was formed for the purpose of guiding this effort to completion, under the supervision of a CDR. A pressing issue that the newly created company had to consider was the Normandy Landfill, which was one of the most visible and controversial landmarks needing attention in the Beirut Central District (BCD).

### History and Background Information

The site known as the Normandy Landfill is located along the northern coast of Beirut, Lebanon (Exhibit 1). It literally forms the sea façade of the BCD. It was created as a result of dumping municipal and other wastes into the Mediterranean sea during 15 yr of civil unrest. The original site consisted of a small bay that used to cut 200 m into the mainland (Exhibit

**Abbreviations:** MSW, municipal solid waste; CDR, Council for Development and Reconstruction; BCD, Beirut Central District; NIMBY, not in my backyard; AUB, American University of Beirut; PU, Purdue University; JUST, Jordanian University of Science and Technology; ISWM, integrated solid waste management.



Exhibit 1. General map of Beirut.

2). Random disposal activities began around 1975 and were suspended in 1994. Initially, the waste was limited to household wastes and later included inert fill and construction material. The site currently covers about 360 000 m<sup>2</sup> and extends about 600 m beyond the original shoreline (Exhibit 3).

During the period 1975 to 1982, the material dumped was mostly municipal waste with some construction rubble. At that point 30 000 m<sup>2</sup> land area had been deposited into the sea (Exhibit 4). Between 1982 and 1983, large quantities of demolition debris were dumped into the sea north of the existing waste piles. The haphazard nature of the dumping type and location continued until 1994, resulting in a heterogeneous fill with areas of inert and organic materials alternating and mixing in no clear pattern.

By 1994 the volume of the landfill reached about 5 million m<sup>3</sup>. Half of this volume was below sea level, reaching water depths of 20 m. Above the water line the fill reached heights of 35 m in some locations (Exhibit 5). In addition, the years of war resulted in significant damages to the city infrastructure, including sewage and wastewater disposal, resulting in the discharge of large volumes of untreated wastewater at the edge of the fill.



Exhibit 2. Aerial view of the Normandy Bay before landfilling activities (1970).

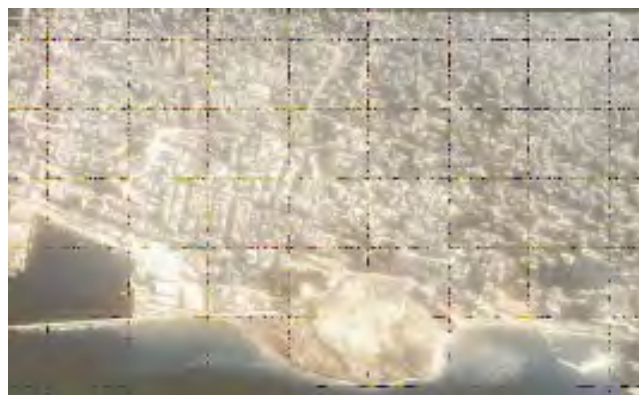


Exhibit 3. Aerial view of the Normandy Bay after landfilling activities (1993).

### Site Characterization

The first step undertaken by SOLIDERE was to conduct a comprehensive site characterization study, which included estimating the deposited waste quantity and composition, and subsurface properties as well as leachate and gas formation potential.

#### *Waste Quantity and Composition*

The total amount of municipal waste dumped in the fill since 1975 cannot be established with any degree of certainty. During the last 2 yr before site closure, about 1090 Mg/d (1200 t/d) were disposed of at the site. The composition of the municipal waste generated in the greater Beirut area was typical of developing countries and was characterized by a high content of food waste compared with developed countries where paper waste predominates (Exhibit 6). Waste composition may affect the possible alternatives for disposal and/or treatment of the already existing and still active materials within the landfill.

Although most waste received at the Normandy Landfill consisted of municipal waste, the landfill also received sig-

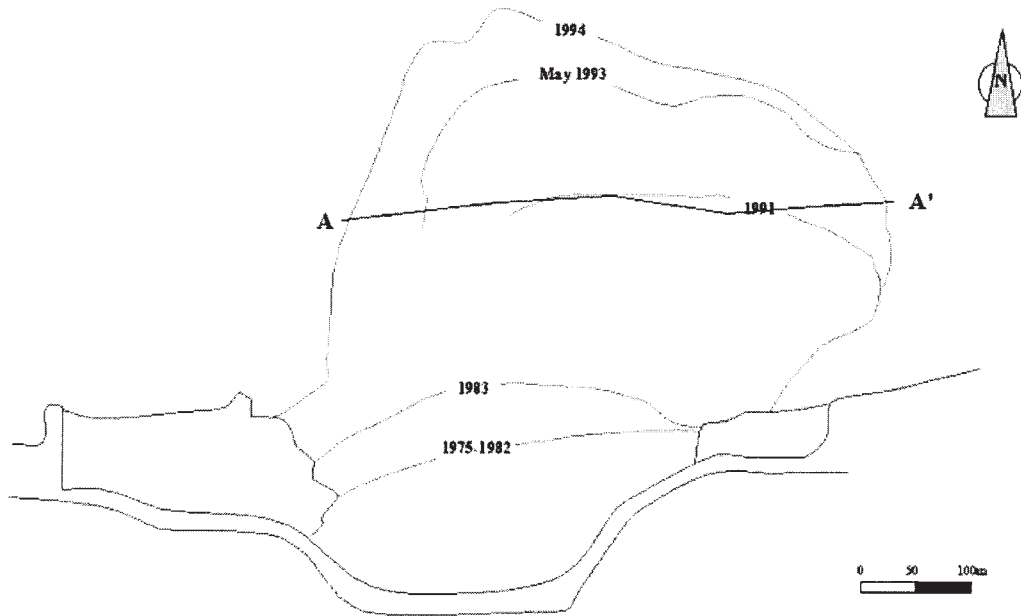


Exhibit 4. Historical development of landfill encroachment into the Mediterranean.

nificant amounts of old household appliances, wrecked cars and car parts, old tires, medical wastes, and industrial wastes including lubricants and cleaning agents (Exhibit 7). In addition, serious consideration had to be given to the possible presence of mines or unexploded ordinance on site. The inert fill that was deposited at the site consisted mainly of cohesionless soil excavated from various construction sites in and around Beirut, and of destruction rubble such as reinforced concrete slabs, boulders, and ceramic tiles and bricks.

**Soil, Gas, and Leachate**

Characterization tests were conducted on the soil, gas, and leachate within the fill. This effort was designed to establish

the location, depth, and age of the waste material present within the landfill. Such data define the zones that require extensive or immediate treatment and help in selecting the appropriate treatment methodologies. The subsurface profiles were characterized by drilling 16 boreholes to maximum depths of 50 m and excavating 40 surface trenches to depths of 5 m. More than 200 gas probes were installed across the site to assess gas generation and composition (Exhibit 8). Monitoring wells were extended below the landfill into the natural strata. Samples of ground water and landfill leachate were collected and chemically analyzed (Exhibit 9). Finally, samples from the inert soils in the landfill were tested for various geotechnical properties (Exhibit 10).

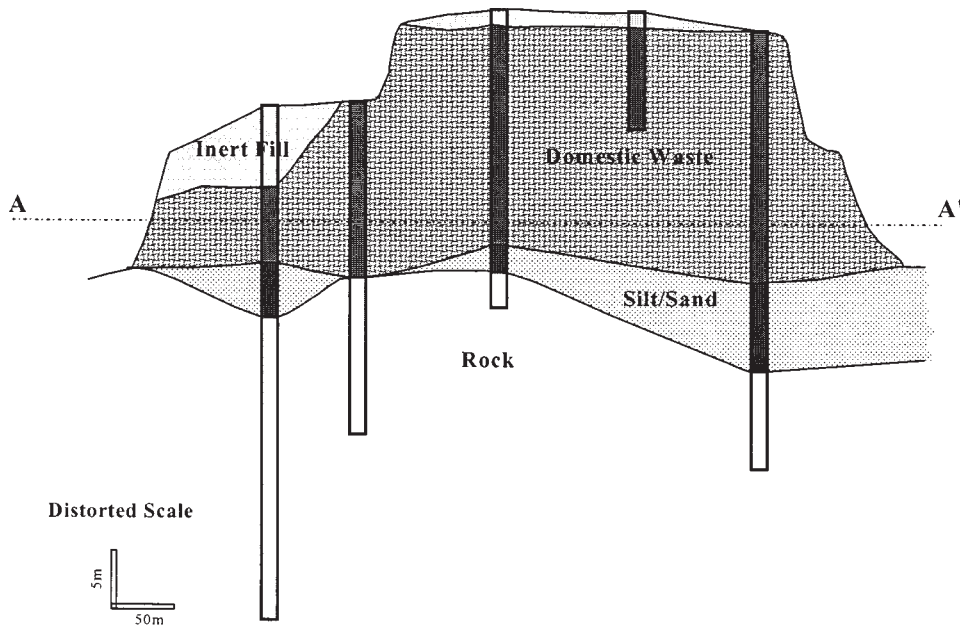


Exhibit 5. Cross-section AA' (the dashed line marks the sea level).



**Exhibit 6. Typical average solid waste composition: Lebanon vs. USA (World Bank, 1995).**

Waste type	Beirut	USA
	% by wet wt.	
Food remains	62	20
Plastics	12	5
Paper/cardboard	13	43
Glass	5	9
Metals	3	7
Other	5	16

**Exhibit 8. Landfill gas composition in selected gas probes.**

Major gases	%	Trace gases	µg/m <sup>3</sup>
Hydrogen	<5	Total volatiles	0.6–22.8
Oxygen	<0.05	Aliphatics	2.7–20.8
Methane	36–47	Chlorinated	0.1–2
Carbon dioxide	36–49	Aromatics	0.1–0.4
		Sulfur	0.1–1

**Exhibit 9. Ground water and leachate chemical composition.**

Physical		Chemical	mg/L	Biological	Col/100 mL
pH	6.1–8	Chloride	240–17 650	Total coliforms	2 500–680 000
Conductivity, mS	2–57	Sodium	228–14 000	Fecal coliforms	0–350 000
Alkalinity, mg/L	145–16 800	Potassium	30–3 380		
		Magnesium	25–945		
		Calcium	20–4 500		
		Lead	<0.04–0.43		
		Iron	2.5–28		

**Exhibit 10. Soil properties within the fill.**

Moisture content, %	18–33
Liquid limit, %	22–76
Plastic limit, %	15.5–29.6
Plasticity index, %	3.5–47.6
Dry density, Mg/m <sup>3</sup>	1.65–2.00

The degree of compaction of the fill was difficult to establish, given the history of the site and the inherent heterogeneities. Furthermore, the internal structure and character of materials forming the fill are constantly changing as a result of the active degradation as indicated by the gas generation and composition results. Therefore, settlements are expected to occur with continuous variation in fill density. In addition, leachate formed within the landfill seeped away from the direct fill area.

### Political and Socio-Economic Context

The location of the landfill along the old demarcation line of the civil war and at the heart of the historic, commercial, touristic, and cultural center of the city of Beirut, placed the Normandy dump at the center of a unique political, social, and economic situation. Implications associated with any envisaged solution were as complex and as varied as the fabric of the Lebanese society emerging from its strife. Politically, the controversy was mainly associated with the allegiances of the entity that was responsible for planning and implementing any solution. This was further exacerbated by concerns regarding the inevitable demographic changes in the newly developed zones. An area that was traditionally the center for a large number of small businesses, artisans, and low to moderate-income housing, was to be potentially transformed into a high-cost, high-end business district, luxury tourist resorts, and



**Exhibit 7. Car carcasses and wrecks as part of the Normandy fill.**

housing complexes. On the other hand, leaving the festering problem at the heart of the city with its associated environmental hazards was not an option. The impact the landfill was having on the center of the city could not be tolerated and nothing short of a radical solution would be acceptable. The NIMBY (not in my backyard) syndrome was clearly evident in discussions with residents of nearby areas. The heart of the dilemma was that without the economic incentive of the new high-end development on the reclaimed lands, the cost of rehabilitation could not be born by the government alone, but that the transformation of the area and the changes in demographics and land use would profoundly change the fabric of a city that was thousands of years in the making.

### The Decision

The board of directors of the company for the reconstruction of the BCD, SOLIDERE, had to develop an appropriate and cost-effective plan to reclaim the Normandy Landfill. The plan needed to be approved by the CDR. Different strategies entailed varying cost and environmental impacts. Any course of action SOLIDERE adopted had to consider environmental, economic, socio-political, and technical aspects, as well as anticipate potential long-term effects of coastal degradation. What alternatives were available to SOLIDERE and CDR to reclaim this site and what should they have done?

### TEACHING NOTE

#### Case Objectives

The objective of the case presented in this paper was to expose the students to issues and concerns related to the disposal of solid wastes. Upon completion of this case, students should be able to:

- Identify adverse environmental impacts of the uncontrolled dumping of solid wastes.
- Identify and evaluate landfill remediation and rehabilitation techniques.
- Identify socio-economic factors in solid waste management.
- Define and evaluate alternatives for solid waste disposal.
- Define siting criteria for landfills.
- Develop a monitoring plan for waste disposal facilities.

### Uses of the Case

The case was developed for senior and graduate level students in environmental engineering and science. However, students of lower levels can benefit from some of the simple and fundamental core issues raised in the case. Design questions are intended for students with some technical background in relation to landfill facility components.

The case, based on country-specific data and events, provides students with the opportunity to conduct a preliminary evaluation of a closure plan for a solid waste disposal facility in a developing and high-growth coastal city, given insufficient and inadequate data in some areas. The students would need to complement the information presented to them with searches ranging from literature sources to local firms, or even field surveys to collect their own data. In evaluating the information, students should learn to sort through and critically evaluate the reliability of the data and their sources.

The case presents a very good opportunity for highlighting and discussing the importance of social and political considerations in deciding community issues, particularly in the context of a developing nation. Further discussion may tackle the role of governments in the face of public opposition for certain developmental projects, which may have important economic implications and benefits.

### Implementation of the Case

The Normandy Landfill case was tested in a number of courses on solid waste and natural resources management at the American University of Beirut (AUB), Purdue University (PU), and the Jordanian University of Science and Technology (JUST). The student makeup of the classes in which the case was tested was quite varied. Students ranged from sophomore level to Ph.D. candidates and had diverse backgrounds (civil engineering, environmental science, agriculture, and liberal arts).

The feedback of students was positive regarding the case study approach. Suggestions were made, some of which led to modifications in the case content and method of implementation. The strategies adopted by various teachers in the different courses and institutions involved, were not identical.

Any one of a number of implementation methods may be used. The case documentation can be assigned as outside reading followed by a general class discussion of the important issues raised and some aspects controlling the decision that needs to be reached. Students may then be asked to submit reports in which they propose solutions with proper justifications. After instructor feedback has been provided, student answers can be discussed in class in the context of the final decision that has been planned or implemented. Some socially oriented questions lend themselves to role-playing

where students assume the roles of the various interests in the case, namely the private company (SOLIDERE), the public interest as represented by the government agency (CDR), and the community-based nongovernment organizations and environmental groups. Testing the students in an exam setting on some of the questions may be considered as well. Note that some questions can be eliminated from the case study if the course is not intended to train students in the design of various waste management schemes and landfill components. Examples of solid waste management textbooks that might be used in conjunction with this case include Robinson (1986) and Tchobanoglous et al. (1993).

### DISCUSSION QUESTIONS AND ANSWERS

**1. Describe environmental impacts associated with uncontrolled dumping of solid waste.** Student answers should discuss typical environmental impacts associated with landfilling such as health hazards either by direct contact, or through contact with vermin, rodents, flies, or pathogens; fire and explosion hazards due to landfill gas generation; air pollution from landfill gas emissions; greenhouse effect; water pollution; effects on vegetation; and offensive odors.

**2. How can these impacts be eliminated or minimized?** Landfills are inherently engineered structures. Provisions must be included in the design to minimize negative environmental impacts and ensure efficient operation at the landfill facility. These measures include a liner system, a leachate collection and treatment system, a gas collection and treatment system, and a final cover system. A summary paper on environmental impacts of solid waste landfilling with control measures can be distributed to students in addressing Questions 1 and 2 (El-Fadel et al., 1997).

**3. Devise a long-term monitoring plan for the Normandy site or for landfills in general.** Landfill processes are dynamic in nature and hence there is a need to continuously monitor the behavior of a landfill to assess its impact on the environment and ensure its progress toward stabilization. The components to be monitored at a landfill site include: waste deposited in the landfill, leachate, landfill gas, surface water, and ground water.

The operator should develop and implement a site monitoring plan to ensure environmental protection during all phases of landfill operations and at least 10 yr after site closure and rehabilitation. A typical monitoring program for the elements listed above is shown in Exhibit 11.

**4. Since the Normandy Landfill is located on prime land in the BCD, what are remedial closure alternatives for the site?** Because the landfill is located in downtown Beirut, levels of treatment and associated specifications for final closure should be very stringent. High real estate values in the area can support the great expense of achieving final closure. The following are potential alternatives that students should evaluate.

*Do Nothing Strategy.* This strategy is not applicable in this particular case, given the need for development of the Normandy area as part of the reconstruction of downtown Beirut. Under different circumstances, all treatment alternatives and approaches should be assessed in reference to this benchmark.

**Exhibit 11. Typical monitoring program at a landfill site.**

Element	Monitoring frequency	Type of analysis†
Waste constituents	Monthly	Paper, cardboard, plastics, textiles, rubber, leather, wood, food wastes, glass, metals, etc.
Waste chemical analysis	Quarterly (leaching test)	pH, As, Pb, Cd, Cr, Cu, Ni, Hg, Zn, Phen, Cn, Mn, Fe, Mg, Ca, K, Na, TOC, and Cl
Surface water downstream	Monthly (depending on water body and flow rate)	pH, Temp, EC, DO, NH <sub>4</sub> -N, Cl, COD
Ground water upstream and downstream	Monthly	Water level, pH, Temp, EC, DO, NH <sub>4</sub> -N, Cl
Leachate at collection system discharge points	Quarterly (may be reduced to 6 monthly if there is evidence of stable conditions).	As monthly plus: SO <sub>4</sub> , Alk, TON, TOC, Na, K, Ca, Mg, Fe, Mn, Cd, Cr, Cl, Ni, Pb, Zn
	Weekly discharge volume	pH, Temp, EC
	Monthly (reduce to quarterly or annually if stable conditions prevail)	As weekly plus: NH <sub>4</sub> -N, Cl, BOD, COD
Leachate at monitoring points within landfill	Quarterly	As monthly plus: DO, Alk, TON, TOC, NA, K, Ca, Mg
	Six-monthly (may be reduced to annually if there is evidence of stable conditions)	As quarterly plus: Fe, Mn, Cd, Cr, Cu, Ni, Pb, Zn
	Monthly leachate level	pH, Temp, EC
Landfill gas	Quarterly (may be reduced to annually if there is evidence of stable conditions).	As monthly plus: Cl, NH <sub>4</sub> -N, SO <sub>4</sub> , Alk, COD, BOD, TON, TOC, Na, K, Ca, Mg
	Annually	As quarterly plus: Fe, Mn, Cd, Cr, Cu, Ni, Pb, Zn
	Generally weekly to six-monthly depending on site specific factors	CH <sub>4</sub> , CO <sub>2</sub> , O <sub>2</sub> , AP, OMD, Temp. VOCs
Other parameters	Annually	Void utilization, settlement

† COD, chemical oxygen demand; TON, total organic nitrogen; TOC, total organic carbon; Temp, temperature; EC, electrical conductivity; BOD, biochemical oxygen demand; DO, dissolved oxygen; VOC, volatile organic carbon.

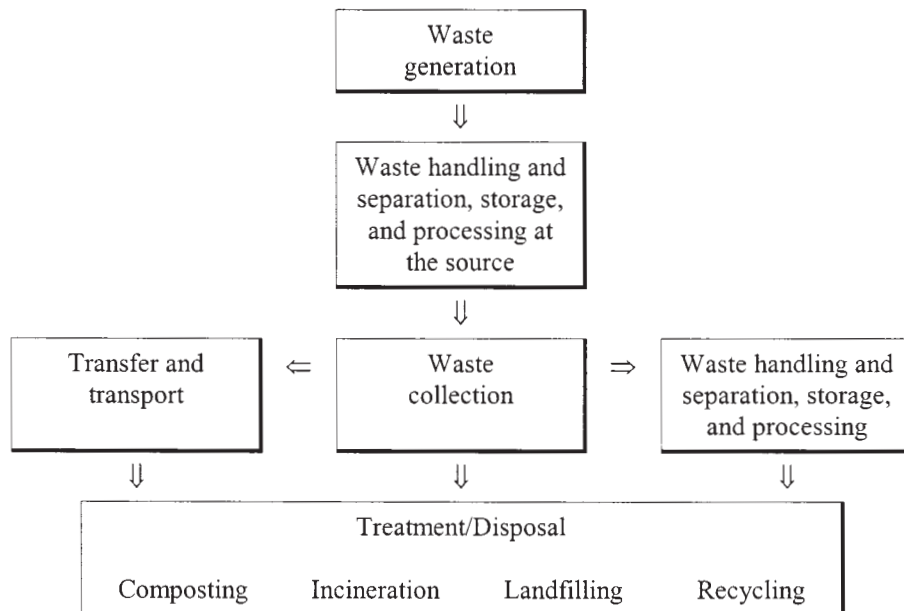
*Isolation/Containment.* Containment and control typically involve surface and subsurface systems. The objective is to minimize contaminant migration and transport by surface water, typically runoff, and through migration in the subsurface. The former is achieved by placing covers over the area of interest and the latter through vertical cutoff walls.

*Excavation and Removal.* Complete excavation and total removal of the waste at the landfill site is an option. Such an approach will resolve the problem; however, a number of issues will need to be addressed. If the material is to be removed, what cost will be incurred? Where will it be disposed of and at what cost? What are the impacts of the removal and disposal activities, both from an environmental perspective and socio-political considerations? What is the availability and cost of replacement backfilling material to develop the area gained

on the sea? Finally, the cost of proper placement and densification of the inert material should be factored in the decision.

*Composting.* Composting is appropriate for solid waste rich in organic material and moisture, which is the case for some of the waste at this site. This alternative would have worked better before waste deposition and mixing with inert construction waste. In the current context, it may not be a feasible or efficient option since most food waste is commingled with inerts or would have partially degraded since the landfill was closed.

*Incineration.* Incineration is most suitable for waste with high thermal energy content and low moisture content. Both of these criteria are not characteristics of the Lebanese waste, thus decreasing the feasibility of this option.



**Exhibit 12. Functional elements of an ISWM plan (Tchobanoglous et al., 1993).**

*Combinations of Two or More of the Above.* This alternative forms the basis of integrated solid waste management (ISWM), particularly prior to waste deposition. Exhibit 12 is a simplified diagram showing the interrelationships between the functional elements of an ISWM system. In the context of the Normandy Landfill, many of these elements can be readily eliminated. The options of containment and excavation appear most feasible.

**5. Identify potential limitations associated with developing former landfill sites.** The student should cite and discuss total and differential settlements; gas and leachate generation and transport; gas and leachate recovery, control and treatment systems; foundations of structures built on landfills. Examples of references that might be used in conjunction with developing answers to this question include Sowers (1968), Blacklock (1987), Isaacson (1991), and Bonaparte (1995).

**6. Since the Normandy Landfill was closed, what would be proper siting criteria to locate a new landfill?** Siting new landfills is one of the most difficult tasks in implementing a solid waste management program. Factors that must be considered in evaluating potential new landfill sites include (Tchobanoglous et al., 1993):

- Haul distance (long-distance hauling is becoming a routine)
- Location restrictions (airports, flood plains, wetlands, fault areas or seismic impact zone, unstable areas)
- Available land area (sufficient area with buffer zone with at least 5 yr of operation)
- Site access
- Soil conditions and topography
- Climatologic conditions
- Surface water hydrology
- Geologic and hydrogeologic conditions
- Local environmental conditions
- Ultimate use of completed landfill

**7. Discuss the socio-economic aspects associated with the solid waste management in general and the reclamation of the Normandy site in particular.** Students could identify various contributors to the total cost of managing the solid waste stream generated by any given community in particular in reference to treatment and disposal costs. In the case of the Normandy Landfill, the added elements associated with the economic incentive of developing all or part of the reclaimed areas need to be addressed. Further, the contrasting

interests of the various players in the case can be discussed, namely the private real estate holding company (SOLID-ERE), the government agency (CDR), and the nongovernmental and environmental organizations. At the time SOLID-ERE was formed, the country faced a number of serious and daunting challenges. The company was established with the stated aim of reconstructing and rehabilitating the downtown area, which was ravaged in the war years. It inherited a waste dump, located along the shoreline of the downtown area, which at the time was the major destination for the solid waste generated in the whole of Beirut. The landfill at the Normandy Bay posed two problems: the first related to the fact that if it were to be closed, alternative disposal or management sites were needed, and the second had to do with the need to reclaim and rehabilitate the landfill area to integrate it into the downtown reconstruction project.

## ACKNOWLEDGMENTS

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# Skirmish at Battle Lake: A Decision Case on Potato Farm Development near Lakeshore Communities

Ami N. Erickson\*

## ABSTRACT

As neighboring communities of agricultural land become more populated, farming practices fall under greater scrutiny. Residents exposed to the dust storms and chemical drift created by certain farming practices are unlikely to welcome agricultural development on new or retired farmland. This case describes the dilemma experienced by a potato (*Solanum tuberosum* L.) grower when attempting to lease retired farmland for a new field near two lakeshore communities. In the spring of 1997, the Peter T. Gifford (PTG) Corporation, one of the nation's largest potato growers, decided to install two center-pivot irrigation systems on 89.5 ha of land leased between West Battle Lake and Clitherall Lake. While PTG filed for a Minnesota Department of Natural Resources (DNR) Water Appropriation Permit, the lakeshore residents submitted petitions to perform an Environmental Assessment Worksheet (EAW). What normally would have been a routine farm expansion became a complicated and public controversy. Issues were diverse, including concerns about the potential effect of high input farming on nitrate leaching, pesticide use, and soil erosion, all of which could contribute to agricultural incompatibility with residential and recreational areas. Richard Griggs, head PTG grower, was responsible for making key decisions about farm development including the proposed development near West Battle Lake. Students will be exposed to factors influencing Griggs' decision making, including aspects of farm development and the concerns of the recreational and residential communities.

AS RESIDENTIAL COMMUNITIES EXPAND, encroaching ever closer to agricultural lands, farming practices are increasingly scrutinized. Residential neighbors often challenge the widespread use of pesticides, fertilizers, and farming equipment inherent in high input farming practices. Farmers usually have the choice of ignoring their neighbors' complaints and continuing their farming practices without change. However, when farms expand, the conflict among residential, recreational, environmental, and agricultural communities can result in the involvement of governmental agencies such as the DNR. The farmers, then, must demonstrate that their farming practices are compatible with the surrounding environment, including lakes, parks, and residential areas. Farms that use precisely defined farming practices can generally demonstrate that their practices do not threaten the surrounding environment. The head of PTG Farming Operations, Richard Griggs would be responsible for defining PTG's farming practices, corresponding with the concerned resi-

dential communities, and advising PTG head decision makers about the direction to take with proposed farm sites.

## THE CASE

### Prologue

The West Battle Lake and Clitherall Lake township residents of Otter Tail County were enjoying a brisk fall, when Jack Avery, a resident of Battle Lake for nearly 30 yr, noticed increased activity and two new pivot irrigation structures in a strip of dormant agricultural land located between the two lakes. He was not pleased. Avery had seen new farm development before and recognized that with irrigation systems come high-input farms with spray planes, tanks of chemicals, and wild dust storms. In fact, in the previous year Otter Tail County had granted permits for more than 60 new irrigation units, and Avery was beginning to wonder if anyone was regulating the increase in agricultural land use. Avery and the other lakeshore residents were keenly aware of nitrates in well water and concerned that increased nitrate levels were linked to farming practices that use a wide variety of fertilizers. Avery also felt that the issuing of Water Appropriation Permits, which allowed farmers to build irrigation structures, was a *rubber-stamp* operation with little regulation. However, he knew of a way to focus more attention to this problem and possibly prevent the conversion of that piece of dormant farmland to yet another *intensively chemical* treated field. But first he needed to determine who was responsible for the new irrigation structures at Battle Lake.

### The Farmer

The Peter T. Gifford (PTG) Corporation was one of the largest french fry potato growers in the country. While farm administration was based in North Dakota, PTG had approximately 20 200 ha of potato farms in nine states from Minnesota to Idaho, and they continued to expand. The PTG Corporation attributed its steady growth to farming efficiently and competitively, while strictly following the goals of raising potato at a low cost and utilizing best management practices (BMPs) recommended for each state. They recognized that utilizing BMPs and demonstrating a philosophy of environmental concern were in their best interest. They also attributed much of the company's growth to communication with neighbors, customers, and even competitors.

Although increasing their potato farming hectarge was not a priority, senior growers at the PTG Corporation, including the head of PTG Farming Operations, Richard Griggs, were always watching for new, quality land to lease. Thus, when 89.5 ha of prime potato growing land became available in Min-

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**Abbreviations:** PTG, Peter T. Gifford; ha, hectares; DNR, Department of Natural Resources; EAW, Environmental Assessment Worksheet; BMPs, Best Management Practices; CRP, Conservation Reserve Program; EIS, Environment Impact Statement; SWCD, Soil and Water Conservation District; MPCA, Minnesota Pollution Control Agency.

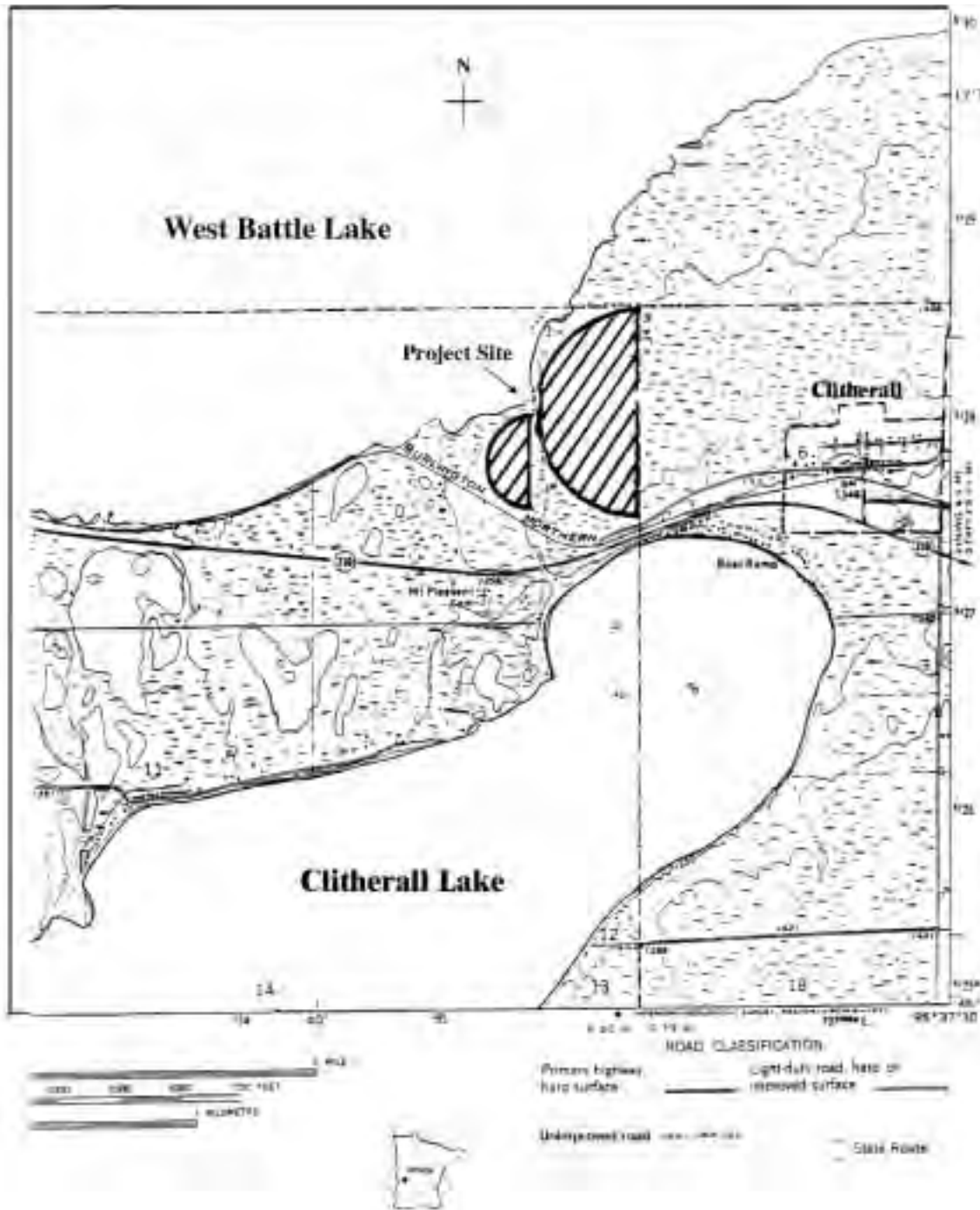


Exhibit 1. Location of the proposed PTG farm site. The map is slightly modified from the 7.5- min, 1:24 000 scale U.S. Geological Survey Quad map (1975).

nesota, Richard Griggs quickly decided to pursue a lease and a water permit.

The proposed farm site had been in grass cover supported by the Conservation Reserve Program (CRP) for 10 yr. The soil was sandy loam,<sup>1</sup> perfect for potato farming, but classified as highly erodible due to its low capacity for holding

<sup>1</sup> 44% Arvilla (Calcic Hapludolls)–Sandberg (Calcic Hapludolls) sandy loam complex, 41% Arvilla sandy loam, and 15% Almora loam (Alfic Argiudolls).

water. Before its enrollment in the CRP, the site had been used for dryland crop production with no irrigation structure or well.

The land was situated between two lakes (Exhibit 1), which in the last 8 yr had become a popular location for vacation and residential lakeshore homes. One hundred fifty meters from the northern border of the farm site was the shore of West Battle Lake, with two residential dwellings located across the road that bordered the site. Ninety meters from the southern border of the farm site was the shore of Clitherall Lake. Between the site and Clitherall Lake was a township gravel road, an

abandoned railroad, Highway 210, and a border of mature deciduous trees. East and west of the site were a number of different property types including dryland agricultural land, land planted to shrubs and trees, and uncultivated agricultural land. Bisecting the site was a gravel surfaced township road that provided access to lakeshore residence from Highway 210.

Before they could begin farming the land, PTG had to obtain a Water Appropriation Permit from the Minnesota Department of Natural Resources (DNR). Richard Griggs did not expect to have any difficulty acquiring a permit. The PTG Corporation had never been refused a permit from the Minnesota DNR in the past. Before requesting the Water Appropriation Permit, PTG was required to drill two wells for water testing. In October 1996, while they waited for acceptance of their permit request, they began construction of center pivot irrigation structures needed to irrigate two half-circle pivots of 49.4 and 11.3 ha for the production of edible bean (*Phaseolus* sp.), potato, and corn (*Zea mays* L.). The center pivot irrigation structures were in place by the end of November, and the permit was expected no later than the following spring.

### Growing Contentions

Jack Avery and two other lakeshore residents had drawn up petition requests for an EAW to be completed before water permits were granted to the PTG Corporation. The three petitions, submitted in February 1997 to the DNR, represented an historical first in the state of Minnesota: on no occasion had three separate petitions been submitted for the same project (Anonymous, 1997a; *Clitherall Lake Reporter*, June 1997). Avery knew that the EAW would identify and describe possible impacts of the center-pivot irrigation systems and the chemical farming practices on the environment. The DNR would consider the type, extent, and reversibility of environmental effects, the extent to which the environmental effects are subject to mitigation by ongoing public regulatory authority, and the extent to which environmental effects can be anticipated and controlled as a result of other available environmental studies undertaken by public agencies or the project proposer (Environmental Quality Board, 1995). After considering the gathered information and submitted comments, the DNR would determine whether the project had potential for significant environmental effects. If such effects were identified, the DNR would then require an Environment Impact Statement (EIS) to be performed. Completion of an EAW and an EIS, if needed, was time consuming, and Avery believed that the farm development could be prevented or delayed indefinitely.

Jack Avery and the other two petitioners were not the only ones concerned about the potential for increased nitrate levels in their water supplies due to intensive farming. The Battle Lake Lakeshore Association and the Clitherall Lake Association had been concerned about their fisheries for the past few years and had been testing the lake water quality. The residents also were aware of a 1993 to 1995 U.S. Geographical Survey study that demonstrated a human-influenced increase of N levels and pesticides in shallow ground water in the Otter Tail area. The study stated that the presence of herbicides and raised nitrate concentrations in the shallow ground water was exacerbated by lower rainfall, warm temperatures, coarse and well sorted soils, deep ground water, small areas

of noncrop land, and irrigation, all of which were characteristics of Otter Tail county (Cowdery, 1995). Although the lake and well water quality in the residents' immediate locality remained high, the increased farming activity in their area and the raised levels of nitrates and pesticides in neighboring areas raised questions such as:

1. What effect does irrigation have on ground water levels?
2. Do chemicals, pumped through the irrigation systems, leach into lakes or well water?
3. Will the irrigation systems decrease lake levels?
4. Why do tillage practices create dust storms?
5. Does soil erosion transfer chemicals to the lakes?

### Back at the Farm

The development of the new farm site in Minnesota was going well until one day in April 1997, when Richard Griggs received a letter from the Minnesota DNR. The PTG Corporation would not receive their water permit that spring. Instead, they would be required to provide information that would allow the DNR to complete an EAW. The EAW would assess the environmental impact that PTG's new farm would have on the surrounding environment and community. The PTG Corporation would be required to develop farming plans that demonstrated a compatibility with the surrounding area. Griggs felt fairly confident about their ability to complete this task. However, PTG was increasingly concerned about the public relations conflict that was developing.

Upon recognizing the concerns of the Battle Lake residents, Richard Griggs and a group of PTG's decision makers quickly drew up plans for public education and improved public relations. The company was sensitive to the citizens' concerns and wanted the residents to understand how PTG planned on solving and/or reducing the impact of their farm.

"We used to just try to do our own thing and do everything according to the law," said PTG General Farm Manager Jim Venuti. "But with the added public opinion that has come on projects like this, we feel we need to do something to educate the people and work with them. Anytime you get agriculture in a tourist area, you have the potential for clashes" (Schumaker, 1997a).

Their first step in reducing conflicts with the public was to open lines of communication. Their first big opportunity for such communication came when the Battle Lake Association hosted a water quality panel to raise public awareness of the issues.

### The Water Quality Panel

*(Questions and answers are paraphrased and quoted from Schumacher, 1997b; the Daily Journal, Fergus Falls, MN, Monday, 23 June 1997)*

On 21 June 1997, both Richard Griggs, head of PTG farming operations, and Ben Peterson, head PTG agronomist, were part of the water quality panel to answer questions for the Battle Lake Association and the participating residents. Members of the panel also included employees of the Minnesota Department of Agriculture, and the Soil and Water Conservation District (SWCD).

Presiding over the panel was Eric Brudvig, president of the Battle Lake Lakeshore Association and long-time resident of Battle Lake.

"From the perspective of the association, we feel it is important to focus on three things," Brudvig said. "First, we want to keep the lines of communication open. There might be something wrong, but we've got to work with (PTG) and not get into an owners versus farmers battle. Second, there's not enough information about water quality available, and we just want to get the facts before we make a decision. Third, we have to determine who has responsibility on an issue like this. A lot of agencies have passed the buck on this issue" (Schumacher, 1997a; *Fergus Falls Daily Journal*, 14 June 1997).

The meeting took place on a sunny afternoon in June, and although the sky was clear, clouds of contention hung over the meeting room. Eric Brudvig read previously submitted questions and occasionally fielded questions from the audience. Many people expressed concerns regarding the proposed operation, including concerns about lake contamination, water table depletion, and pesticide drift from spray-planes.

Brudvig, reading from a submitted question, addressed the first question to the East Otter SWCD supervisor, Ken Phillips. "What have groundwater studies revealed about the level of nitrates in the area, and what are the causes of nitrates if they are present?"

Unfortunately, a definitive answer was not available. Phillips explained that it was impossible to trace groundwater contamination to individual sources. "Movement from the surface to the groundwater tables is very slow, and it doesn't go straight down." In many cases drinking water is 30 yr old. Nitrates may occur naturally in ground water, resulting from decayed vegetation, atmospheric N contained in rainfall, and minerals found in certain soils. The major sources, however, are animal and human wastes and N fertilizers. Improper management of nitrate wastes, failing septic systems, improper well construction, and poor management of N fertilizer can all contribute to raised nitrate levels in ground water (Anonymous, 1997b, *Battle Lake Review*, 30 July 1997).

Brudvig then directed questions toward PTG representatives, focusing on what they would be prepared to do to ease the anxieties of nearby residents. "Would you be willing to test for nitrate seepage at the root level?"

"Yes, we would be willing to do so," said Richard Griggs.

Ben Peterson, head PTG agronomist, also expressed a willingness to work with residents to reduce the negative impact of pesticide spraying. He maintained, however, that aerial spraying was the best way to get the needed pesticides to the crops.

Another question read, "Other than water, what is pumped through the irrigators?"

Peterson briefly answered "Nitrogen fertilizer. Ground rigs are used to apply the insecticides. However, we are working on a new form of pesticide spraying, mounting it directly below the irrigation system. This would eliminate the need for planes once we get it worked out."

One questioner said he had a well located not far from the croplands and wanted to know what would happen if the irrigation wells caused his well to dry up.

"That is termed *water interference*, and it's the responsibility of the person who drilled the new well to rectify the sit-

uation," said Jennifer Holmquist, a DNR hydrologist present in the audience, but not a participant of the panel. "It is worked out through the DNR and doesn't usually go to court."

After the meeting, Brudvig expressed optimism that the PTG Corporation would be willing to work with the residents of the area, regardless of the finding of the Environmental Assessment Worksheet. "It's better to build bridges than walls," he said. "It's also easier to preserve a lake than it is to restore one." (Balcom, 1997).

The PTG Corporation had one more event planned to heighten awareness within the community. A tour of PTG farm sites, located in the Clitherall and Battle Lake area, would be offered in August.

### The Farm Tour

(From *Malmstrom*, 1997; *Battle Lake Review*, 20 Aug. 1997)

The tour of the Clitherall and Battle Lake farm sites consisted of guided bus tours leaving from three towns. Once the citizens arrived at the irrigation sites they were introduced to such topics as irrigation processes, soil moisture monitoring, and the use of technology to precisely monitor and manage ground water. At one field, SWCD demonstrated how their professionals work with area farmers to manage irrigation. They explained how strict irrigation schedules were important due to the low capacity of sandy loam soils for holding water. They also explained how the Minnesota BMPs for N use on irrigated, coarse-textured soils (Exhibit 2) provides guidelines for scheduling irrigation and N application to minimize nutrient contamination of surface and ground water (Schmitt et al., 1993).

At the next demonstration site, the PTG farmers outlined their insecticide, herbicide, and fungicide spraying processes and explained how chemical applications were scheduled. The residents were told about the toxicity of chemicals applied at the farm sites (Exhibits 3 and 4) and were presented with live examples of the insects that such chemicals control. Questions and concerns about chemicals and aerial application were addressed.

Brian Olsen, representing the Minnesota Department of Agriculture, presented the results of a nutrient assessment study that involved Otter Tail County. The report concluded that excess N from irrigated potato was a minor contributor to ground water nitrates in the county. Major contamination usually occurs from manure and N application to corn. During the tour, Olsen complimented PTG for their development of practices, research, and innovation to preserve the environment.

After the farm tour, lakeshore residents waited anxiously to see the results of the EAW. Their concerns about pesticide drift and nitrate leaching had not been completely resolved by the farm tour or water panel. After the farm tour, a letter to the *Battle Lake Review* editor from the Otter Tail County Coalition of Lake Associations president Jim Larrson appeared. "We conceded that corporate agriculture uses 'BMPs' but for the most part, our county's sandy soil allows any nitrogen (as nitrates) to go straight into the ground water once it gets below the root zone of vegetation. Therefore, the BMPs are not good enough. It takes years for nitrates to reach the aquifer. When this pollution is finally detected it is too late because



# Best Management Practices for Nitrogen Use on Irrigated, Coarse-Textured Soils

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These nitrogen BMPs were assembled by the University of Minnesota and the Minnesota Department of Agriculture (MDA) as part of the Nitrogen Fertilizer Management Plan developed by the Nitrogen Fertilizer Task Force coordinated by the MDA.

## Summary

Nitrogen (N) is an essential plant nutrient that contributes greatly to the agricultural economy of Minnesota crop producers. Unfortunately, the nitrate form of nitrogen can leach into surface and groundwaters if nitrogen management is not practiced carefully. The public will not tolerate contamination of water resources by agricultural production systems; laws regulating use of nitrogen fertilizers could be adopted if contamination from agricultural activities is not minimized.

The research-based Best Management Practices (BMPs) outlined in this bulletin are economically and environmentally sound. It is strongly suggested that farmers adopt them voluntarily. By following these recommendations, agriculture can avoid the threat of fertilizer regulations and enjoy a more profitable and better community.

Exhibit 2. University of Minnesota Extension Service Publ. FO-6131-B. Printed with permission of the Univ. of Minnesota Ext. Service. See Schmitt et al. (1993). For the full report, available online, go to <http://www.extension.umn.edu/distribution/cropsystems/DC6131.html>.

### Exhibit 3. Proposed pesticide use and timing of application for the new PTG farm site.†

Pesticide class	Commercial name	Intended crop	Timing of application	Method of application	Runoff potential	Leaching potential	Signal word ‡
Herbicide	Turbo	Potato	Pre-emergence	Ground applied §	Medium	Large-medium	Caution
Herbicide	Diquat	Potato	Desiccant prior to harvest	Ground applied	Small	Small	Warning
Fungicide	Ridomil	Potato	Early July (once)	Aerial	Small	Large	Danger
Fungicide	Bravo 500	Potato	Every 5-6 days from June to August	Ground (pulse or pivot): aerial when required	Large	Small	Warning
Insecticide	Asana XL	Potato	Based on IPM ¶	Ground applied	Large	Small	Warning
Insecticide	Malathion	Potato	Based on IPM	Ground applied	Small	Small	Caution
Insecticide	Cygon	Potato	Based on IPM	Ground applied	Small	Medium	Warning
Insecticide	Monitor 4L	Potato	Based on IPM	Ground applied	Small	Large	Danger-poison
Herbicide	Dual	Corn	Pre-emergence	Ground applied	Medium	Medium	Caution
Herbicide	Clarity	Corn	Post-emergence	Ground applied	Small	Large	Caution
Herbicide	Sonolan	Edible bean	Preplant incorporate	Ground applied	Large	Small	Warning
Herbicide	Basagran	Edible bean	Post-emergence	Ground applied	Medium	Large	Caution
Fungicide	Benlate	Edible bean	10% Bloom	Ground applied	Large	Large	Caution

† Information for the table was obtained from the completed EAW for the PTG farm site.

‡ Based on the most toxic route of entry (acute oral, dermal, or inhalation) determined by studies on small mammals. Signal words are prominently displayed on the pesticide label and are designated as follows: Danger and Danger/Poison—product is highly hazardous; Warning—Product is moderately hazardous; Caution—Product is slightly hazardous to nonhazardous.

§ Pesticides would be applied by ground rig or by pulse applicator except Monitor 4L, which, in an extreme emergency, can be aerially applied.

¶ Decision to apply will be based on integrated pest management (IPM) techniques.

**Exhibit 4. Relative pesticide toxicities or hazards for fish and wildlife.†**

Pesticide	Active ingredient	Fish‡	Bird‡	Bee‡	Small mammal §
Turbo	Metribuzin	ST	MT	PNT	Slightly to nonhazardous
	Metolachlor	MT	PNT	PNT	Slightly to nonhazardous
Diquat	Diquat	ST	MT	PNT	Moderately hazardous
Ridomil	Metaxyl	PNT	PNT	PNT	Highly hazardous
Bravo 500	Chlorothalonil	HT	PNT	PNT	Moderately hazardous
Asana XL	Esfenvalerate	HT	ST	HT	Moderately hazardous
Malathion	Malathion	HT	MT	HT	Slightly to nonhazardous
Cygon	Dimethoate		HT	HT	Moderately hazardous
Monitor 4L	Methamidophos	ST	HT	T	Highly hazardous
Dual	Metolachlor	MT	PNT	PNT	Slightly to nonhazardous
Clarity	Dicamba	ST	PNT	PNT	Slightly to nonhazardous
Sonolan	Ethafuralin			PNT	Moderately hazardous
Basagran	Bentazon	PNT	ST	PNT	Slightly to nonhazardous
Benlate	Benomyl	VHT	MT	PNT	Slightly to nonhazardous

† Information for the table was obtained from the completed EAW for the PTG farm site.

‡ Relative toxicities: PNT—practically nontoxic; ST—slightly toxic; MT—moderately toxic; T—toxic; HT—highly toxic; VHT very highly toxic. Sources: *Farm Chemicals Handbook*, Mesiter Publishing Co., 1996; *Pesticide Profiles*, Lewis Publishers, Michael Kamrin, ed. for esfenvalerate, chlorothalonil, and benomyl. No information available for ethafuralin from these sources.

§ Relative hazards based on product label signal words and are based on the most toxic route of entry (acute oral, dermal, or inhalation) in small mammal studies (rats and rabbits).

years worth of additional pollution is on the way” (Malmstrom, 1997; *Battle Lake Review*, 20 Aug. 1997).

Eric Brudvig also wrote an editorial to the *Battle Lake Review* stating, “Countrywide zoning and state regulations of certain farming practices around lakes and streams may be needed. The EAW may show that (PTG’s) plan for the two irrigators needs adjustment. But while the government engine finds its bearings, we can find some solutions by working with the predominant agribusiness in our area.... Are there still some significant issues that need to be mitigated? Absolutely, and I believe we’re all better equipped to deal with them, following the Farm Tour” (Malmstrom, 1997; *Battle Lake Review*, 20 Aug. 1997).

**The Environmental Assessment Worksheet**

(Area descriptions, defined conflicts, and proposed solutions are paraphrased from Balcom, 1997; the completed Environmental Assessment Worksheet)

Many residents hoped that the EAW would ease their worries. Yet, others still hoped that a follow-up EIS would be required. On 18 Aug. 1997, 2 wk after the farm tour, the EAW was completed and delivered to all interested parties. The issues were clearly defined.

The PTG Corporation planned to rotate potato production with field corn and edible bean production. Irrigation would be provided by two wells, 29.7 and 67.2 m deep, with two half-circle pivots for 49.4 and 11.3 ha, respectively. The project area referred to the 89.5 ha leased by PTG, while the project site referred to the 60.7 ha that would be irrigated for crop production within the project area.

**Potential Conflicts Described in the EAW Included:**

1. Potential incompatibility between lakeshore residential use on land adjacent to the farm site and intensive agricultural use on the project site. Agricultural activity is a permitted use in shoreland zones and is compatible with the lake shoreland environment according to the county shore-

land ordinance. Nearby residents may view the project as incompatible with a recreation-based lakeshore residential community.

2. Potential adverse, indirect effect on fisheries and aquatic organisms due to potential runoff or inadvertent off-site drift of agricultural chemicals applied to the project site. Effects of these chemicals on aquatic organisms and fish could include reduction of food sources to fish due to direct mortality of forage species such as aquatic invertebrates and in some cases direct mortality of fish. The area with the greatest potential to be adversely affected is the private marina on West Battle Lake directly north of the project area, because of the potential concentration of contaminated, spring snowmelt runoff, or wind-borne soil.
3. Potential adverse effect on wildlife due to the loss of habitat associated with the conversion of 60.7 ha of grass cover as well as some woodland to intensively managed agriculture. Populations of songbirds and small mammals may be lost by the reduction in habitat and use of agricultural chemicals toxic to wildlife. Drift or other offsite movement of agricultural chemicals to habitat land surrounding the project site could create secondary effects on wildlife.

**Solutions Proposed by PTG Corp. to Minimize the Impact of Their Farm Included:**

1. Establish 28.7 ha on the periphery of the project site in grass or woodland to provide a buffer area around the irrigated areas as well as wildlife habitat.
2. Program the end sprinkler guns on the pivots to shut down near the road, reducing drift of irrigation water into the road right-of-way.
3. Irrigate with low-pressure sprinklers and drop tubes that will reduce evaporation losses, minimize drip, and provide accurate placement of irrigation water and agricultural chemicals through the irrigation system.
4. Use advanced irrigation schedules to maintain the proper soil moisture to meet crop water demands and minimize leaching.
5. Use soil conservation plans developed by the Natural Resources Conservation Service (NRCS) to minimize surface water runoff and wind erosion. The operator would be required to retain a minimum of 30% corn residue after planting of edible bean by using a mulch tillage system; 10% edible bean and rye (*Secale cereale* L.) residue after the planting of potato; and 30% potato-rye residue after the planting of corn. A rye cover crop would be established following the harvest of the bean and potato crops. Corn would be seeded into the standing rye to control spring wind erosion. Following the corn harvest, stalks would be chopped and incorporated with a chisel plow leaving >50% ground cover residue. Potato would be harvested by mid-September, which would allow adequate time to establish the rye cover crop to protect the soil during the fall, winter, and following spring.
6. Maintain a grass buffer around the irrigated fields to trap sediment.
7. Comply with pesticide label restrictions.
8. Restrict aerial chemical applications to no-wind conditions to prevent drift. Eventually replace more of the aerial applications with a pulse application system for pesticides.

9. Install an observation well to monitor ground water quality and to detect nitrate or pesticide leaching, as a condition of the water appropriation permit.
10. Follow Minnesota's BMPs for N developed for crop production on coarse-textured soils (Exhibit 2).

### Responses and Decisions

Once the EAW was released, it was open for comments for 30 d. A public open house was hosted on 6 Sept. 1997 by the DNR. On 26 September, after the open comment period, the DNR received a letter from the Minnesota Pollution Control Agency (MPCA) discussing the completed EAW and proposed use of the site. They felt that many questions remained, particularly about the impacts of the herbicides Ridomil (metaxyl) and Bravo 500 (chlorothalonil) and on prevention of water pollution at the source (i.e., at the farm site).

The MPCA felt that human health issues had not been addressed adequately in the EAW, and that the aerial application of Bravo 500 posed potential health risks, warranting further analysis and discussion. The MPCA also felt that the water quality of the lakes would be adversely affected by increased algal growth resulting from P fertilizers. In addition, the MPCA did not feel that the EAW provided enough information on the potential for ground water contamination by agricultural chemicals. In summary, the MPCA requested an environmental review that would address the prevention of water pollution at the source. They argued that this was particularly important because of the proximity of the proposed sites to the lakes with high quality water and the high erodibility of sandy-loam soil at the site. They strongly recommended that the DNR give serious consideration to the preparation of an EIS.

The MPCA's letter was addressed to the Minnesota DNR, but copies of the letter were also sent to PTG. After receiving the MPCA's response to the EAW, Richard Griggs believed that an EIS would most certainly be required by the DNR. This would be costly as well as require a significant amount of time to complete, which would delay further production at the site. In the end there would be no guarantee that farming would be allowed, even after completion of an EIS. The PTG Corporation had already invested valuable time and finances to complete the EAW and to educate the community. It was apparent that the lakeshore community was not supportive of the project, even though PTG had demonstrated willingness to work with residents. Griggs pondered the possibility of abandoning the project.

However, the site was a valuable one, and projected annual income after the site became active was >20 million dollars. They also had already drilled the wells. If they let the site go, within a year or two, chances were someone else would be farming it. Richard Griggs' responsibility, now, would be to thoroughly evaluate the situation and present a proposed decision to the PTG president and board of head growers. Should Griggs propose that PTG continue investing in the farm site, hoping the EIS would be supportive of farm development, or should Griggs suggest that the farmsite be abandoned for less contentious fields? If PTG persists with development of the new farm site, are there cost-effective ways to make the site more acceptable to the community and less of a threat to the environment? If they abandon the new field, will residential

neighbors of their other fields challenge PTG's presence, and will it be more difficult to develop alternative sites? The decision is an important one with significant impacts on PTG and the lakeshore community. It also will set a precedent for agriculture-citizen interrelationships that could have far-reaching consequences.

### TEACHING NOTE

#### Case Objectives

Upon completing this case, students should have a better understanding of:

1. The potential environmental impacts by high input potato farming.
2. The concerns and questions that the neighboring communities have about farming practices.
3. The farming strategies available and common to farming operations to reduce or minimize environmental impact.
4. The PTG Corporation's response to public concerns and objections of farming practices.
5. The Water Appropriation Permit and Environmental Assessment processes.

#### Use of the Case

This case was developed for the Program for Decision Cases, College of Agricultural, Food, and Environmental Sciences, University of Minnesota to explore issues in agricultural pollution prevention and resource conservation. While this case represents an actual situation, all names have been changed. The case can be used in a variety of courses including introductory agriculture, sustainable agriculture, cropping systems, and vegetable production classes. It can provide an introduction to the environmental and public policy issues that influence decisions made by large farms, as well as the steps taken to obtain new farm permits. This case can introduce students to pest management and fertilization strategies and the environmental impact of large vegetable farming. From this case, students can gain an understanding of the conflicts among recreational, residential, and agricultural land use and the need for improved communication among these sectors. Students should recognize the need for further research into the impact of fertilizer and pesticide use on environmental and human health.

#### Materials Needed

1. Copies of the written portion of the case and exhibits.
2. Blackboard, flip chart, or overhead projector, or other means of displaying comments.
3. (Optional) Study questions; additional research topics; outside readings on farming practices, pest management, and impacts of agricultural chemicals on the environment also may be assigned to help students prepare for the in-class discussion of the case.

### DISCUSSION QUESTIONS

1. **Why did the decision to develop a high-input potato farm at the particular site create a controversy?** This question can be used to help define the issues involved with

developing a new farm site with emphasis on public perception of high-input farming practices. The case defines a variety of potential conflicts between high-input farm practices and the environment or communities. It may be useful to debate about which issues most influence the farmer's decisions and the public's concerns.

2. **Would the farm site have created such a controversy if it had not been located near two lakes?** This question provides an opportunity to discuss the importance of location to farm development. Students may debate conflicts inherent in the farming practices utilized by large farms, as well as the environmental issues of water contamination.
3. **What was PTG's public relations strategy, and was it effective?** This question emphasizes the importance of communication with the public and the concerns that the nonagricultural community has toward farming practices. Students can discuss whether the effort that PTG made toward educating the community helped ease concerns and reduce conflicts. Students also may discuss ways to increase public understanding of agricultural issues and to improve communication between agricultural and nonagricultural sectors.
4. **What options are available to PTG to reduce the farm's impact on the environment and the neighboring community?** Peter T. Gifford Corporation's production plans are well defined in the EAW, and the case suggests actions that will reduce their impact. Students can discuss the effectiveness of these plans, as well as the effects on the environment that PTG could not prevent with their proposed plan.

This question also provides an opportunity for the students to incorporate their knowledge from other class materials and courses to discuss potential solutions to the environmental impact of agriculture that growers at PTG had not discussed or imagined. It may be useful to discuss biocontrol options for controlling pest problems, alternatives to chemical fertilization, or even the potential of certified organic potato production, as well as the limitations of these alternatives.

5. **What are Richard Griggs' options with respect to proceeding with PTG's farm development project at Battle Lake?** After considering all the possible options available to PTG and the impact of each, the decision needs to be made. One of the central benefits of a decision case is the opportunity for the students to make a decision. Students can put the decision to a class vote or decide individually which path PTG should take. This is their chance to be the decision maker, and they should be encouraged to thoroughly explore and present the justification for their decision.

## 6. What decision did Richard Griggs and PTG make?

The instructor is not encouraged to share the actual conclusion to this case, but if curiosity requires, PTG responded to the dilemma as follows.

The PTG Corporation decided not to follow through with the farm development on the site located between Battle Lake and Clitherall Lake. According to Richard Griggs, the decision to forgo farm development at that site was made to "do what was best for our long-term relationship with the community" (Anonymous, 1997c; *The Forum*, 1 Nov. 1997).

If the final result of the decision case is shared with the students, it is important to make clear that the actual decision is not necessarily the "correct" decision. This conclusion, however, demonstrates that public opinion can affect large-farm decision making.

## ACKNOWLEDGMENTS

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# Nothing Risked, Nothing Gained: A Case Study about a Dairy Farm Expansion Gone Awry<sup>1</sup>

C. William Heald\* and Lisa A. Holden

## ABSTRACT

Dairy (*Bos taurus*) farming is becoming more complex while the margin for error is diminishing. Few owner-operators who have managed a mid-sized dairy are prepared for the management challenges of expansion and the subsequent financial vulnerability. Despite their best efforts at careful planning, Tom and Jackie Fabian's dairy farm expansion was fraught with unexpected dilemmas and changing conditions that threatened the very survival of the farm and years of accumulated equity. After expansion, feed prices rose, milk prices dropped, feed quality suffered, production per cow declined, and many problems went unaddressed. Fabian created a professional advisory team that offered solutions to tactical problems and addressed the impending financial crisis. The Fabians needed to develop a strategic plan that would assure the farm's success, protect their retirement equity, and afford Tom and his wife time to pursue family, church, and community activities neglected during the time constraints of expansion. This case demonstrates the many business risks associated with dairy management and affords the opportunity to discuss practical methods to reduce those risks. The case is suitable for use with workshops for dairy advisors and for use with production management courses for graduate and undergraduate students.

**D**AIRY PRODUCERS have faced decreasing profit margins in recent years. One way to lower costs, increase competitiveness, and improve profits is through expanding herd size (Bailey, 1997). Six characteristics of successful managers that are important in dairy expansion are (Cornell Coop. Ext., 1994):

1. They manage people, delegate responsibilities, and communicate effectively.
2. They make investments that can pay for themselves within 5 to 7 yr.
3. They monitor their business carefully.
4. They are organized with a carefully developed mission, objectives, and goals.
5. They instill trust willingly, share information, and are committed to the professional development of people on their management team.
6. They have an engaging personality that favors people wanting to work with them.

Net cash income per cow has been found to be highest in large herds and lowest in medium-sized, high producing herds (Zweigbaum et al., 1989). Also, the greatest increase in net

farm income was reported in the herds growing fastest in number (Jack and Knoblauch, 1994). This supports the common notion that mid-sized herds are at a financial disadvantage. Bailey (1997) concluded that dairy farms must lower their production costs, by expanding 30 to 50% every 5 yr. Stahl et al. (1999) identified several advantages for herds that expanded during a 4-yr period—increased milk per cow, increased milk per worker, and increased cows per worker. More than half the herds used milking parlors by the end of the study, and this probably accounted for much of the improvement in labor efficiency. Financing milking parlors is a major consideration in herd expansion.

Some herds grew internally but most purchased cows and/or pregnant heifers (Stahl et al., 1999). With expansion, many herds purchased more feeds. They also found that with expansion the producer tended to do less of the milking, manure handling, calf rearing, breeding, and estrous detection. These duties were shifted to hired labor, or to a lesser extent, spouses and unpaid labor. Use of job descriptions, incentive pay, vacation, and performance evaluations increased.

But expansions can also be fraught with risks. Areas of difficulty found after expansion included uncertain economic times, limited capital access for emergencies, difficulty finding employees, differing expert opinions, and meeting environmental regulations (Stahl et al., 1999).

Managers of well-run, mid-sized dairies milking approximately 100 cows with little hired labor can test their management skills to the limits when growing rapidly. The skills needed for managing 100 cows—with the owner providing much of the labor,—changed markedly for <300-cow operations where planning, implementing, and monitoring are a full-time job. The shift from a self-employed worker to a planner and manager of expanded resources in 1 yr presents a major change in the chief decision maker's habits and duties. Employees become an essential resource for getting work done, and the manager often has little experience with managing people. Inadequate planning can result in cash flow problems, inadequate financing, or lack of the resources that are needed for successful expansion (Bailey, 1997).

This case describes a dairy family who expanded and encountered unanticipated difficulties. The well-planned state-of-the-art facility was built just before a steep drop in milk prices and a rapid rise in purchased feed costs. The family was caught between having too few milking cows to generate sufficient cash and too few employees to do the work well. There was too much to be done and too little time for management—anticipating, planning, organizing, staffing, directing, and monitoring the farm systems.

## THE CASE

Tom Fabian loved to farm. In the winter of 1997, at the age of 51, he owned 360 acres; a herd of 306 milking cows; a state-

Abbreviations: TMR, total mixed ration; SCC, somatic cell count; BVD, bovine viral diarrhea; bST, bovine somatotropin, AI, artificial insemination.

<sup>1</sup> This journal uses SI units, according to the ASA-CSSA-SSSA style. Due to the circumstances of this case study, however, English units are used.

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of-the-art, six-row, drive-through barn; and a double 14 parallel parlor—all fashioned to his personal specifications. During the planning phase, Tom saw his next milestone as one of two possibilities: doubling the herd size with an investing partner or selling his assets for early retirement with his wife, Jackie. After a series of unexpected production-lowering problems (feed and water quality, cow health, and decreased reproduction efficiency) postexpansion, Tom and Jackie found that, despite their best efforts at planning, the equity that they had spent decades building was at risk. They were 3 mo behind in loan payments, and the banker had called an emergency meeting. Tom and Jackie needed to preserve a lifetime of building capital (human, cattle, facilities, and land) and eventually be able to withdraw assets from the dairy operation for retirement. How were they to achieve these goals?

### Getting Started in Farming

Tom grew up in the western part of the state. After serving in the military, he attended the state university and graduated with a B.S. degree in agronomy in 1973. He met and married Jackie, and their only child, Carl, was born in 1973. During college and for the 8 yr after graduation, Tom worked as a research assistant in the field of agronomy.

“After college I had an overwhelming desire to farm but could not conceptualize how to start without equity,” Tom said. “Eventually I advertised in the farm press for a dairy farmer who was retiring and would help a young person get started. I knew crops but needed practical cattle experience and coaching from an established farmer.”

“I found a willing mentor and financial backer in a north-eastern county. My plan was to buy 17 of his cows the first year, buy machinery the second year, and by the seventh year purchase the farm. Several years into the purchase agreement I wanted to reduce labor requirements, improve cow comfort, and increase milk production by making improvements to the old bank barn. The owner and I could not agree on the renovations needed and how they should be expensed so I suggested moving up the purchase date. The owner was not mentally prepared to sell his farm, but after some delay he had the farm appraised. I think he set the price well above the market value of comparable farms in the area just because he was not ready to sell.”

Tom explained that after the disappointing setback he wanted a place of his own. “I searched long and hard. I eventually had to settle for another farm rental halfway across the state. This time the situation appeared much more favorable to my goals. The barn was a 44-stall flat barn milking facility in an old tiestall barn with a 72-cow free stall attached. The house was comfortable and still is our home.”

“After five years at this location the same roadblocks began to appear. I wanted to improve the facility, but the owner did not want the expense. Finally, he wanted to increase the annual rent. In 1993 the rent was raised above what I could cash-flow with the crops and cows.”

### A Farm of His Own

While operating field machinery during the cropping season, Tom reflected on his progress toward reaching his goals. He was successful in many ways, but his dream of owning his own farm was still just a dream. He had started from scratch,

had risked much, and worked harder than most for his accomplishments. He was in his late 40s, had a supportive wife and a nice home, had put his son through college, owned cows and machinery, and was building equity.

However, he was not satisfied with the profitability of his business. Even though he owned cows and machinery, he did not feel that he could achieve security until he owned his own land and buildings. If he could purchase the farm where he was currently renting, he could make renovations, increase milk production, and reduce some of the drudgery of operating an old crowded combination tiestall and freestall facility. If he could increase production, he could build equity faster for his retirement; he and his wife could slow down and enjoy life as other professionals were doing in their fifth decade of life.

As Tom thought about the financial figures from the last 6 yr and the last report from the farm management services, he was troubled (see Exhibits 1 and 2). On the positive side, milk income and gross sales were climbing, more cows and better feed added to the income side of the ledger, and additional employees made business life less demanding. However, after all the long hours of work, the family income was inadequate and year-end balances were marginal. Tom was confident that an adequate cow facility and control over the land would allow him to meet his full potential as a maturing dairy producer.

“Again, I started prospecting for a new location with an eye on ownership,” said Tom. “Eventually, I found 360 acres of unimproved land nearby that appeared to be good land according to the soil maps. It was over-priced but had been on the market for two years. Little of it was in crops and it was land-locked. Another year passed before I negotiated a price, acquired access to a county road, and put together finances that were satisfactory to Jackie and me. Twenty years after college graduation we were land owners.”

### Considerations before Expansion

As Tom planned for his new facilities, he had several objectives on his mind:

- Lifestyle and quality of life were becoming an issue for Tom and Jackie in 1993, as Tom was just a few years short of his 50th birthday. Before farming, Tom had enjoyed sports (particularly baseball), hunting, fishing, wilderness exploration, touring historic sites, and especially his church, which was important for Tom’s sense of well being. “The press of farming and the need to expand had given me little time for nonfarm activities,” said Tom. “Most days had become hard, 15-hour work days with little or no time off during the year. I would like to enjoy some leisure time and hand over the daily operations of the farm someday.”
- Tom felt that building equity for life after farming was also important. “As we have gone along we have put a little aside in IRAs and mutual funds for life after farming,” he said.
- Tom was also thinking about his son, who was interested in farming. “My son, Carl, followed in my footsteps, graduating from the state university with a degree in agronomy and serving in the military. Today, he is newly married and gaining farm experience working with a farmer in the neighboring county. It is probably best that sons work for someone else before they consider working in partnerships with their fathers. Because he is newly married, and with the stress we are under right now, I think it best that he work

Exhibits 1 and 2. Tom Fabian's decision to expand his dairy business was based in part on the discouraging financial performance found in Income and Expense and the Comparative Balance statements for Fabian Farms.

Exhibit 1

	1988	1989	1990	1991	1992	1993	Avg.
Income							
Milk income	\$200 032	\$215 285	\$257 232	\$247 111	\$296 008	\$268 333	\$247 334
Gross farm income	\$214 100	\$231 913	\$302 367	\$283 156	\$369 510	\$322 899	\$287 324
Expenses							
Hired labor	\$ 27 306	\$ 28 318	\$ 41 804	\$ 39 545	\$ 50 319	\$ 60 187	\$ 41 247
Purchased feed	\$ 35 085	\$ 45 440	\$ 68 657	\$ 62 370	\$ 77 341	\$ 58 111	\$ 57 834
Total operating expenses	\$188 991	\$219 603	\$233 560	\$249 152	\$337 681	\$315 508	\$257 416
Net farm income	\$ 25 109	\$ 12 310	\$ 68 807	\$ 34 004	\$ 31 829	\$ 7 391	\$ 29 908
Disposable income	\$ 30 109	\$ 22 310	\$ 81 307	\$ 42 683	\$ 37 841	\$ 21 937	\$ 39 365
Ending cash balance†	-\$17 041	\$ 1 912	\$ 15 289	\$ 3 792	\$ 4 582	\$ 24 448	\$ 5 497
Total assets			\$332 281	\$387 250	\$412 768	\$407 093	\$384 848

† After a very modest family living draw (<\$20K), taxes, machinery expense, and loan payments.

Exhibit 2

Confidential

1992-1993 Comparative Balance Statement For The Fabian Farm, Inc.

Prepared by the SW State Farm Bureau Farm Management Service  
233 Southwest Main St., West Cambia, SW

We have compiled the accompanying comparative balance sheets as of 31 Dec. 1992 and 1993 and the related statements of income and cash flows for the 12 months then ended, in accordance with standards established by the American Institute of Certified Public Accountants. The financial statements have been prepared on the accounting basis used for Federal Income Tax Purposes, which is a comprehensive basis of accounting other than generally accepted accounting principles.

Some pertinent facts reported by these financial statements:

- Net Cash Income for the Current Year is \$446
- Net Family Withdrawals for Current Year Totaled \$22 567
- Tax Basis Net Worth Changed in the Current Year by \$19 419
- Net Worth as a Percent of Total Assets at End of Year 48.70%
- Rate of Return on Investment for Current Year is 1.06%

A complication is limited to presenting in the form of financial statements information that is the representation of management (owners). We have not audited or reviewed the accompanying financial statements and, accordingly, do not express an opinion or any other form of assurance on them.

30 Mar. 1994

off the farm so that we don't risk spoiling the family closeness. If some day he wants to farm here he is welcome to join us."

- Also an issue was the welfare of his employees and animals. "In addition, I want satisfied, long-term employees. I want my cows to be comfortable, and [my] employees to be proud of their animals and facilities, to enjoy working here, and to have competitive salaries with some leisure time," he said.
- The image his farm presented was important to Tom, too. "I think the image of dairy farmers in the public eye can be improved. I am careful about the appearance of my farm, my lifestyle, and how my employees and I appear when we mix with nonfarm people."

Tom concluded, "My vision is for the farm to evolve to the point that someone could manage it someday without the struggle and sacrifice that I have been experiencing. I am not there yet, and the cashflow will not allow me to get there this year."

The New Facilities Become Reality

Tom began planning for expansion in 1993-1994. First, he developed an expansion concept on paper (see Exhibit 3). Next, a FINPACK analysis, developed by the state extension specialist, showed Tom that instead of 280 cows he needed 360 cows to pay for the new land and facilities (see Exhibit 4). To support that many cows, he needed 350 acres of corn, 250 of alfalfa, and 50 of pasture. Although he owned 360 acres, he still had to rent land.

Tom didn't hesitate. "In anticipation of expanding herd size, I immediately started to build cow numbers by crowding cows and heifers in old facilities and switching milk cows from various shelters to get them milked through the old 44-stall barn. Then I hired an engineering firm to develop the site and building plan, sought bids from builders, and shopped for money." In the fall of 1996, after 3 yr of visiting other facilities, extensive planning, and construction, Tom started milking in the new facility that housed a new double 14 parallel milking parlor, a 300-stall barn, and 4000-ton bunker silos (see Exhibits 5 and 6) in November.

Exhibit 3. Tom and Jackie developed this expansion concept to share with consultants and lenders as they initiated the planning process.

Proposed expansion of Fabian Farm Inc. owned by Tom and Jackie Fabian from 120 to 280 milking cow herd.

February 1994

Present operation consists of:

- 120 milking Holsteins
- 130 replacements
- Bank barn (rented) with 44 tie stalls, used for milking only
- Adjacent free-stall barn with 72 free-stalls
- Three conventional silos used for corn silage, haylage, and high moisture corn
- Manure storage, with 4 mo holding capacity
- 290 crop acres

New operation will consist of:

- 280 milking Holsteins
- 170 replacements
- Free stall barn with 280 stalls
- 6 mo manure storage beneath the free stall barn
- Double 14 parallel milking parlor with adjacent maternity and hospital area
- Feed bunks and commodity shed for 280 head
- 605 crop acres

Summary and discussion

Significant gains will be made in labor efficiency, production, animal health, animal longevity, creature, and operator comfort. Conservative figures place the improvements at \$828.00/cow per year over the present facilities. This saving equates to \$231 840 per year.

Criterion for expansion

1. The Fabians have 12 yr of demonstrated farm management skills
  - Demonstrated skills in dairy production and management
  - Demonstrated skills in crop production
  - Demonstrated skills with machinery operation and maintenance
  - Ability to manage labor
2. The expansion is an opportunity to develop new facilities on a site that has no constraints with existing buildings or access. The new facilities will be an opportunity to apply state-of-the-art handling and housing improvements.
3. The Fabians have the experience and educational background to confront difficult market and management situations and succeed. The Fabians have achieved a leading farm operation over the last 12 yr in spite of 4 adverse weather years.

Why expand now?

1. The dairy market with extended periods of low prices does not favor the small and mid-sized farms. The last 2 yr have seen droves of small farms failing and near collapse. While government supports are drying up, there is no compassion in Harrisburg nor Washington to help sustain the family farm. While there is lip service there is no substance. Survival and prosperity will depend on efficiency and operating improvements as we have cited.
2. Tom and Jackie are 48 and 47. They have one son, who has completed his agronomy degree at State University and is currently finishing his third year in the army. Additionally, Tom has assembled an interested and dedicated staff who want to continue and prosper in the industry.
3. Interest rates are low.

### Problems during the First Winter

After moving to the new facility, production dropped from the usual 65 lb. per cow per day to a low of 43 lb. As everyone went into overload during herd expansion and the completion of the building program, proficiency dropped and some things suffered. This was probably the most stressful time in Tom's life. He was having trouble sleeping and he lost weight. His key employee, Jerry, was also showing signs of the stress. "Production took a hit because of many things, including stress on cows and people," said Tom. "Instead of preventative management, the overworked staff reverted to crisis management."

Problems included the following:

- The number of lame cows increased, due primarily to foot infections acquired from purchased cattle. Some cows became thin, and reproductive efficiency slipped.
- Cows were assembled from various sources, which added to interruptions and problems.

- The new water well had coliform and nitrate contamination.
- Corn silage harvest was late and low in energy.
- Good, high-moisture corn was available, but it had to be hauled from the old facility.
- Mycotoxins were found in the corn silage, and Tom had to feed a commercial product with the TMR (total mixed ration) to help counteract the problem.
- The haylage was good quality, but insufficient quantities existed.
- The expansion budget anticipated milk prices at \$12.80/cwt and feed prices at \$4.20/cwt of milk. Milk price dropped to less than \$12.80/cwt while feed prices rose to \$6.14/cwt.
- Crop acreage was not expanded as rapidly as the milking herd. The cow numbers had to be expanded unexpectedly in an attempt to raise milk income following the steep drop in milk prices and raising feed prices.
- Transition cows did not receive proper care because the staff was overextended.

### Solutions

In response to the crises, Tom was advised to establish a professional advisory team. Tom selected his nutritionist, lender, veterinarian, herdsman, and inseminator as his core team. At first they met weekly and later monthly to address management problems. At times they added specialists to advise on critical problems.

Because of shortfalls in income and missed loan payments, corrective actions were limited to low cost options. The water quality problem was corrected by wellhead improvements. Through aggressive management the somatic cell count (SCC) was held at or below 250 000 and new operating procedures were set to improve failing reproduction. Daily feedings were modified. "Our daily feeding program involved making two fresh batches of TMR each day for each management group," Tom reported. "Each feeding was pushed up to the cows once per day to encourage feed intake. Mix quantities were adjusted for 1 to 5% refusal. Refusals were fed to dry cows and heifers, depending on amount."

The solutions began to work. "By February 1997, we had 307 cows milking. Production was rebounding as fresh cows enter the herd," said Tom. By February, production had climbed to 53 lb. (see Exhibit 7).

### Continuing Challenges

The challenges for late winter included:

- Increasing the per-cow production and assembling more cows that met health and production criteria.
- Continuing to monitor and correct the water quality problem.
- Lowering the stress on the management team and employees.

The challenges for the spring included:

- Achieving crop yield and quality goals.
- Purchasing needed high capacity machinery.
- Hiring a competent field crop equipment operator.

In their haste to complete construction of the facility in late fall, and in an effort to stay within budget, the mechanical ventilation and cow cooling system was delayed. The heat of the 1997 summer caused milk production to fall during periods



Exhibit 4. The Finpack analyses (abbreviated here) demonstrated that the original expansion to 280 cows would not meet the financial planning objectives and that additional cows would be needed.

Center For Farm Financial Management © 1992 University of Minnesota User: WILLIAM HEALD PENN STATE			New Enterprise, SW 19999 Plan: New facilities File: FABIAN Date: 13 Feb. 1994			
Plan description			Base Plan Present 125 Cows 129 Repl	Alt. 1 280 Cows Avg. MP Avg. yield	Alt. 7 280 Cows Low MP Low yield	Alt. 9 360 Cows Avg. MP Avg. Yield
Total crop acres			418	500	605	605
Total labor hours			10 393	22 687	22 955	28 149
Change in farm assets			--	1 043 100	1 043 100	1 043 100
Change in farm liabilities			--	1 146 890	1 146 890	1 146 890
Crop plan	Yield/Acre	Share				
Corn silage, avg. yield	20.0 ton	100 %	55.0	177.0	--	240.0
Feed corn, avg. yield	120.0 bu.	100 %	216.0	118.0	160.0	160.0
Alfalfa hay, establishment	3.0 ton	100 %	40.0	50.0	50.0	50.0
Corn silage, low yield	15.0 ton	100 %	--	--	240.0	--
Alfalfa hay, low yield	4.0 ton	100 %	--	--	155.0	--
Alfalfa hay, avg. yield	5.8 ton	100 %	107.0	155.0	--	155.0
Livestock plan	Unit	Sales/Unit				
Dairy, cow with	Cow	19 800 lb.	--	280	--	360
Dairy replacement heifers	Head	1.00 head	65	85	85	85
Dairy, low milk price	Cow	19 800 lb.	--	--	280	--
Dairy, before changes	Cow	19 800 lb.	125	--	--	--
Dairy, long range—5 yr	Cow	20 500 lb.	--	--	--	--
Corn equivalents, bu.						
Produced			25 920	14 160	19 200	19 200
Fed			12 771	27 335	27 335	34 635
Balance			13 149	-13 175	-8 135	-15 435
Hay equivalents, ton						
Produced			741	1 049	770	1 049
Fed			475	829	829	1 004
Balance			266	221	-58	44
Silage equivalents, ton						
Produced			1 100	3 540	3 600	4 800
Fed			1 065	3 831	3 831	4 780
Balance			35	-291	-231	20
Sensitivity analysis—effect of a decrease in production or price						
Effect of a 10% decrease in all enterprises						
Net farm income			10 103	-26 566	-90 774	69 103
Cash surplus or deficit			2 192	-77 508	-141 717	1 625
Net worth change per year			-919	-35 546	-99 754	43 588

of heat and humidity. Apart from these immediate challenges, Tom still felt that reliance on rented lands and some latent health problems were continuing threats. Tom had assembled cows from a number of herds and feared that purchased cows could carry bovine viral diarrhea (BVD), Johne's, contagious mastitis, or some similar hidden disease. Past experience with landlords and their changing expectations made Tom cautious about relying on landlords in the long run.

### Staffing Goals

Tom needed to develop an organizational chart and standard operating procedures. He saw the farm team as:

- Tom, the owner and overall manager. He oversaw all aspects, procedures, routines, sanitation, finance, resources, quality control, and employees.
- Jerry, the herd manager. He monitored production and was responsible for milking shifts, cow health, nutrition, and structure and equipment maintenance.
- Milkers and feeders (both full-time and part-time).
- A machinery operator also was the heifer caretaker.
- A machinery and crops manager. This was a new position to be filled in the spring.

- Jackie, Tom's wife. She is his confidant, sounding board, mentor, and *reality checker*. She is a behind-the-scenes partner and involved with family and community. She does most of the bookkeeping and works off the farm.
- Two off-farm, experienced mentors who have the same values as Tom. Tom found their wisdom critical for his planning.
- An advisory team composed of the lender, veterinarian, feed sales person, nutritionist, Jerry, and artificial insemination (AI) technician.

Tom wanted his employees to take responsibility and be self-directed, but "they must demonstrate this ability first and earn my trust before I give them freedom to do things independently. I have too much at stake to risk employee mistakes in judgment," said Tom.

### Long-Term Strategies for Success

Tom's strategy for success was summarized as, "The critical success factors that I watch are milk production, cash control, and efficiency ratios. My efficiency measures include milk per cow, worker, acre, facility, dollar borrowed, and dollar of equity. The most important factor is profitability. If the



Packard & Rishel Farm Appraisers  
P.O. Box 873  
Newfarm, SW

Site Improvements: Farm—New dairy farm buildings

Analysis/comments: Appraisal is based on completion of plans with quality workmanship and materials.

Free Stall Dairy Cattle Barn and Milking Center

Size 229 by 105 ft one-story frame. Two hundred eighty-nine free stall. Capacity is 300+ dairy cows.

This “Waffle Slatted” cattle barn has a manure system that uses a concrete open waffle design floor, this adds to animal comfort, lowers production cost, reduces labor cost, improves sanitation, and gives better disease and parasite control. No machinery is used in the collection and storage of manure which passes through the waffle slatted floor into [below grade] two poured concrete manure pits 43.6 by 229 ft by 8 ft deep, gravity flow, with capacity for 6 mo, this storage is under barn storage. There are six pit pump out chambers.

The 289 free stall area has natural ventilation design built into the 12 to 30 ft ceiling with a ridge vent and curtains.

Four / twelve roof pitch, micro-laminated roof beams with 2 by 8 inch purlin. Aluminum 0.032 ultra rib roofing. This design will control the bird population that causes disease from dropping, and eliminates bird roosting. 6 by 6 inch glulam post will be covered with PTD steel siding. Access will be through 8 by 12 ft sliding doors and 16 by 18 ft overhead doors.

The open free stall concept allows dairy cows free access to feeding and watering areas. The adjoining milking center allows the dairy cows to walk into the milking parlor that is attached. The milking parlor has 14 milking stations on each side. Office, pump room, bath, storage room, milking room, custodial room, and loading chute are built into the milking center. Overall area is 50 by 216 ft with waffle slatted floor and under floor manure storage. Appraiser was not furnished a equipment list, therefore no value has been place upon equipment, in this appraisal.

Precast concrete bunker silos 4000 ton capacity, size 120 by 144 ft.

Preliminary building plans that are attached were used to estimate building cost. These building cost were taken from Agricultural Cost Estimator-Marshall & Swift, Means Square Foot Cost 15th Annual Edition, and contractors that are in the agricultural building business.

Exhibit 5. An itemized description provided by the financial appraisers of the new dairy facility is presented in this report.

endeavor is not profitable or will not improve profitability, discontinue it. When there is no light at the end of the tunnel, look for another tunnel. I take pride in my ability and diligence at information collection, seeking council from mentors, questioning a network of university researchers, and critical perusal of the agricultural press.”

#### Conclusion

When Tom sat back and reflected on his 51 yr and the last 16 yr of very hard work to bring a dream of owning a dairy farm into reality, his thoughts were on family, his team of employees, and the cows. Tom shared, “What is the meaning of life? To me it is how we touch people around us. I want to make this a better place for family, employees, and cows.” When asked for his advice to others entering herd expansion Tom replied, “Prepare your family for the realities of the overload during the expansion stage. Leisure and family time will be shortened. To survive, one needs to lower the risk associated with expansion. Each farm is unique. Growth means trying the untried, experiencing the unexperienced, blazing new trails, and learning from others’ mistakes.”

#### TEACHING NOTE

##### Case Objectives

Upon completing the case, learners will:

1. Understand the complexity of dairy herd expansion.
2. Understand the added vulnerability of expansion projects to unavoidable and unexpected problems.
3. Understand the need for contingency planning during and after dairy herd expansion—cash reserves, human resources, replacement animals, and feeds.
4. Appreciate the importance of having experienced outside advisors during the planning and implementation phases.
5. Experience the critical thinking and analytical skills required for management to rapidly address lapses in management (monitoring critical control points) that occur during the transition from manager-laborer to full time manager.

The case provides financial and production information that learners can use to evaluate strategic as well as tactical management actions. This case chronicling Tom Fabian’s dairy expansion demonstrated that unexpected setbacks after major facility expansion can have near catastrophic business consequences. Having state-of-the-art facilities gave little protection against external forces. Most of the production dilemmas addressed in the case were not unique, but rather those encountered in many high-producing herds that experience major changes to daily routines; e.g., changing water or feed source, adding more cows, acquiring new employees, mov-



## Tactical Questions

1. How would you increase milk production? This question helps focus on what needs to be done and what can be done—improvements in feed quality and dry matter intake, better transition cow management, use of bovine somatotropin (bST), changing to three times a day milking, and adding more cows are common answers to this question.

2. What standard operating procedures would you design for transition cows? This question is critical for audiences where you want to develop the concept of a *systems approach* to management. It focuses on a specific area (transition cows) and allows participants to design something that could have a significant impact on the operation in the case as well as their own personal situations. You must have some technical expertise (nutrition, health) in the participant group to use this question. Answers will vary, based on time allowed, from a listing of ideas to a more complex flow diagram with some standard operating procedures.

3. How would you reduce the stress on cows and employees caused by so much change while maintaining cash reserves for the unexpected? This is a great discussion question for a variety of audiences. It highlights both the complexity of the case situation, as well as points out the unexpected issues that can arise. Depending on your audience and their level of experience and attitude, answers can range from sell out to a list of steps to be successful. It helps to have some lenders in the audience for discussion purposes, but producers or college students with a good understanding of financial management can also do well.

4. How would you assure team harmony and labor efficiency? This question helps to show how the team has been effective in making progress in the operation. This question is especially useful when you are trying to develop discussion around the people aspects of problem solving. Participants who are used to dealing with details such as cows, forages, and cash flow step back a bit with this question—they begin to think about how the various personalities and viewpoints affect the day-to-day operation and the bottom line. Answers range from tips, to using consultants, to developing policies and procedures for employees.

5. What should be “fixed” first to make the most difference? What criteria did you use to determine the most important goals/tasks? This is a great choice for a question when time is limited. It quickly gets to the endpoint. The second part about criteria helps participants to think through the people and important aspects of the situation (i.e., Tom’s desire to be independent vs. the bank’s willingness to lend money). Most audiences tackle the items needed to increase income (improve forage quality, dry matter intake, and milk production) first. Then they list the intermediate-term items like training employees, dealing with turnover, beginning to pay down debt, and increasing cow numbers.

6. What are several goals for Tom’s business? When time is limited and participants receive the case that day, this question can be used as a large group activity to get discussion started. All decisions made are based on Tom’s goals and values. He wants to own a profitable dairy. He wants to provide a good place for employees to work. He wants to be respected as an employer in his community. He wants to produce high-quality milk at the lowest possible cost.

## Strategic Questions

1. What options do Tom and Jackie have for the future? This question builds on the Strengths, Weaknesses, Opportunities, and Threats analysis and provides great framework for teaching the importance of strategic planning. Tom and Jackie have many options including increasing herd size, incorporating partners into the business, retiring from daily activities and hiring an overall manager, exiting the industry, and starting a younger producer into the business. Producer audiences tend to be reluctant to discuss partners unless it would be their son returning to the business. Most participants feel that it will be a long time before Tom and Jackie are able to retire (financial reasons). More than half of the groups that we have worked with raise the issue of selling the dairy. Along with that issue comes the discussion of can it be sold for dairy purposes and what will the Fabians leave the industry with in terms of real dollars.

2. How will Tom and Jackie put to use a lifetime of building capital (human, cattle, facilities, and land) and withdraw their assets from the dairy operation for retirement? This is the dilemma question. Most agree that their retirement goals and timeline are too aggressive. Many participants want to encourage the son to return. Most participants want to tackle production and management issues needed to increase cash flow and income before moving to the more strategic and longer-term pieces.

### Analysis by the Authors

Tom Fabian (herd owner) had always rented farms during his 15-yr dairy career. He was frustrated because he felt that the land and facilities he rented were obstructing his production goals. Purchasing land and building new milking facilities were his solutions to previous business limitations. Before construction, Tom and Jackie carefully developed a management strategy and sought the best counsel for designing, planning, and building. Then Tom and Jackie acquired their first land, designed and built ideal cow housing and milking facilities, moved to those facilities, and nearly doubled the herd size to more than 300 milking cows. During the expansion they experienced new employees, delayed construction deadlines, falling milk production, changing management roles, and most recently increased purchased feed costs as well as declining milk prices.

As dairy farmers expand their facilities to meet shrinking profit margins or gain economies of scale, they go through a period of high mental and physical stress and greater financial risk. Tom’s herd had been at 65 lb. and climbing under adverse housing conditions prior to expansion. Tom anticipated an increase in production due to improved facilities. The expansion budget presented to the lender was built on a realistic 65 lb. milk per cow production in the preexpansion herd; however, the herd experienced a postexpansion production of 43 lb. in the new facility.

The case documents postconstruction herd expansion and production management challenges during a very difficult time for the owners, lenders, and employees. Water, feed, cow, employee, and business management are documented so that learners can sense the challenges, diagnose herd production management opportunities, evaluate risk management of the transition period, learn decision making, develop judgment

skills, and realize that major herd expansion can be accomplished with proper knowledge, planning, and training. Consideration of transition management includes tactical as well as strategic issues. At the conclusion of the case, Tom is meeting monthly with his professional advisory teams to deal with more threatening problems.

### *Summary of Tom's Situation*

**Strengths.** New facilities, positive attitude, years of management experience, good management skills, dedicated employees, experience with producing quality forages, good control of somatic cell count, and network of advisors.

**Weaknesses.** Little time off, overcrowding before and during expansion, poor quality corn silage, difficult cash flow situation, questionable but improving water quality, low body condition scores of cows, mycotoxins in feed, substandard transition cow management, foot and leg problems, owner controlling too many decision processes, and crowding in the high production group.

**Opportunities.** Room for more expansion of facilities, 60% of herd is first lactation, use of an effective advisory team, potential for bST use, potential three times a day milking, availability of labor, good infrastructure to support dairy, owner open to changing management style as risk is lowered.

**Threats.** Low milk production, low cash flow, little financial flexibility, poor crop year this season, questionable water quality, rented land, cow health, lack of long-term business plan, not prepared for hot weather, and behind in loan payments.

### General Conclusions by the Authors

During the winter, after the herd was moved to the new facilities, the owner and advisory team identified and implemented a number of tactical changes to improve production and cash flow for the short run. Tactical changes are included in the list below. Strategic issues were temporarily postponed until factors affecting cash flow were improved.

### *Problem/Solution*

**Lack of Cash Flow.** Improve milk sold (add cows, increase production per cow, and use bST on selected cows), consider three times a day milking when cow body condition improves, and delay as many purchases as possible.

**Low Cow Numbers.** Purchase select cows from select dealers using modest bio-security and aggressive vaccination protocol.

**Foot and Leg Problems.** Treat cows with recommended protocol.

**Thin Cows.** Improve dry matter intake and increase energy intake.

**Less than Optimal Reproduction.** Hire AI technician to heat watch 1.5 h/d and improve energy balance.

**Bacteria in Well.** Grout wellhead and hyperchlorinate the water system.

**Mycotoxin in Corn Silage.** Feed additive and forage dilution.

**Crowding in High Production Group.** Move some cows to low production group.

**Low Peak Milks.** Evaluate transition cow management and concentrate on getting cows on feed early.

**Low Feed Quality.** Implement a crop management system to assure timely harvest.

**Summer Heat Stress.** Install fans and sprinklers.

Strategic issues still to be resolved include:

- Reduce overhead costs of milking facilities.
- Find a forage source for additional cows.
- Expand and train the labor force.
- Acquire a junior partner for ownership transfer in the future.
- Accommodate a son who may join the operation.
- Plan retirement income and eventual sale of operation.

Learners should review Tom's personal goals before resolving these issues, and then consider how a business plan would be written to meet these goals.

### The Situation Today

The Fabian's milk production returned to above projections within the year, but the high feed costs and low milk prices caused a protracted cash flow problem. The debt finally had to be restructured. Shortly after restructuring, the economic climate changed to record high milk prices and low feed prices. The addition of more milking cows in 1997 greatly improved the viability of the farm. With time, management restructured the labor force and grew with the changing management challenges. The Fabians have valued the dairy advisory team they formed early in 1997. In the words of Tom, "By using the dairy advisory team my overall financial and herd management style improved. I increased both my herd and my management by four times." Three years later, production exceeded expectations, reaching 26 000 lb. per lactation, or 93 lb. per cow per day with 350 cows. At this high level of production, the margin of error is very small and the advisory team is addressing new management challenges. All accounts are current. Over the next 10 yr, the Fabians anticipate turning more of the daily herd management over to key employees as they continue to build equity. The son is employed outside of agriculture. Tom says, "The fun is back in farming and the future looks bright."

### ACKNOWLEDGMENT

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# The Israeli Palestinian Mountain Aquifer: A Case Study in Ground Water Conflict Resolution

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## ABSTRACT

The dispute between Israelis and Palestinians over shared water resources of the Mountain Aquifer is one potential obstacle in the path of peace in the Middle East. This aquifer is the only source of water for Palestinians in the West Bank and the main provider of freshwater to Israelis. The majority of its natural recharge area lies within the West Bank territories with two of its three basins flowing naturally toward Israel. In 1967, Israel occupied the West Bank and imposed strict control policies over the utilization of the Mountain Aquifer's water. At present, Palestinians and Israelis are moving toward a political resolution of their more than half a century old conflict. In the Declaration of Principles, Israelis and Palestinians created preconditions for the coming negotiations and the Israelis recognized water rights for Palestinians. There is no clear indication of the extent to which water would be under Palestinian control during the interim period, but there is an implicit recognition of the need to reform the existing water allocation system. In the Final Status Negotiations, the Joint Mountain Aquifer Committee, members from the Israeli government and the Palestinian National Authority must make decisions regarding the equitable distribution and joint management of the shared water of the Mountain Aquifer. This paper provides a decision case for a course at the graduate or senior undergraduate level based on water resources issues impacting the peace process.

IN THE MIDDLE EAST, the Arab-Israeli conflict involved intense disagreements over sharing scarce common water resources (Sosland, 1998). Due to the prevailing aridity, the Middle East is one of the poorest regions in the world in terms of water resources (Exh. 1). In most of the region, water consumption exceeds renewable potable water. Hence, most Middle Eastern countries are considered water stressed (Rosegrant, 1995). According to World Bank estimates, by 2025, renewable water supplies in the Middle East will barely cover basic human needs (Morris, 1998). The problem of water shortages is exacerbated by the fact that water resources in the region are shared by more than one country, a situation which fuels tensions over water rights and makes water a significant political issue (Haddad and Mizyed, 1996).

One of the most intricate water conflicts in the region is that of the Jordan River basin (Exh. 2). The involved parties are Jordan, Syria, the Palestinian Authority (defined as occupants of the Gaza Strip and the West Bank), Lebanon, and Israel. Major issues in the Jordan River Basin conflict include water flow, diversion, and ownership (Morris, 1998). In addition, the Palestinian-Israeli water conflict includes the Jor-

dan and Yarmouk River systems along with the Mountain Aquifer of the West Bank.

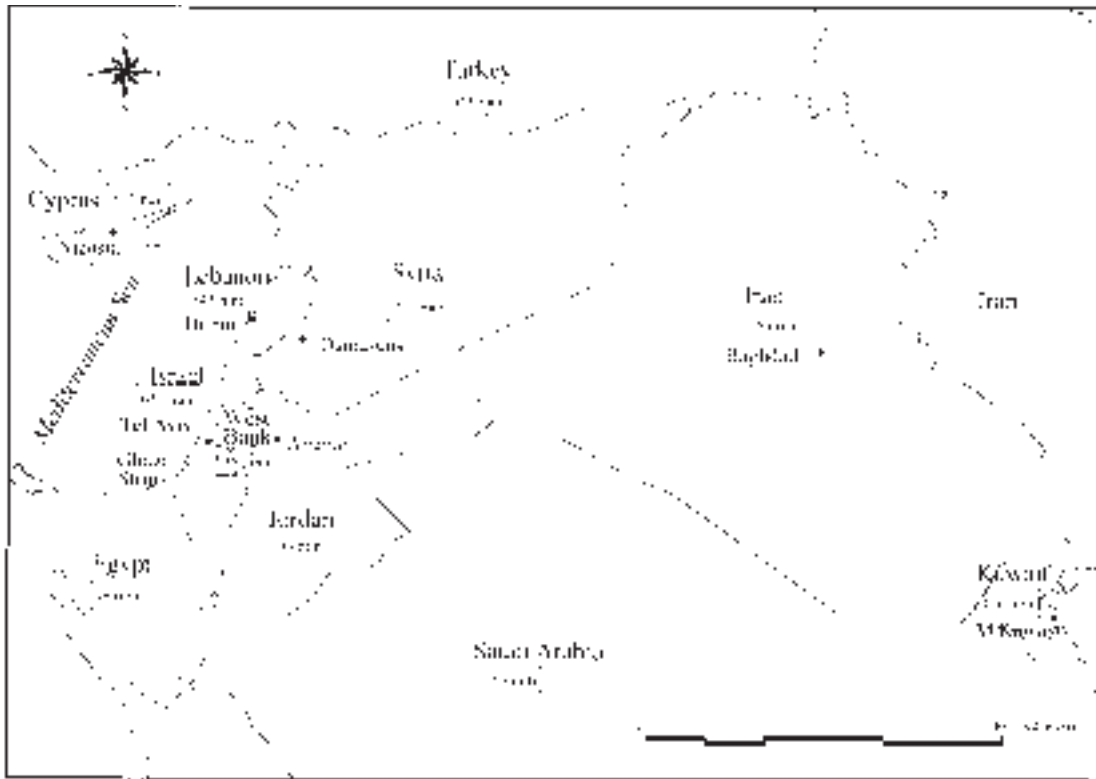
This case study focuses on the Israeli-Palestinian conflict over the shared water resources of the Mountain Aquifer. It is intended for use by graduate or senior undergraduate students to role-play as opponents, supporters, and/or mediators in a conflict resolution setting. The conflict over the Mountain Aquifer is exacerbated by the tense political and military conflict between the Israelis and the Palestinians, which dates back to the beginnings of the 20th century. Israelis tend to defend their water rights by stating that they have been using the major portions of the aquifer's water for more than 60 yr, and that reducing their present water allocation could cause them social and economic distress. On the other hand, Palestinians defend their water rights by stating that the majority of the Mountain Aquifer lies within the West Bank territory, they are the indigenous inhabitants of the region, and they are in greater need for water to build their industrial and agricultural sectors.

Although peace agreements were signed by both sides, such agreements did not fully normalize the relationships nor settle the conflicts. Allocation of shared water resources of the Mountain Aquifer is one of the political core issues that remain to be addressed in the permanent status negotiations (Libiszewski, 1995). Israeli and Palestinian members of the Joint Water Committee (JWC) are responsible for resolving this conflict. The JWC, established in accordance with the Oslo II agreement, is in charge of the protection and coordinated management of water sources and systems. The JWC must decide on an equitable ground water management scheme satisfactory to their respective constituencies. The decision should balance the allocation of available water resources with demand management (conservation and appropriate utilization of water supplies) and enhancement of existing supplies.

## THE CASE

The West Bank came under Israeli control following the Six Day War of June 1967 between Israel on one side and Jordan, Syria, and Egypt on the other. Since then, Israel has been closely monitoring water resources in these territories and hindering Palestinians from exploiting ground water resources, particularly the Mountain Aquifer. Israel has been utilizing about 80% of the West Bank's shared water resources leaving the Palestinians with about 20% (Libiszewski, 1995). Based on the Declaration of Principles (DOP), signed on 13 Sept. 1993, and subsequent agreements (Oslo I in May 1994, agreement on the preparatory transfer of power and responsibilities in August 1994, Oslo II in September 1995, and Wye River in October 1998), Palestinians and Israelis are moving toward a peaceful resolution of their overall political conflict. Although the DOP and Oslo II recognized the Pales-

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Exh. 1. Political map of the Middle East with annual rainfall (mm) in selected countries.

tinians' water rights, the larger issue of water resources management, and the concrete definition of water rights remain to be agreed on in the Final Status Negotiations (Isaac and Selby, 1996). The allocation of existing water supplies of the Mountain Aquifer has become an important issue that needs to be addressed in solving the Israeli–Palestinian dispute.<sup>1</sup> While 80 to 90% of the aquifer recharge area is in Palestinian territories, the majority of the aquifer's water is used by Israelis. Over-pumping threatens water quality of the whole aquifer since its basins are hydraulically connected. The geography and hydrology of the aquifer are factors considered in dividing water according to international law.

### Aquifer Characterization

The Mountain Aquifer is the main ground water basin in the region. It supplies nearly all of the West Bank's water requirements and one-third of Israel's water budget. It is located west of the Jordan River covering the central area of the West Bank and a wide strip of adjacent Israeli territory (Exh. 3). Based on water flow direction, it can be divided into three general basins: the Western basin (also referred to as Yarkon–Tanninim in Israel), the North Eastern basin, and the Eastern basin. The permeable recharge areas extend along the upper mountain slopes and ridges at an altitude of 500 m above sea level. The aquifer is exploited through its natural springs and a network of artesian wells. Its potential yield varies consid-

<sup>1</sup> While there are more pressing issues to be resolved (such as the status of East Jerusalem, the right to return of Palestinian refugees, the disposition of Israeli settlements, the final borders of the new Palestinian state and the sovereignty of this state) this does not underestimate the significance of the conflict over water.

erably depending on the reporting source (Exh. 4). Israeli researchers tend to underestimate shared water resources to protect them from new claims and overestimate exclusively Palestinian water resources. Conversely, suspicious about the political dimension of Israeli researchers, Palestinian researchers tended to overestimate shared water resources and underestimate exclusively Palestinian water resources (Alatout, 2000). Safe yields of 632 million m<sup>3</sup>, including natural recharge of springs and 180 million m<sup>3</sup> of brackish water (i.e., having more than 400 mg/L of total dissolved solids), were estimated and agreed on by a joint team of Israeli and Palestinian water experts (Libiszewski, 1995).

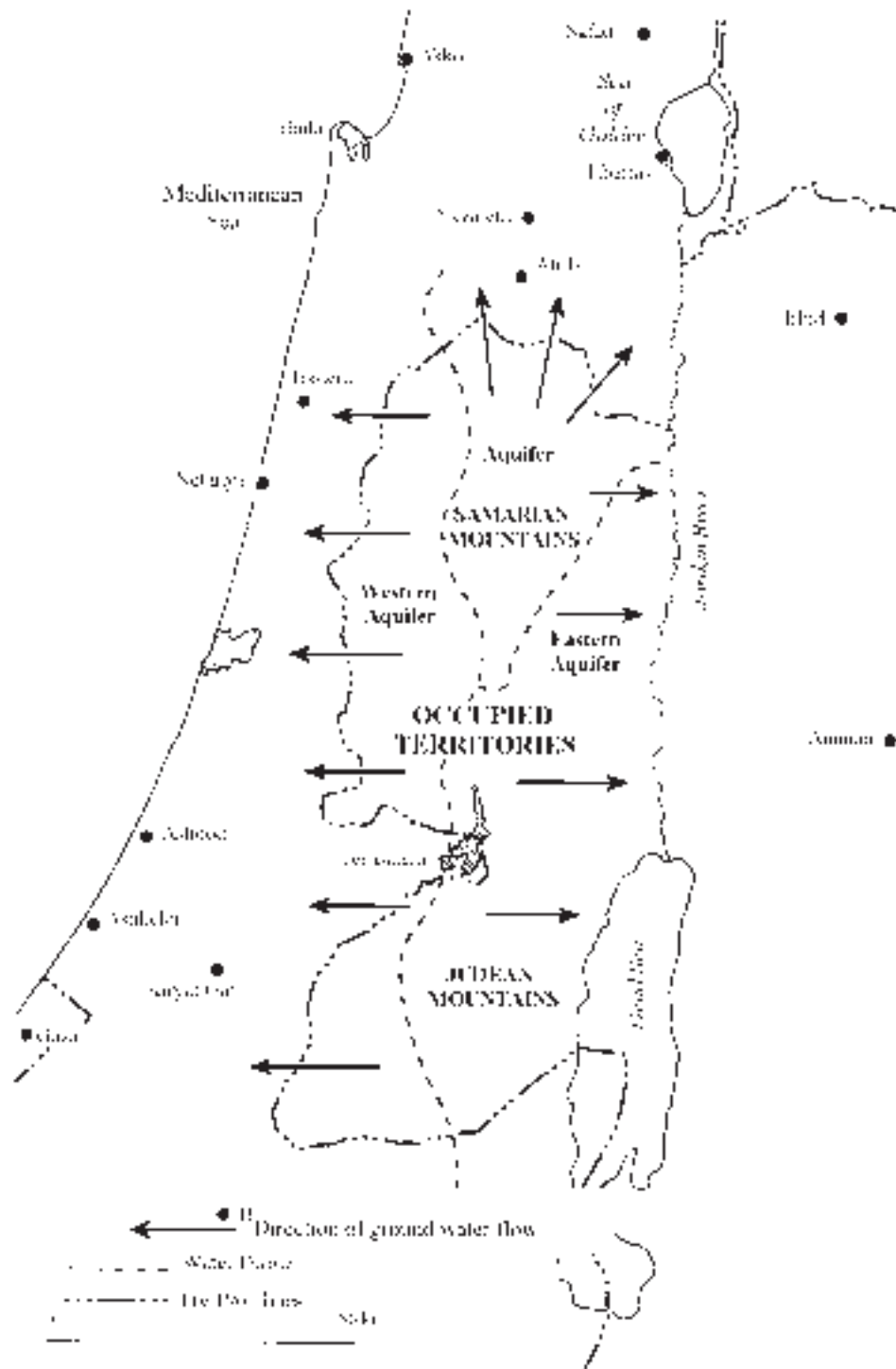
### The Western Basin

The Western basin is the largest and most abundant basin. It consists of several subaquifers that supply more than half of the Mountain Aquifer's total yield. Estimates of the annual renewable yield of this basin vary between 310 and 350 million m<sup>3</sup>. About 40 million m<sup>3</sup> are brackish rendering them unsuitable for most use. Politically, the Western basin can be considered as transboundary since it crosses the 1949 United Nations Armistice Demarcation Line (also called the *Green Line*). About 80 to 90% of the basin is recharged by precipitation falling within the boundaries of the West Bank area. The water then flows underground in a western direction toward the Mediterranean Sea (Libiszewski, 1995; Shuval, 1996).

Historically, the local Palestinian population utilized part of the springs' flow and about 20 to 27 million m<sup>3</sup> from traditionally drilled wells in the coastal area. With the onset of an organized worldwide Jewish migration into Palestine at the end of the 19th century, the new settlers started sharing water







Exh. 3. The Mountain Aquifer (adopted from Shoval, 1996).

well as aquifer conservation and pollution prevention should be settled.

### The Eastern Basin

Compared with the other basins, the Eastern basin cannot be considered an international water resource. It is composed of several subaquifers that lie entirely within the West Bank territory. Water from this basin flows eastward and discharges into the Jordan River and the Dead Sea (Exh. 3). Estimates of

its potential yield vary between 125 and 151 million m<sup>3</sup>/yr. While Palestinians in the West Bank use 39 to 48% of the water from this aquifer, Israeli settlers use up to 60% (Exh. 4).

### Aquifer Geology

The basin consists of two main strata, the Upper and Lower Cenomanian, separated by an impermeable layer of several hundred meters in thickness. The Upper Cenomanian, which is a relatively thin stratum, drains naturally eastward into a se-

**Exhibit 4. Various estimates of the Mountain Aquifer annual recharge rate.**

Basin	Palestinian allocation				Israeli allocation				Total capacity			
	1†	2	3	4	1	2	3	4	1	2	3	4
	million m <sup>3</sup> /yr											
Western	25	27	20	22	310	323	300	340	335	350	320	362
N-Eastern	30	25	20	42	110	106	120	103	140	131	140	145
Eastern	60	58	50	54	35	35	75	40	125	151	125	172
Total	115	110	90	118	485	463	495	483	600	632	585	679

† 1 = Zarour and Isaac, 1991; 2 = Shuval, 1996; 3 = Wolf, 1993; 4 = Sosland, 1998.

ries of springs used by Palestinians. This stratum has limited storage capacity and its recharge is dependent on the rainfall of the previous season. The lower Cenomanian on the other hand, is a deep stratum with fresh water flowing naturally from high mountain infiltration areas in the east down to the Jordan Valley, where it mixes with a layer of saline ground water (Shuval, 1996). Before 1967, Palestinian villagers and farmers used this basin, the lower Cenomanian, exclusively. After 1967, the Israeli authorities extended their control to this section of the Mountain Aquifer and used it to supply Israeli settlements in the area by tapping the fresh water sources along the upper slopes. Similar to the other basins, this ground water is the only source of fresh water for both Palestinians and Israeli settlers living on the eastern part of the West Bank due to the high salinity of the lower section of the Jordan River waters.

### Environmental Stresses

The water quality of the three basins is threatened by over-pumping and the resulting rapid rate of saline water infiltration. The use of the Western and North-Eastern basins reached the limit of safe yield in the mid-1970s, while the Eastern basin still contains an unutilized portion of about 60 million m<sup>3</sup> of brackish water that requires treatment before usage. In several parts of the Eastern basin, wells have been over-pumped. For example, the water table in the Jordan Valley has dropped 16 m since 1969, which has resulted in the deterioration of the water quality. Over-exploitation can lead to the seepage of brackish water into the fresh water body since nearby saline layers underlie the fresh water layers. It is reported that total salt and chloride concentrations have risen by 130 and 50%, respectively, between the years 1982 and 1991 (Libsiewicz, 1995). Similar deterioration in water quality is also reported in some parts of the Western basin.

### Water Allocation and Demand

As part of political pressure, Israelis and Palestinians have been at odds since the beginning of the 20th century because of historical territorial disputes. Palestinians consider themselves the indigenous population and resent the worldwide emigration of Israeli settlers to their old Palestine territory. Israelis

**Exhibit 5. Total and per capita consumption in Israel and the West Bank for 1990 Isaac and Selby, 1996).**

	Israel	West Bank and the Gaza Strip	West Bank settlers	Palestinians in the West Bank
Annual total consumption, million m <sup>3</sup>	1700	219	65	123
Population, millions	4.6	2.07	0.1	1.33
Annual per capita consumption, m <sup>3</sup>	370	107	650	93

consider this land as their historical, undisputed biblical land. Religious, ethnic, and linguistic differences exacerbate the nature of the conflict. The majority of Palestinians are Moslems or Christians with Arabic ancestors, whereas Israelis are primarily Jewish and a majority are recent European emigrants who arrived in the country following World Wars I and II.

The tense political relations between Israelis and Palestinians were exacerbated by the Israeli nationalization of the West Bank's water resources in 1967. Limits were placed on the amount of water that could be withdrawn from each existing well to satisfy Palestinian water demands. On the other hand, new wells were drilled to account for the water needs of new Israeli settlements (Wolf and Ross, 1992). Stringent Israeli water policies prevented Palestinians from exploiting ground water in the West Bank for more than three decades. Permission for well drilling had to be obtained from Israel's military authorities. Between 19 and 46 ground water exploitation permits were granted, according to the reporting source (Sosland, 1998; United Nations, 1992), between 1967 and 1991. In addition, pumping was controlled through heavy fines determined by the Israeli civil administration (Isaac and Selby, 1996). Current water supplies in the West Bank are insufficient to meet actual needs. Although most Palestinians survive on water tank supplies for several months, some districts of the West Bank were without piped water until 1990. Currently, 26% of Palestinian households have no piped water. Comparable shortfalls in domestic water supply in Israel are uncommon. These restrictions by Israel are not consistent with international rules governing occupation such as The Hague Regulations of 1907 and the Fourth Geneva Convention (Farinelli, 1997).

The situation has been changing after the signature of the Oslo II agreement, which resulted in an increase in the amounts of water allocated to Palestinians during the interim period. As such, 70 to 80 million m<sup>3</sup> have been made available for Palestinians to use at a cost. Pumping is being controlled through a joint Israeli-Palestinian monitoring and enforcement committee. Although the rigorous quotas imposed on Palestinians are being relaxed, Palestinians still consume far less on a per-capita basis than Israelis. In this context, the average Israeli consumes 3.5 times more than the average Palestinian. The per-capita consumption of Israeli settlers is seven times that of Palestinians in the West Bank (Exh. 5). In addition, Palestinians continue to pay higher premiums than Israelis for their water supply. While settlers pay \$0.35 to \$0.4/m<sup>3</sup> for domestic water and \$0.16 to \$0.19/m<sup>3</sup> for agricultural water, Palestinians pay a standard rate of \$1.2/m<sup>3</sup> (Isaac and Selby, 1996; Lithwick, 2000).

Water for agricultural use is another important factor in the Israeli-Palestinian water crisis. Seventy to 80% of the re-

**Exhibit 6. A comparison between Israeli and Palestinian agriculture sectors.**

Parameter	Isaac and Selby, 1996		Various sources	
	Israel	West Bank and Gaza Strip	Israel	West Bank and Gaza Strip
Agriculture sector contribution to GDP, %	6	23–29	2†	33†
Agriculture sector contribution to total employment, %	3.5	26.3	2.6†	13†
Irrigated agriculture land, %	47	9	49.43§	10.36§
Total water consumption, million m <sup>3</sup>	1700	225	1710‡	220‡
Agricultural water use, as % of total consumption	75	62	64‡	73‡
Total annual water consumption for irrigation, million m <sup>3</sup>	1275	140	1094‡	160‡
Population, millions	4.56 (1990)	2.03 (1990)	5.75 (1999)†	2.72 (1999)†
Per capita annual water consumption for irrigation, m <sup>3</sup>	280	69	190	59

† CIA, 2000a (Israel); CIA, 2000b (West Bank).

‡ Arlosoroff, 1996.

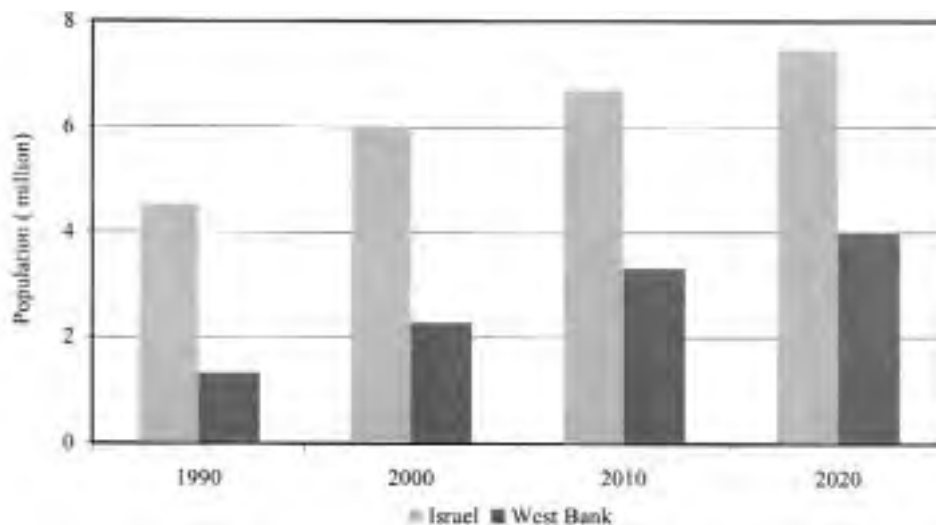
§ Awartani, 1994.

gion's water is assigned to irrigation of agricultural crops in both Israel and the West Bank (Becker and Zeitouni, 1998). Almost 75% of Israeli water resources are used for irrigated agriculture. Nearly half of Israel's cultivated land and 70% of West Bank settlers' cultivated land is irrigated. By contrast, all but 6% of Palestinian cultivated land is dependent on rainfall. While agriculture is central to the Palestinian economy, representing >25% of both GDP and employment, it accounts for 4% of Israel's GDP and 3.5% of its employment. Yet, the Palestinian per capita annual water quantity used for irrigation represents 25% of the corresponding Israeli value (Exh. 6).

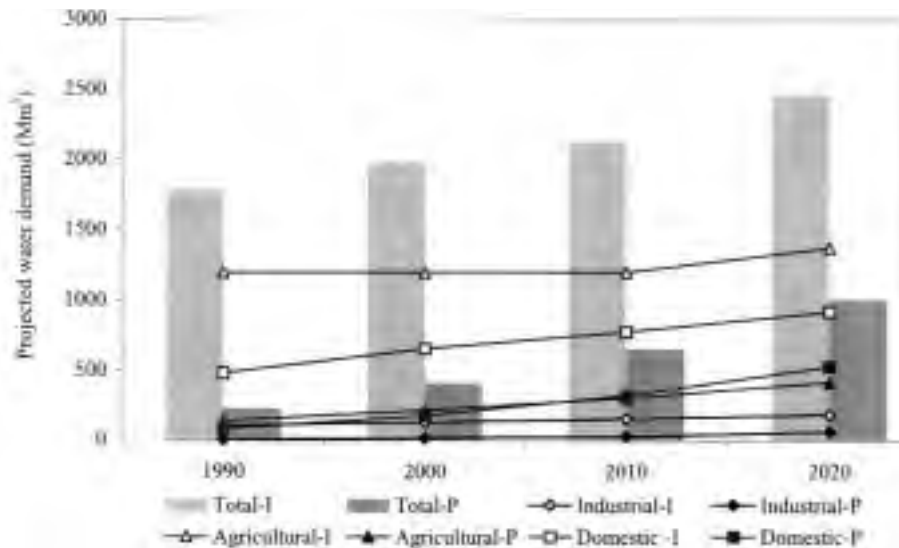
Prospects of substantial increases in water demand in the coming years make it critical to find a solution to water shortage. Israeli and Palestinian populations are both expected to grow significantly (Exh. 7) and population increase is bound to heighten the demand for water (Exh. 8). A *minimum water requirements* analysis reflects a shortage for Palestinians and an excess for Israelis (Exh. 9). Still, the continuing immigration to Israel will result in economic and population growth that will inevitably lead to increased water demand by Israel. Therefore, any moves toward resolution of the Israeli–Palestinian water crisis must account not only for the current hydro-political situation but also for probable future changes in demand. The Mountain Aquifer as well as other shared water resources must be allocated properly to maintain sustainable de-

velopment. Note that the major portion of the region's water is assigned for irrigation. In fact, the Israeli–Palestinian water crisis is often described as one concerning water for agricultural use. In the West Bank, population increase combined with limited water resources has, to a certain extent, forced a shift of water consumption from agricultural to domestic use. On the other hand, the pricing system in Israel traditionally has supported and still supports agricultural activities through subsidizing irrigation water prices (Becker and Zeitouni, 1998).

As depicted in Exh. 8, the projections for Palestinian domestic water demand assume a relatively high population growth and a decrease in the restrictions imposed on water resources, leading to a higher per-capita water demand. For Israel, per-capita water supply for the domestic sector is adequate. The projected increase in Israeli domestic water demand is the result of an expected rise in population induced by immigration. For the Palestinian industrial sector, the projections are based on the premise that tourism and construction will prosper due to the ending of the occupation. Water demand for this sector is thus expected to continue to increase. As for the agricultural sector, the assumption that the Palestinians will irrigate areas well suited for irrigation in addition to those currently irrigated by the settlers explains the projected increase in water demand for irrigation. In turn, the increase in Israel's irrigation water demand is dependent upon the extent to which



**Exh. 7. Population growth projections for Israel and the West Bank (Isaac and Selby, 1996).**



Exh. 8. Projected water demand for Israelis (I) and Palestinians (P). (Alatout, 2000; Lithwick, 2000).

new irrigation technologies are adopted and the extent to which prices reflect the true cost of the water (Isaac and Selby, 1996). Although Israel has been able to improve water usage efficiency,<sup>3</sup> it still faces the challenge of reducing the share of its agricultural sector of water, the largest consumer of water (Lithwick, 2000).

#### WATER CONFLICT AND INTERNATIONAL LAWS

Ideally, water conflict resolution should be achieved by the application of international water laws, which address the fundamental interests of the international community, namely, maintenance of international peace and security; development of friendly relations among nations; achievement of international cooperation on problems of an economic, social, cultural, or humanitarian nature; sovereign equality of all member states; and peaceful settlement of disputes. International water laws have evolved mainly for solving issues concerning surface water. While they are sufficiently flexible to be adapted to the particular requirements of ground water issues in different locations, laws on international ground water are in the early stages of development. This is probably due to a lack of scientific data and knowledge of the geo-hydrology, as well as the complex hydro-political issues involved in many parts of the world. The application of international laws is hindered by their ambiguity and by the fact that they can easily be rendered impotent when a state ignores, or is not party to, the laws in question.

International ground water laws currently in use were formulated by the International Law Association and the International Law Commission (Berberis, 1991; Haston and Utton, 1989). They include the Helsinki Rules (1966), the Bellagio draft treaty (1989), and the Seoul Rules (1986) (Exh. 10). None of these rules are binding in international law. They are simply articles that have been adopted by the International Law Association.

<sup>3</sup> Israel and Palestine have among the most efficient irrigation systems in the world through the use of micro-irrigation, which is applied in about 40% of irrigated areas in the West Bank and 50% of areas in Israel (Isaac and Selby, 1996).

While geography and hydrology principles of the Helsinki Rules provide a legitimate basis for a Palestinian to claim sovereignty over West Bank waters (since the majority of the aquifer drainage and recharge area are in the West Bank), Israelis argue that current utilization of water must be distributed in accordance with the second principle of the Helsinki Rules, namely that “prior use determines water rights.” Israel has honored prior use water rights of Palestinians but appropriated all of the ground water that was not being exploited in 1967. Israel is also keen to emphasize the economic and social damage it would suffer if its water allocations were reduced. From a Palestinian perspective, the expected population growth will lead to increased water stress since the Mountain Aquifer is the only source of available water in the West Bank. This is aggravated because current allocation of water resources is insufficient for Palestinian economic and social development.

#### WATER AND THE PEACE PROCESS

In the peace process, Israel seeks to protect its historical water supply and Palestine wants to increase its available water supply and establish its water rights in the West Bank. The Israeli–Palestinian DOP was followed by three agreements: (i) the Gaza–Jericho Agreement (also called Oslo I) signed on 4 May 1994; (ii) the Agreement signed on 29 Aug. 1994 preparing for transfer of power and responsibilities to the Palestinians; and (iii) the Israeli–Palestinian Interim Agree-

Exhibit 9. Estimated ability of water resources to meet minimum water requirements (MWR) for survival at 125 m<sup>3</sup>/person per yr for domestic–urban–industrial use and the cultivation of fresh vegetables (Shual, 1994).

	Population		Water resources potential million m <sup>3</sup> /yr	Total water		Total MWR 2023 million m <sup>3</sup> †	Total excess short
	1993	2023		1993	2023		
	— millions —		million m <sup>3</sup> /yr	m <sup>3</sup> /capita per yr		— million m <sup>3</sup> † —	
Israel	5	10	1500	300	150	1250	+250
Palestinians	2	5	200	100	40	625	-425

† Based on 125 m<sup>3</sup>/person per yr.

**Exhibit 10. Major principles of international ground water laws (Berberis, 1991; Haston and Utton, 1989).**

International rules	Major principles
Helsinki Rules (1966)	The resolution of a conflict depends on: <ul style="list-style-type: none"> <li>•Geography† and hydrology of the basin‡</li> <li>•The past utilization of the basin waters</li> <li>•Availability of other water resources</li> <li>•The economic and social needs of the basin states</li> <li>•The population dependent on the basin waters</li> </ul>
Bellagio Treaty (1989)	<ul style="list-style-type: none"> <li>•Ensuring reasonable and equitable development and management of ground water</li> <li>•Attaining optimum utilization and conservation of trans-boundary ground water</li> <li>•Developing reliable data to rationally use and protect the ground water</li> </ul>
Seoul Rules (1986)	<ul style="list-style-type: none"> <li>•Basin states should prevent the pollution of international ground water</li> <li>•Basin states should consult and exchange available information and data</li> <li>•Basin states should cooperate for the purpose of collecting and analyzing additional needed information and data</li> </ul>

† Such as the drainage area in the territory of each basin state.

‡ Such as the contribution of water by each basin state.

ment on the West Bank and Gaza Strip (also called Oslo II) signed on 28 Sept. 1995 (Sosland, 1998).

In the DOP, Palestinians and Israelis established preconditions for further negotiations. In this agreement, the Israelis allocated water rights for the Palestinians without a clear indication of the extent to which water should be under Palestinian control during the interim period. The DOP, however, implicitly recognizes the existing inequality in water allocations.

The Oslo II agreement provided the Palestinians with additional water for domestic purposes (28 million m<sup>3</sup>/yr) and guaranteed that all measures will be taken “to prevent any harm to water resources including those utilized by the other side.” Oslo II defined the existing extractions and estimated the potential of the West Bank aquifers (Exh. 11). In the Final Status negotiations, the equitable utilization of joint water resources and the control over land and water are to be resolved.

**THE DECISION**

A delicate conflict over the control and equitable allocation of the Mountain Aquifer water is impeding the Palestinian–Israeli peace process. The Palestinians consider the current water allocation to be inequitable, while the Israelis claim to have priority due to historic water use patterns. Based on the information provided, the JWC must decide upon a mutually acceptable, shared water allocation arrangement. Taking into consideration both the Israeli and Palestinian perspectives, current constraints, and imminent future shortages, what should the committee members decide to ensure the approval of their respective constituency?

**Exhibit 11. Existing extractions and estimated potential of the Mountain Aquifers (Sosland, 1998).**

	Eastern Basin	Northern Basin	Western Basin
	million m <sup>3</sup> /yr		
Palestinians	54	42	22
Israelis	40	103	340
Quantities to be developed	78	--	--
Total	172	145	362

**TEACHING NOTE**

**Case Objectives**

This case study presents one of the most controversial issues in recent Middle Eastern history. Upon completion of the case, students will have:

1. Enhanced their objectivity in tackling sensitive socio-political water resources issues.
2. Understood the magnitude and dimension of the various aspects of water conflict in the framework of the overall Israeli–Palestinian political conflict.
3. Recognized the interrelation between natural resources and politics.
4. Become familiar with the main themes of international law for water conflict resolution.
5. Analyzed and evaluated alternatives for water conflict resolution.

**Uses of the Case**

While this case study was developed for senior and graduate-level students in natural or water resources studies, it can easily be used at other levels for students in political sciences, social studies, agricultural sciences, or related fields. Students will use decision-making skills to integrate primarily the scientific and socio-political components of the case. The case, based on region-specific data and events, provides students an opportunity to evaluate water resources management in a water-scarce region. Social and political considerations play a major role in this case due to the historical and long-standing conflict between the populations involved.

**Implementation of the Case**

Given the sensitive socio-political aspects of the case, scientific objectivity is necessary in the implementation of this case. It is helpful if students are briefly exposed to the history of the Israeli–Palestinian political conflict before using the case. Many books have been written in this regard and much information can be found on the Internet. Shashaa (2000) is a recent example. The case was used in a graduate-level course on environmental case studies and conflict resolution at the American University of Beirut. The class was composed primarily of environmental science students with diverse backgrounds (chemistry, geology, physics, civil engineering, ecosystem management, and environmental education). Invariably, the feedback of students was important and, in fact, their input was used to improve on the case and refine certain questions.

Case studies can be used in a variety of ways in a classroom setting (Herreid, 1994);<sup>4</sup> however, the implementation should be appropriate to the background of the students and the objectives of the course. This particular case lends itself to role-

<sup>4</sup> (i) assigned as outside reading followed by a general class discussion with a decision that needs to be reached with the corresponding justification; (ii) written reports could be required for grading purposes and after correction of the reports, answers can be discussed in class in the context of actual events and what the final decision could be; (iii) the case can be read in class (about a 3-h class; the case would be too long for a 1-h session) followed by either small group or whole class discussion of all or selected questions. The latter approach requires the least amount of class time, but it also provides less chance for students to reflect on the issues of the case.

playing whereby students assume the role of opponents or supporters of Israeli or Palestinian views. An outside panel totally unfamiliar with the case could be invited in to listen to the debate and make a decision based on the arguments presented by the students. Role-playing offers the advantage of nurturing analytical skills, practicing public speaking, and developing awareness of socio-economic, political, and cultural constraints.

## DISCUSSION QUESTIONS AND ANSWERS

### 1. How are water scarcity issues generally approached?

Water scarcity in this region can be organized into five main themes: security, economy, legal, technological, and environmental (Dolatyar and Gray, 2000a).

First, water is often considered to be a source of power. It is a critical and highly strategic issue, which affects the social and economic development of nations, and consequently threatens to undermine their political power. In this context, Israelis have historically perceived the Palestinians as a threat and the support of neighboring Arab countries has only deepened their sense of insecurity. As a result, Israelis resort to maintaining a military edge to successfully ensure control over water resources in the region.

Second, economists often argue that water scarcity is basically an economic problem, which will be alleviated if nations treat water as an economic asset (i.e., through market mechanisms). Water marketing may be problematic for agricultural workers, particularly Palestinians who are relatively poor. The establishment of free markets in the near term can exacerbate instability, as it might be perceived as unfair for Palestinians because of the large economic discrepancy between Israelis and Palestinians.

Third, the absence of proper international agreements between the two populations, which clearly define the system of property rights, can indeed be considered as the root cause of the water crisis. Successful resolution should result in the establishment of water rights at the national, as well as the international level. In this context, the Palestinians feel that they are not negotiating on an equal footing with the Israelis. While Israel is a sovereign state with worldwide recognition (with the exception of several Arab countries, that remain at conflict with Israel), the Palestinian territory is not yet recognized as a sovereign country, not to mention the dramatic imbalance in military and economic power between the two.

Fourth, some optimists claim that water scarcity problems are best solved by better technological management of water resources arguing that such advances would eliminate the possibility of occurrence of shortages. Israelis have pioneered technological advances in irrigation systems, while Palestinians still rely on outdated and inefficient practices as a result of economic damages caused by the Israeli occupation. Palestinians are at a disadvantage in applying advanced water resources management techniques.

Finally, water crises can be viewed as part of larger environmental management crises. The notions of limits to growth, sustainable development, and environmental security are introduced in this last approach. From this perspective, water scarcity is an environmental problem that can be attributed to nonsustainable exploitation practices. The practice of resorting to military, economic, legal, or technological solutions not

only cannot solve the problem but also exacerbates the predicament. The solution is to understand the limits to growth of the eco-geographical regions and adopt rational and sustainable policies within the context of overall conflict resolution.

**2. How can the political conflicts between Israelis and Palestinians be traced back to the conflict around water resources?** Although primarily political in their nature, the various conflicts in the Final Status Negotiation between Israel and Palestinians can be linked to conflicts over water.

1. *The return of the Palestinian Refugees.* While the UN resolution 194 (December 1948) stated clearly the right of the refugees to return to their homes, Israel constantly resists the return of the refugees. In addition to the legal, political, demographic, and economic implications, the return of the refugees will increase the Palestinian population, which can be used as an argument for demanding a higher allocation of the shared water resources such as the Mountain aquifer.

2. *The final borders between Israel and the new Palestinian state.* Setting the border of the Palestinian State has its implication on water resources distribution. In effect, the expansion or shrinking of the border of the proposed Palestinian State can imply an increase or decrease in water resources allocated to Palestinians. For instance, the western side of the Jordan River is currently under Israeli control. The adoption of this river as a border for the new Palestinian state might limit Israeli usage of this source.

3. *The sovereignty of the Palestinian state.* A decision on the extent of sovereignty that the Palestinian state will have can affect water allocation. For instance, if this state will have the full authority for deciding on building reservoirs for water catchment, this could affect aquifer recharge and hence Israeli share of the aquifer water.

4. *The status of East Jerusalem.* The sovereignty over East Jerusalem has its implication on water management. If Israel continues to control East Jerusalem, it will be responsible for providing water to Palestinians residing there. This water might be deducted from the Palestinians share of water resources.

5. *The disposition of the settlers in the West Bank.* The fate of the settlers in the West Bank could affect water allocation. Historically, the settlers had high water consumption due to subsidized agricultural activities. For instance, settlers use up to 60% of the water from the Eastern aquifer, which is entirely within the West Bank. If settlers continue to reside in the West Bank, the share and source of their water supply have to be examined.

### 3. Do you think that a comprehensive treaty that satisfies both Israelis and Palestinians can be reached?

Throughout history, the fair division of water between nations has been constantly impeded by the conflicting interests of coriparian actors. In real life cases, the dominant country in the basin has imposed a solution that best suits its interests. However, some attempts at solving water conflicts have resulted in comprehensive rules, the most common are the Helsinki and ILC rules, which consider several factors (i.e., drainage basin area, population, climate, dependence on water) to distribute water among riparian states in an equitable manner.

### 4. Based on international water laws, what argument may be presented by each party in defending its water

**Exhibit 12. Israeli and Palestinian perspectives of water rights of the Mountain Aquifer.**

Factor	Israeli perspective	Palestinian perspective
Geography and hydrology	<ul style="list-style-type: none"> <li>•Most of the optimal pumping area lies under Israeli territory (natural historical outlet).</li> <li>•The source of a trans-boundary body of water is not the sole criterion in determining water rights.</li> </ul>	<ul style="list-style-type: none"> <li>•80 to 90% of the Mountain Aquifer flow is derived from rainfall over the West Bank.</li> <li>•The majority of the mountain aquifer lies within the West Bank territory.</li> </ul>
Historic use	<ul style="list-style-type: none"> <li>•Israel inherited water resources that had been under British mandate control.</li> <li>•For more than 60 yr, the Israelis have been developing and fully utilizing major portions of the aquifer flow.</li> </ul>	<ul style="list-style-type: none"> <li>•Palestinians are the indigenous inhabitants of the region and are therefore the party with historical prior use rights.</li> <li>•Stringent occupation policies prevented Palestinians from exploiting the ground water of the West Bank.</li> <li>•Israel has violated the Geneva Convention and misused its authority as the occupier by developing many new water supplies in the West Bank.</li> </ul>
Resource availability	25.3% of Israeli water is derived from the West Bank.	The Mountain aquifer is the only source of fresh water.
Economic and social needs	<ul style="list-style-type: none"> <li>•Reducing the current water allocation would cause social and economic damage.</li> </ul>	<ul style="list-style-type: none"> <li>•The contribution of agriculture, the major water-consuming sector, to Israeli GDP and employment is minimal compared with its contribution to Palestinian GDP and employment.</li> <li>•Palestinians need water to build industry and agriculture.</li> <li>•In the past, Israel has allocated insufficient amounts of water for Palestinian urban, industrial, and agricultural development.</li> </ul>
Population	<ul style="list-style-type: none"> <li>•The Israeli population is almost double the Palestinians, which should give them higher share of the water source.</li> </ul>	<ul style="list-style-type: none"> <li>•Israel has a higher population relative to Palestinian population because they are encouraging mass immigration of Jews while restricting the return of Palestinian refugees to their homeland.</li> </ul>
Equitable use of water	<ul style="list-style-type: none"> <li>•Water supplied to Palestinians is enough to meet their needs.</li> </ul>	<ul style="list-style-type: none"> <li>•Water level consumption in 1992 reflects a 4:1 ratio in per capita use in favor of Israeli settlers. The current water available to Palestinians fails to meet their minimal requirements for social and economic well-being.</li> <li>•80 to 90% of aquifer renewable water supply is extracted from deep wells mainly by Israelis.</li> </ul>
Preventing environmental damage	<ul style="list-style-type: none"> <li>•Israel fears that any major unregulated increase in pumping from the Mountain Aquifer in the West Bank area would result in a drastic reduction of Israel's source of drinking water.</li> <li>•Israelis are concerned about the degradation of water quality resulting from inadequate Palestinian control of urban pollution, municipal wastewater, industrial, and agricultural waste.</li> </ul>	<ul style="list-style-type: none"> <li>•Israeli drilling of new deep wells within the West Bank is thought to have caused the drying of traditional springs and shallow wells in the West Bank.</li> </ul>

**rights?** Although the international law of water resources has not yet reached the level of maturity and sophistication, which is desirable given the urgent nature of water problems in many parts of the world, important basic principles and rules have evolved. Israeli and Palestinian perspectives in defending their water rights and respective positions are depicted in Exh. 12.

**5. What are general water management strategies that could be adopted to alleviate water resource constraints?** Management strategies include decreasing demand and increasing supply. Demand could be decreased by controlling population growth, water rationing, increasing public awareness about the scarcity of water resources, water pricing reforms, and increasing the efficiency of water use especially in agriculture (drip irrigation, shift to drought resistant and salinity resistant crops, shift from open drainage to open ground pipes). Increasing the water supply includes reverting to unconventional water sources such as wastewater reclamation, desalinization of sea water and brackish ground water, and rain water harvesting. For instance, in Bogor, Indonesia, household water demand decreased by 30% as a result of increasing water tariff from 0.15 to 0.42 USD/m<sup>3</sup> (Dinar et al., 1997).

**6. What are the available alternatives for solving the Israeli–Palestinian conflict over the Mountain Aquifer shared water resources?** A successful approach for solving the Palestinian–Israeli water conflict must incorporate a balance among three elements:

- Allocation of available water supplies based on an agreement between both parties on the sovereignty over water re-

sources in the West Bank as well as the rightful allocation of the shared water.

- Demand management including conservation and appropriate utilization of water supplies such as monitoring for leakage to minimize water losses in the distribution system and improving the efficiency of existing irrigation systems.
- Enhancement of existing water supplies either through increasing unconventional sources (e.g., water desalination, wastewater reclamation, import of water) or reducing demand (e.g., water pricing) or a combination of both.

This approach for the resolution of the Mountain Aquifer conflict should be an inseparable part of the broader framework for resolving the Jordan River basin conflict. The later is best attained through a comprehensive and integrated regional plan for cooperation on water resources. This should involve negotiations among multiple parties (Jordan, the Palestinian Authority, Syria, Lebanon, and Israel) to reach an agreement on equitable utilization and protection of water resources in the basin region. The agreement should also establish an institution for the joint management of the water resources. Then, each riparian state would have to reinforce its legislation on water issues to be able to implement the remaining components of the regional plan, including water demand and supply management along with public awareness campaigns on regional water issues. Possible components, objectives, and their implementation are summarized in Exh. 13. This approach is considered comprehensive and integrated because it links the political, technical, socio-economic, environmental, infrastructural, and other aspects of water resource management.

### Exhibit 13. Integrated regional water resource management plan.

Component	Objective(s)	Implementation
1. Negotiating agreements.	<ul style="list-style-type: none"> <li>•To allow cooperative water management plans and equitable water allocation of both surface and ground water resources (Berman and Wihbey, 1999).</li> <li>•To promote regional water security and alleviate the fear among the riparians of the Jordan River basin (Berman and Wihbey, 1999).</li> </ul>	<ul style="list-style-type: none"> <li>•By adopting a regional water charter for distributing water rights equitably among the riparian states according to the international law principle of human conditions (Benvenisti, 1994; Haddad and Mizyed, 1996).</li> <li>•By adopting a political–military framework on water issues through the formal signing of a memorandum on collaborative ventures such as the mutual defense of regional water supplies by military coordination and banning the destruction or contamination of water supplies and facilities (Benvenisti, 1994; Haddad and Mizyed, 1996).</li> </ul>
2. Creating a specialized institution for the joint management of both surface and ground water resources.	<ul style="list-style-type: none"> <li>•To achieve a harmonious and optimal exploitation of shared water resources and to facilitate the resolution of any future conflict (Haddad and Mizyed, 1996; Kliot and Shmueli, 1998; Mostert, 1998).</li> <li>•To prevent uncontrolled digging of wells and over abstraction of aquifers (Kliot and Shmueli, 1998; Nasser, 1996).</li> <li>•To build a regional database that will aid in responding to emerging water conditions and changes (Kliot and Shmueli, 1998; Nasser, 1996).</li> <li>•To set water quality standards (Kliot and Shmueli, 1998; Nasser, 1996).</li> <li>•To manage the regional sharing of information on environmental conditions and technological breakthroughs (Kliot and Shmueli, 1998; Nasser, 1996).</li> </ul>	<ul style="list-style-type: none"> <li>•By developing a permit system and the installation of meters on every well (Nasser, 1996).</li> <li>•By collecting, assessing, and analyzing data and transforming hydrological and water data into information for planning, decision making, and operation of sound management systems (Nasser, 1996).</li> </ul>
3. Implementing legislative and institutional reforms (Haddadin, 1996).	<ul style="list-style-type: none"> <li>•To monitor and enforce the laws, agreements, rules, and standards, especially those to be adopted in the regional water plan (Haddadin, 1996).</li> </ul>	<ul style="list-style-type: none"> <li>•By the improvement and reinforcement of the water sector institutions in each of the riparian states (Haddadin, 1996).</li> </ul>
4. Harmonizing water pricing and cost recovery policies among the riparian states (Haddad and Mizyed, 1996).	<ul style="list-style-type: none"> <li>•To recover operation and maintenance costs in addition to a portion of the investment costs (Haddadin, 1996).</li> <li>•To encourage efficient resource utilization (Haddadin, 1996).</li> </ul>	<ul style="list-style-type: none"> <li>•By establishing cooperative water policies among the riparian states (Haddadin, 1996).</li> </ul>
5. Optimizing water use in all riparian states through exchanging water demand management experiences (Arlosoroff, 1996).	<ul style="list-style-type: none"> <li>•To reduce water demand, which will lessen the problem of water scarcity and in turn reduce the likelihood and intensity of possible water conflicts (Arlosoroff, 1996).</li> </ul>	<ul style="list-style-type: none"> <li>•By increasing the efficiency of irrigation systems (i.e., drip, sprinkler, and automation) (Arlosoroff, 1996).</li> <li>•By reclaiming industrial effluents (most probably for irrigation purposes) and adopting water saving efforts (cascading changes and cooling methods) (Arlosoroff, 1996).</li> <li>•By conserving water at the municipal level through decreasing losses due to unaccounted-for-water and utilizing demand reducing kits such as toilet flush reduction, regulated showerheads, two-volume flushing, flow regulators in kitchen and bathroom sink taps, leakage control, and technologies for improving garden and park irrigation (Arlosoroff, 1996).</li> </ul>
6. Selecting regional water supply development projects (Arlosoroff, 1996).	<ul style="list-style-type: none"> <li>•To augment irrigation, industrial, and municipal water supplies.</li> </ul>	<ul style="list-style-type: none"> <li>•Water harvesting through constructing micro-scale dams and aquifers to collect the rainfall and storm runoff could increase water supplies to Jordan, Israel, and the Palestinian Authority by 5% (Berman and Wihbey, 1999).</li> <li>•By re-using municipal wastewater and brackish water for irrigation purposes (Arlosoroff, 1996).</li> <li>•By desalination of brackish and seawater, which, in spite of its relatively high cost, could be relied upon for augmenting municipal and industrial supplies.</li> <li>•By developing inter-basin water transfer projects such as the Jordanian water transfer from Azraq to Amman and the Israeli National Water Carrier (Haddadin, 1996).</li> </ul>
7. Enhancing regional public awareness campaigns (Haddadin, 1996; Nasser, 1996; Stout, 1994).	<ul style="list-style-type: none"> <li>•To expand the knowledge base of decision-makers for achieving wise natural resources management (Haddadin, 1996; Nasser, 1996; Stout, 1994).</li> <li>•To convince the population of the region that water resources are scarce and that water should be regarded as a commodity (Haddadin, 1996; Nasser, 1996; Stout, 1994).</li> <li>•To expose the population to the cost of producing, treating, and distributing water to achieve wise water utilization (Haddadin, 1996; Nasser, 1996; Stout, 1994).</li> </ul>	<ul style="list-style-type: none"> <li>•By conducting public awareness and media campaigns, and specialized seminars (Haddadin, 1996; Nasser, 1996; Stout, 1994).</li> </ul>

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# Out of the Creek: A Wastewater Decision Case<sup>1</sup>

J. D. Miersch,\* J. C. Bell, and J. L. Anderson

## ABSTRACT

Today there are many choices for a community faced with the need to upgrade its failing sewage treatment system. The objective of this case is to teach participants how to weigh choices that affect the whole community by involving them in a decision of wastewater treatment in a small rural town. Current alternative wastewater systems as well as traditional systems should be considered. The dilemma is to choose a system that will be efficient, affordable for the citizens of the community, and ultimately avoid surface and ground water pollution. Once a system has been chosen, it must follow a management plan to be effective over time. The decision involves not only the citizens of the town, but the city engineer and other state and county agencies concerned with the environmental and human health hazards caused by inadequate wastewater treatment.

THIS CASE focuses on a wastewater decision in a small rural town and is designed to be used for educational purposes in college level courses or by decision-makers from other small communities, city engineers, and other agencies involved with wastewater treatment decisions. In decision cases, students are asked to critically evaluate facts, to weigh all the issues of concern, and to develop an answer to the problem. The use of this case study can be very valuable in teaching because it involves familiarity with wastewater regulations along with the complexity of limited funds. The Spring Hill case presented here represents the information the city and its representatives were given at the time of the decision.

## THE CASE (ABRIDGED)<sup>2</sup>

“Everyone in Spring Hill has their own septic system. The water (effluent) from each septic tank goes right into the storm sewer leading to the creek (ditch). We don’t see the pathogens and had no (city) water quality testing, so we didn’t know about the problem,” explained Mayor Mary Wuertz of Spring Hill, MN. Although the city council and mayor would make the final decision, Mayor Wuertz also wanted the opinion of residents. She knew that some residents could not understand why the sewage issue had become so important when the current system had operated for decades.

<sup>1</sup> This journal uses SI units, according to the ASA-CSSA-SSSA style. Due to the circumstances of this case study, however, English units are used, either alone or along with SI units.

<sup>2</sup> This is an abridgement of the complete case. The complete case consists of 10 pages of text, 11 exhibits, 34 pages of teaching notes, and a glossary. For a copy of the complete case, contact the corresponding author (miers004@tc.umn.edu).

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The Stearns County Highway Department assessed the roads in Spring Hill in 1997. The Highway Department found the drain lines under the highway contained raw sewage. Upon further investigation, they discovered there was a major problem with sewage treatment in Spring Hill. Of the 38 homes and businesses, only two were in compliance with state and federal regulations for wastewater and sewage treatment. Each house had a septic tank (primary sewage treatment), but only one had secondary treatment of septic tank effluent such as conventional mound or trench systems. All effluent from the septic tanks discharged directly to the county ditch running to the Sauk River creating environmental and human health hazards.

Once the problem was identified, it was the responsibility of the city council and mayor of Spring Hill to decide upon the best solution. The city council is comprised of four members elected from the community, and meets monthly to consider ordinances, resolutions, and other such actions as may be required by law or circumstance.

The community of Spring Hill is located in west central Stearns County, Minnesota, 30 miles (48 km) west of St. Cloud (Exhibit 1). The city was established in the farming community 10 July 1871. The population in 1999 was 75 residents. With an average household income of \$12 500, according to 1990 census data, the community was not eager to have their taxes raised or to have fines assessed. Since two-thirds of the residents were on low, fixed incomes, they could not afford the expense to upgrade their individual wastewater treatment systems.

More than 100 small rural towns and cities in Minnesota face similar dilemmas: how to choose the best wastewater treatment system to protect human health and the environment and comply with the Minnesota Pollution Control Agency (MPCA) regulations. “We could build a case against Spring Hill,” explained Ken LeVoir, MPCA representative in Brainerd, MN, “but instead we are working with the community for a solution.” The city took responsibility, so the MPCA did not have to step in with the “2 by 4 between the eyes,” LeVoir said. The mayor and city council of Spring Hill sought professional advice and involved all citizens of the community in the exploration of alternatives for their decision. Citizen involvement, and development of community understanding of the problem were the strengths in the Spring Hill decision process. News of the sewage problem in Spring Hill spread. “Local television stations came out to do a story on our sewer water running right to the creek,” said Mayor Wuertz. “That made some bad publicity for our community.”

With the advent of automatic washing machines, dishwashers, and showers for indoor bathrooms, the volume of wastewater has increased considerably. Inadequate sewage treatment may result in the contamination of well water if bacteria and viruses from the wastewater reach the ground water

**Abbreviations:** BOD, biochemical oxygen demand; TSS, total suspended solids; ISTS, Individual Sewage Treatment System; MPCA, Minnesota Pollution Control Agency; WSN, Widseth Smith Nolting & Associates; GEM, Greenwald, Elrosa, and Meire Grove.

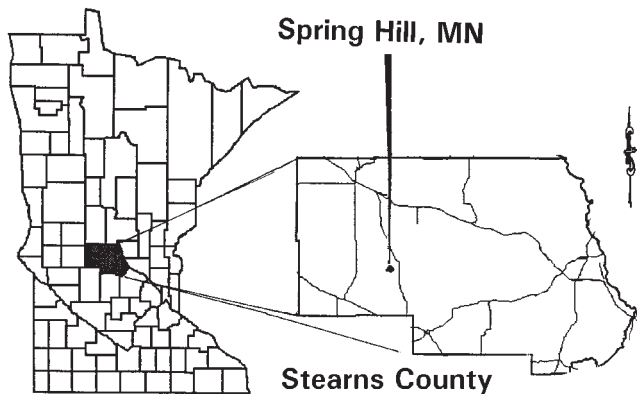


Exhibit 1. Location of Spring Hill, MN.

(Olson et al., 1997). The challenge for the advisors for Spring Hill was not only to suggest solutions to the wastewater problem, but also to keep in mind future changes in volume of sewage, so the choice made would continue to meet the needs of the community. State, federal, and city funds could help defray the total cost of any wastewater treatment. Most, if not all, municipalities rely on a significant proportion of state and federal government funding for the original design and installation costs of wastewater systems. Since many residents of Spring Hill are on low-level fixed incomes, access to government grants and loans would be important.

The factors that are important in a wastewater system decision are:

- Cost
- Amount of wastewater flow
- Land features (e.g., elevation gradient, soil characteristics)
- Availability of suitable land
- Climate
- Appearance
- Reliability
- Ease of maintenance

Widseth Smith Nolting and Associates (WSN), an engineering firm in Alexandria, MN, was hired to act as city engineer for Spring Hill's sewage treatment project. They had worked with the federal and state regulations for wastewater treatment in other communities in Minnesota and were familiar with the alternatives. Mayor Wuertz said, "Tim Bayerl (technical engineer at WSN) knew all the rules and regulations, the laws, and what you have to do." The first step was to write a preliminary engineering report listing the facts and alternatives.

Jim Merrick (USDA Rural Development) became involved in the discussion of wastewater treatment in Spring Hill within the first month. Rural Development works to streamline agency procedures, reduce red tape, and target resources to develop sustainable communities in rural America. Merrick would help Mayor Wuertz complete the proper grant funding applications once the decision was made. Chris English (technical advisor from Rural Development) wanted Spring Hill's choice to be economical and use the least amount of land—a solution with a *smaller footprint*. His role was to review the project before approval for funding.

The agencies working to help them were eager to make the right choice. "Everybody was easy to work with because we

all have the same goal. We all want to see no sewage running in our creek," Mayor Wuertz stated. With the advice and guidance from Environmental Services, MPCA, the Minnesota Assistance Program, Rural Development, and WSN, the city council and mayor of Spring Hill were able to make an informed decision about the future wastewater treatment for the community. Most of the community attended the city council meetings where they learned the wastewater treatment options. Presentations and discussions lasted 6 to 8 mo from November 1997 into the summer of 1998.

### The Options

In addition to the desire to protect the health of humans and the environment, all of the options presented to the mayor and city council for Spring Hill's wastewater treatment needed to consider the site condition, the cost, and the management required. Examples of standard wastewater systems considered are septic tanks and mounds. New technology in sewage treatment considered for Spring Hill included the options of aerobic tanks, constructed wetlands, and drip irrigation. Municipal stabilization ponds were also considered.

Feasibility for each option was based on soil texture (for permeability), water table elevation, elevation gradient, and estimated daily load. Karen Voz, Stearns County Environmental Services, working with Spring Hill said, "Soils on one side of County Road 80 are one type and the other side of the road are another. Half the town could have trenches, while the other half would need mounds." In Minnesota, treatment systems must have 3 ft (0.9 m) of separation between the treatment area and the water table, bedrock, or compacted soil. Soil borings and percolation tests are necessary to determine proper location of a waste treatment system. In addition, county and city ordinances set limits for distance between treatment systems and wells or lakes, property lines, or rights-of-way. All the alternatives address the need for effective wastewater treatment to protect human health and the environment and have the same endpoint.

After examining the environmental conditions of Spring Hill, five alternatives were proposed by Tim Bayerl for the city council and mayor to consider (not prioritized):

**1. Construct a new municipal stabilization pond in Spring Hill.** A stabilization pond is a conventional treatment system often used in small cities where wastewater is collected from the entire community and treated in an open lagoon. Microorganisms break down the organic wastes in the lagoon. Sun and wind along with the biota reduce biochemical oxygen demand (BOD) and nitrogen concentrations in the effluent, but have little effect on total suspended solids (TSS) and phosphorus concentrations. The initial cost is high for this option and the costs during a 20-yr design life for operation, maintenance, and repair are the highest of all the options. The advantage of the municipal stabilization pond is that it is a common method of wastewater treatment, so management requirements are well established.

**2. Connect to a municipal sewage treatment plant 7 miles (11.2 km) northeast of Spring Hill.** The communities of Greenwald, Elrosa, and Meire Grove (GEM) had joined forces about 12 yr earlier to build a centralized sanitation plant with open lagoons. Pipelines and a lift station would need to be installed to force Spring Hill's wastewater to the GEM

sewage treatment lagoons. The project costs included the 7 miles (11.2 km) of pipeline and the lift station. In addition, GEM would establish monthly sanitary sewer service charges that would be billed to the residents of Spring Hill. It was possible that the GEM project would need to enlarge its system to accommodate Spring Hill, which would further add to the cost.

**3. Collection of Spring Hill wastewater from individual septic tanks at each residence followed by aerobic treatment of the combined sewage in a centralized location.** Septic tank systems rely on an anaerobic (without oxygen) breakdown process, which produces the characteristic septic odor (hydrogen sulfide gas). In an aerobic treatment unit, water passes into an aeration chamber where a pump and compressor supply a constant flow of air. A stirring mechanism helps oxygenate the water, creating optimum conditions for aerobic microorganisms to decompose organic compounds. An electrical power supply is necessary to run the pump, compressor, and stirring mechanism. An aerobic treatment unit allows more organic material in the water to be digested than occurs in a septic tank, thus reducing the amount of pathogens, BOD, and TSS. Water exiting the aerobic tank would discharge to subsurface drip irrigation using the soil for final treatment. The aerobic unit would be located within or very near the city limits similar to option no. 1. The site location guidelines for an aerobic tank are similar to those for a septic tank. The disadvantages of the aerobic tank alternative are that its effluent varies in quality and it requires highly skilled technicians to operate and maintain systems, adding to the overall cost.

**4. Install individual sewage treatment system (ISTS) mounds for clusters of houses or single homes.** A sewage treatment mound is a seepage bed of clean sand raised to provide separation between the wastewater and the water table or bedrock beneath. A mound system follows primary treatment in a septic tank. Life expectancy is approximately 30 yr (Univ. of Minn., 2000). The challenge facing Spring Hill for this option is that space is limited on each property or near each cluster of properties in which to build a mound. If neighbors share a mound, a legal agreement is necessary. Where space is a problem, adjacent land might need to be bought, assuming the owner is willing to sell. The advantages of ISTS mounds are that they require little maintenance if properly constructed and dosed, and their low cost. The disadvantages are the possibility of freezing or clogging in winter and the amount of land necessary for proper distribution of effluent.

**5. Centralized constructed wetland for additional treatment of septic tank effluent.** Constructed wetlands are managed ecosystems designed, engineered, and constructed to handle the estimated amount of wastewater generated. The principal design goal is to remove nutrients, pathogens, toxicants, biodegradable materials, and some trace metals. Pre-treatment at individual or municipally owned septic tank(s) is required before the wastewater enters two gravel-filled wetland cells. Septic tank effluent is pumped from the septic tank(s) through cell no. 1, then no. 2. Each cell is lined with an impermeable liner. Plants in each wetland cell take up nutrients and provide a source of oxygen at their roots for microorganisms. Final treatment occurs in an unlined wetland cell, a trench, or a drainfield–drip irrigation area. Wetland systems can filter wastewater indefinitely if they do not reach

**Exhibit 2. Equivalent annual cost summary (assumed interest rate = 8.00%).**

	Collection and stabilization pond	Collection and forcemain to GEM	Collection and aerobic treatment	Individual sewage treatment system (ISTS)	Constructed wetland total (cost)†
Estimated project cost	\$815 290	\$855 858	\$537 206	\$433 130	\$656 600
O, M, and R costs over 20-yr design life‡ (based on present \$)	+\$147 270	+\$ 78 348	+\$107 998	+\$ 49 090	+\$ 61 853

† Total cost includes drip irrigation and all lines, connections, pumps, wetland cells, etc.  
‡ O, M, and R costs are the operation, maintenance, and repair costs.

chemical equilibrium. However, if phosphorus or metals accumulate in the sediments over time, the system may fail unless they are removed. The proposed design of Spring Hill’s constructed wetland wastewater treatment would include pumping the effluent to a drip irrigation area after the second wetland cell. Mulch applied to the ground and snowcover in winter provide insulation for the system, but that does not guarantee there will not be problems with freezing. The disadvantages of this option are the need to monitor rate of inflow to effectively treat the effluent, the need to monitor for nutrients leaving the system, increased maintenance, and the cost of construction.

## THE DECISION

Usually the first choice when faced with wastewater decisions is to modify the existing system using an easy, efficient method. But even simple changes can add to the tax burden of the community. The majority of municipal sewage treatment systems have federal, state, and local government financial assistance available. Grant money may be limited to specific treatment options.

In Spring Hill, each option was examined for the estimated project cost including the annual operation, management, and repair costs. Gross annual costs per resident can be computed based on the total cost (75 people during 20 yr), but the true cost per resident cannot be determined until available grant money is subtracted from the total cost. Mayor Wuertz said that Mark Ritter (Midwest Assistance Program) and Jim Merrick (USDA Rural Development) would help her file the appropriate grant fund requests once the decision was made.

One of the biggest challenges in the decision for the city council and mayor was the cost of the project. “Two-thirds of our community is on fixed income (retired or on assistance). Some don’t even make \$5000 a year,” said Mayor Wuertz with genuine concern. “We have one house here in town that doesn’t even have running water. A 93-yr-old woman lives there. She has a hand pump and no bathroom or kitchen.” Many of the younger residents have moved out of Spring Hill. The Spring Hill city council not only wanted to avoid the MPCA fines, they wanted to choose a wastewater treatment system that would be effective, low cost, and would have relatively little impact on the environment. Exhibit 2 is adapted from Wiseth Smith Nolting and Associates’ engineering report 11 Nov. 1998.

Almost all the people of the community supported the plan for a new system. Mayor Wuertz contacted the residents to see what they thought; only five did not voice an opinion.

Some residents wondered what would have happened if the Stearns County Highway Department hadn't discovered the problem. Mayor Mary Wuertz and the city council worked many months to educate themselves and the community about the options available for their wastewater dilemma. "Everyone knew we had a problem early on and were aware of all the choices. We had to look at which alternative the community could afford. And we didn't want our water to contaminate the creek," said Mayor Wuertz. Knowledge of water quality and concern about long-range environmental effects has increased over the last decades. Mayor Wuertz quickly noted, "Many other towns in Minnesota have the same problem, so they are watching us to see if we succeed. Our decision will affect others who are not in compliance with MPCA regulations."

Mayor Wuertz wondered if the decision they made at the city council meeting would make their neighbors angry. She had tried so hard to include the community. "It's never easy to change from the old ways, but we have got to do something about our wastewater," she said. "What is the right choice? And how will we explain that choice to our residents?"

### **EPILOGUE: OUTCOME OF SPRING HILL'S DECISION**

After many months of discussion, the city council came to a decision for wastewater treatment in Spring Hill. The existing individual septic tanks would be capped and drained, new sewer lines would be installed leading to two 6000-gallon (2280-L) septic tanks, and two 45 by 155 ft (13.5 by 46.5 m) lined wetlands would be constructed. The final treatment would pump the effluent to six drip irrigation areas. A split rail fence would be installed around the wetland cells and signs will be posted to discourage traffic, such as snowmobiles, that would compact the soil.

### **USING THIS CASE IN TEACHING**

Teaching with a decision case gives students the opportunity to actively participate in the learning process by thinking independently about the facts that are presented, by listening to other viewpoints, and by defending their own perspective during classroom discussions. Historically, decision cases have been used in business, law, and medical schools where the needs for critical analysis and problem-solving skills have been emphasized. More recently, decision cases have been used in teacher education, social work, and areas requiring technical decision-making such as engineering and agriculture (Brakke et al., 1994).

The objective of this case is to involve participants in a decision of community wastewater treatment. This case is suitable for use in college level courses on the subjects of water resources management, soil and water management, public affairs, and environmental science. It might also be used to educate decision-makers from other small communities, city engineers, and other agencies involved with wastewater treatment decisions. Although cost and available funding were issues for the city of Spring Hill, the key issues for the professionals who advised the city were protection of human health and the environment, in light of factors such as soil texture,

elevation gradient, depth to water table, and geology. The facilitator–discussion leader can add information to further define wastewater regulations for their community, wastewater characteristics, average household generation of wastewater, and illustrations of wastewater treatment options. He or she can decide on the method of discussion, depending on time and the depth of understanding he or she wants to achieve.

The authors used this case in an upper-level wetland soils course of 24 students during one 3-h class. The students were divided into small groups of 4 to 6 students each. The discussion leader described the case and the choices, then acted as the decision maker. Individual groups addressed the dilemma from the perspective of the following roles: community representatives (e.g., young citizen, citizen on limited income, older citizen), technical engineer who has reported the options, agency representatives who are aware of regulations and the environmental aspects of the case, and the engineer from a constructed wetland firm. Since the object of a decision case is to examine the diversity of perspectives in the decision-making process, a lively discussion of the options developed from these diverse groups. The discussion leader concluded with the epilogue to the case. The students felt the case helped them understand the role of soils in wastewater treatment. They also understood how difficult it could be to make decisions that affect all the residents in a community.

### **DISCUSSION QUESTIONS**

The following questions could be used to orient participants to the case before the group discussion. The questions could also serve as an aid during discussion of the case and its issues, so they could be handed out to the groups during the role-play.

1. What is the problem facing the city council and mayor of Spring Hill? How urgent is it that they find a solution?
2. Discuss the roles and objectives of: the city council and mayor, the MPCA, and Stearns County Environmental Services.
3. What are the factors that must be considered in making this decision? What is the relative importance of each?
4. Which option should the city of Spring Hill choose? Why?

A discussion of this case should cover a comprehensive range of options that could preferably resolve the dilemma of wastewater treatment compliant to Minnesota Statutes and Rules in a small rural community. Soil conditions, rate of wastewater inflow, climate and precipitation, square footage of land needed, appearance of the treatment, reliability, and ease and cost of construction and maintenance are factors that must be considered for every similar situation.

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# Develop Critical Thinking in Group Problem Solving through Computer-Supported Collaborative Argumentation: A Case Study

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## ABSTRACT

This paper reports a study of supporting development of critical thinking skills for 30 students. The students were engaged in ill-structured problem solving exercises in a turfgrass management course with a Computer-Supported Collaborative Argumentation (CSCA) tool. The instructional approach was case-based problem solving involving student presentations, instructor-led discussions, and unmoderated small-group discussions. The students used a CSCA tool, QuestMap, to generate arguments for problem analysis and solutions during small-group discussions. A survey given to the students at the end of the course revealed that the CSCA tool increased clarity of thought, enhanced organization of ideas, enabled in-depth analysis, facilitated sharing of multiple perspectives, and allowed visualization of arguments and discussions. However, out of the 14 respondents, 8 encountered some difficulty in operating the program. Observation of a small group engaging in discussion was used to validate some of the feedback obtained in the survey. It also revealed the students' tendency to make more Claims and Grounds than Warrants in their arguments and to rarely formulate other components of arguments. The group was found to use the CSCA tool as a peripheral tool rather than as a mediation tool during the discussion, an arrangement that might weaken the effect of CSCA.

TRAINING students to become rational thinkers and good problem solvers has been an important educational goal in American schools; problem-solving activities have thus been included as an important part of school curricula. Traditionally, theories, rules, and principles are first taught to students, followed by their application to well-structured problems typified by the end-of-chapter problems in most textbooks. However, problem-solving skills thus acquired may not be transferable to real-life problems, which are often complex and ill structured, and therefore require different skills for successful solutions (Hong, 1998). As a result, there is a movement toward the use of authentic, situated problems (Brown et al., 1989). The problems not only reflect the complexity of the real world, but also necessitate acquisition of knowledge one needs to solve problems, thus making learning more meaningful.

Such authentic, ill-structured problems are ill defined in that there are unstated constraints, and one or more aspects of the problem situation are not well specified (Chi and Glaser, 1985; Voss, 1988). For such problems, there are no general rules or principles to apply. There are often multiple solutions

and solution paths, and consensual agreement on the most appropriate solution is difficult (Kitchner, 1983; Voss, 1988).

Ill-structured problems present immense cognitive loads for problem solvers. Solving ill-structured problems requires learners:

1. To form explicit opinions or beliefs about the problems (Meacham and Emont, 1989).
2. To understand alternative perspectives on the problems.
3. To assess the strengths and weaknesses of these alternative approaches.
4. To make decisions and defend them (Jonassen, 1997).
5. To assemble problem-related information from the memory (Voss and Post, 1988).
6. To monitor the process with metacognitive skills, as well as with an awareness of the validity of alternative solutions (Kitchner, 1983).

Research studies have shown a myriad of difficulties faced by novice problem solvers (Chi et al., 1981; Voss et al., 1983), to whom solving ill-structured problems is an immense challenge.

To support novice problem solvers, one must define the critical skills needed for ill-structured problem solving. Rittel and Webber (1973) proposed that solving ill-structured problems involves debate, negotiation, and conflict, and therefore the central intellectual activity in solving ill-structured problems is argumentation. Cerbin (1988) reinforces this view by claiming (i) the argument is the product of an informal reasoning process and (ii) informal reasoning is the "central intellectual ability involved in solving problems, making judgments and decisions, and formulating ideas and beliefs." Unlike formal reasoning that uses logical rules to prove things to be true, informal reasoning deals with subject matter that can be approached from different perspectives and requires one to state claims and justify them with grounds appropriate to that situation (Toulmin et al., 1984). There are multiple ways to represent ill-structured problems and each way will lead to a different solution. Because there is no best solution, learners should form an argument for their preferred solution and the reasons against alternative solutions. This means that learners have to make claims for their solutions; warrant those claims with theories, rules, or principles; and back them up with supportive evidence (Voss, 1988). Through the process of arguing and counter-arguing individually or within a group, learners can present more cogent arguments for their problem representations and solutions.

Zeidler et al. (1992) see argumentation as a process that engages learners in critical thinking that is necessary for the execution of problem-solving strategies. They contend that when learners make claims and defend their claims through argument and counter-argument, they are using essential critical-thinking operations. These operations include determining the

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accuracy of statements, identifying ambiguous claims or arguments, identifying unstated assumptions, and assessing the strength of an argument or claim (Beyer, 1988).

Argumentation is an important means to ill-structured problem solving, but students often have difficulties with reasoning and forming sound arguments. Results of the National Assessment of Educational Progress (NAEP) (Applebee et al., 1986) showed that only a small percentage of students were rated competent or better on a persuasive topic. Even college students have problems with presenting sound arguments (Perkins, 1985; Cerbin, 1988). To help students develop debate skills, many scholars advocate direct instruction on the structure and notation of arguments (Kneupper, 1978; Cerbin, 1988; Knudson, 1991, 1992; Yeh, 1998). However, to provide support to the learners engaging in group discussions in the absence of an instructor, a scaffolding strategy can be used (Gauvian and Rogoff, 1989; Freund, 1990).

Unlike direct instruction, *scaffolding* involves providing just enough support to learners so they will internalize the processes being supported and will be able to perform them when the support is removed. The process is much like the scaffolding that supports the construction of a new structure and is removed when the structure is completed (Pressley and McCormick, 1995, p. 9). Typically, an adult or a more capable peer could provide scaffolding to assist a child or a learner in learning and mental development. However, scaffolding can also be provided by a cognitive tool (Lajoie and Derry, 1993), which “enhances the cognitive power of human beings during thinking, problem solving, and learning” (Jonassen and Reeves, 1996). A cognitive tool provides scaffolding by assuming the role of an intellectual partner, relieving the learners of unproductive tasks but engaging them to think more critically (Salomon, 1993; Perkins, 1993). Cognitive tools are not “fingertip tools” (Perkins, 1993) that learners can use effortlessly; rather, they provide essential components of a learning environment that causes learners to generate thoughts more critically than they would without the support. Such tools encourage learners to exert greater cognitive effort in constructing their own knowledge (Salomon and Globerson, 1987).

In the case of group problem solving, a Computer-Supported Collaborative Argumentation (CSCA) tool can act as a cognitive tool to scaffold argumentation during the problem-solving process. It can help to scaffold argumentation skills by providing an argument structure and notations that enable learners to make explicit important assumptions, distinctions, and relationships in their arguments (Buckingham Shum et al., 1997). Computer-Supported Collaborative Argumentation tools in graphical modes have the added advantage of enabling users to visualize internal abstractions and make the deliberation process explicit. They also help in collaborative group work by serving as referential objects that allow participants to keep track of and refer to ideas under discussion. While one can also use the symbolism for elements of argumentation on paper, using computer-based tools allows one to maintain an overview of the arguments and expand the details of arguments simply with mouse clicks. Computer-based tools also record the user’s name, date, and time of creation of arguments automatically. More importantly, they allow users at different locations to contribute to the argumentation and thus facilitate collaborative problem solving.

As CSCA is a relatively new technology, there were only a few studies on the use of CSCA in higher education. Carr (1999) found no significant difference in argumentation skills between second-year law students who used a CSCA tool during discussions and their counterparts who were not supported by the tool. He suggested that for law students, who are already highly skilled in argumentation, CSCA functions as an efficiency tool that supports the process of discussion rather than scaffolding the development of argumentation skills. In a preliminary study, Veerman et al. (1999) compared three different modes of collaborative discussion carried out by college students enrolled in Educational Technology and Computer Based Learning courses: an unstructured synchronous discussion (*NetMeeting*), a structured synchronous CSCA tool (*Belvédère*), and an asynchronous threaded forum discussion (*Allaire Forums*). Through comparison of descriptive statistics, the *Belvédère* system generated the most frequent argumentative discussions, even more so than students who received coaching in the *NetMeeting*. Veerman et al. (1999) attributed this to the argumentation interface provided by the *Belvédère* system. The above studies indicate the potential benefit of CSCA tools, especially for users who are not highly skilled in argumentation. However, the paucity of research in this area suggests that this is an area that could be more extensively studied. This study aims to fill in this gap by exploring the applicability of CSCA in supporting ill-structured problem solving in a higher education setting.

## INSTRUCTIONAL ACTIVITIES

Turfgrass management is a complex domain that requires one to understand a wide range of knowledge including agronomic principles of turfgrasses, expectation of golfers, pest control, management of employees, project management, and budget control (Danneberger, 1994). To bridge the gap between classroom learning and real world decision-making in golf turf management, students are required to take the course “Case Studies in Turfgrass Management.” Using this approach, students have to analyze complex real-life cases to develop solution strategies and detailed action plans for dealing with issues emerging from their analyses.

The 30 Caucasian male students who attended the course were mostly employees at golf courses before they were enrolled in a 2-yr technical certificate program on golf turf management offered by a large land-grant university in the north-eastern USA.

The course spanned a period of 7 wk. The students met twice each week with the instructor, and the duration of each class meeting was 75 min. The instructor spent the first seven class meetings thoroughly analyzing the first case problem and exploring solution options through instructor-led discussions. Three important components of turfgrass case studies were discussed—problem identification, analysis, and solution; financial management; and project management. The instructor used the first case study to demonstrate the strategy for problem solving in turfgrass management. Subsequent to the first case study, the students were given three other case-based problems as assignments to be done in groups. The students were randomly assigned to groups of three or four students. Before the whole-class discussion of a case, the students were to meet in small groups and generate group reports,

which were to include problem analysis and solution using QuestMap, a CSCA tool.

During a typical class meeting, all groups would meet for a face-to-face discussion facilitated by the instructor. A group would role-play the various stakeholders involved in a case so as to represent and define the problem. A second group would present their analysis of the problem, and a third group would present and explain their solutions to the problem. Each group presentation was followed by a question-and-answer session, during which the students or the instructor could ask for clarifications on some issues brought out during the presentation. After the student presentations, the instructor would elaborate on key issues of the case and conduct short lectures on relevant concepts, rules, and principles when appropriate.

### Supporting Argumentation with a CSCA Tool

QuestMap, the CSCA tool used in this study, is a Windows-based program that was designed and developed by Conklin and Yakemovic (1991). It has been used commercially by some corporations for group activities such as strategic planning or new product design (Group Decision Support Systems, 2001) and can be adapted to educational settings for collaborative discussion (Carr, 1999). Structurally, it can be used to model a simplified version of Toulmin's model of argument (Toulmin, 1958; Toulmin et al., 1984).

The students received instruction on the use of QuestMap during the second class meeting. The instructor showed the students how to make use of QuestMap notations to construct arguments for problem analysis and solution. A tutorial hand-out was given to the students to assist them with the operation of the program. The students made use of QuestMap to generate three reports during a 4-wk period.

An example of QuestMap argumentation created by a group of students is shown in Fig. 1. The discussion was about solutions to a particular green with drainage, shading, and traffic compaction problems. A student started by creating the problem statement (denoted by the ? icon). Another student put forth his suggestion to the problem: control traffic (denoted by a *bulb* icon). He explained why controlling traffic effect could be a solution (the + icon) and citing soil compaction symptom from the problem description as an evidence of the traffic problem (the *note* icon). Using QuestMap, the students created an overview of their arguments with linkages between their Claims, Grounds, Warrants, or Rebuttals. Each icon could be expanded by a mouse click to show detailed descriptions of their arguments.

### STUDENT FEEDBACK ON THE CSCA TOOL

A survey was administered at the end of the course to find out, from a student's perspective, how QuestMap had helped or hindered the discussion and problem-solving processes. The take-home survey contained five open-ended questions:

1. Describe how your group made use of QuestMap during discussions. (e.g., Did you create the arguments as you analyzed the problem, or did you analyze the problem first and then transform the analysis into arguments? Did the whole group construct the arguments with QuestMap together? Did you work with paper and

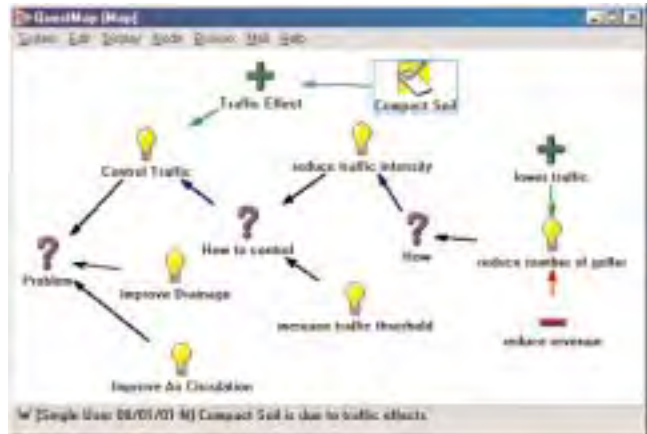


Fig. 1. A example of a QuestMap argumentation on a turfgrass problem.

pencil first before transferring the arguments to computer?)

2. Did you find the use of QuestMap helpful to your case study? If your answer is *yes*, explain how it helps in the case study. If your answer is *no*, explain why you think it was not helpful.
3. Did you find the use of QuestMap helpful to the group discussion process? If your answer is *yes*, explain how it helped in the discussion. If your answer is *no*, explain why you think it was not helpful.
4. What other ways do you think you have benefited from the use of QuestMap?
5. Describe any problems you encountered when you were using QuestMap. How did you overcome these problems?

There were 20 students who agreed to participate in this survey, and 14 individuals replied.

### How QuestMap Was Used

About 40% of the respondents did their arguments on paper using QuestMap notations before transferring them to computer on the grounds that it was easier and faster than putting information directly into the computer. This could be due to the computer competency level of the students. On the other hand, another 40% of the students indicated their preference to work directly with the computer program because they found it more efficient.

For the problem-solving process, the students typically discussed the problems, analyzed them, and transformed the analyses into arguments. As one student mentioned:

As a group, we more or less did straight analysis first. We left the arguments for later after we had researched certain symptoms or the data that was made available to us with each specific case.

### How QuestMap Helped or Hindered the Case Studies

About 70% of the respondents gave favorable comments on the use of QuestMap in case studies. One student described it as "a constructive process to find a good solution to the prob-



lems.” More specifically, the students noted some cognitive benefits of QuestMap. About 29% of the respondents felt that QuestMap could help to promote clarity of thought. QuestMap was described as an effective tool to allow students to “get to the heart of the matter” by guiding them through the “process of concrete analysis” and “enabling them to be clear and concise right to the point.” QuestMap also enabled the students to better organize and study their ideas. This could be attributed to the structure of argument it provides, which some said gave them “a valuable outline to follow” or “an order to proceed through the problem solving process.” About 20% of the respondents indicated that the QuestMap structure enabled them to come up with more in-depth analyses and solutions. One student wrote:

I think that the main benefit of using the QuestMap was it made us go deeper into our analyses of our problems, as well as come up with more than one solution. This made us examine the possibilities of different solutions instead of simply coming up with one obvious solution that may have not been right, but appeared right after only reading the problem.

However, the students also mentioned some drawbacks to QuestMap, the main concern being the difficulty in operating the program and using the notations, a problem labeled as “cognitive overhead” by Buckingham Shum et al. (1997). About 29% of the respondents felt it was too time-consuming and took a long time to become proficient at using the program. One student also found it “confusing and repetitive at times and was unsure of where to put the information.” Another student felt that “it took too long to become proficient at using the program, and hindered our discussions.”

### **How QuestMap Helped or Hindered the Discussions**

About 79% of the respondents found QuestMap helpful in making the “group discussion clearer and easier to follow.” QuestMap provided structure and organization for discussion, helped to “organize thoughts and ideas,” and allowed students “to be specific and talk about certain points without having to discuss the problem as a whole.” Furthermore, it provided visual representations and by making arguments visual, “it was easier to follow people’s trains of thought.” It was also felt that QuestMap could promote multiple ideas and perspectives and that it helped the students to discuss “different viewpoints and come up with different problems and different solutions for these problems.”

On the other hand, about 21% of the respondents did not find QuestMap helpful in the discussion process. One student revealed that the group members usually completed their discussion before doing their maps. Another felt that the group was able to have a quality discussion without using QuestMap.

### **Other Benefits of QuestMap**

The responses to Question 4 were scanty and most could be grouped under other questions. Besides being helpful to case studies and group discussion, one student felt QuestMap was a valuable tool for problem solving, even in a noneducational setting. Another student found it an excellent tool for presentation, which helped in “getting the ideas across in a clear manner.”

### **Problems Encountered When Using QuestMap**

The students encountered one main problem in using QuestMap: technical difficulties in using the program. About 43% of the respondents had difficulty saving the program to a disk. This was because the students had to export the file to an ASCII format so that it could be imported to another computer for presentation or assessment purposes. The students also found the program not user friendly and felt that the tutorial session on the use of QuestMap could be more in-depth. The situation was aggravated because the instructor also encountered technical difficulties in getting the computer projector to work in the small classroom. Within the three sessions of presentation, only one group succeeded in presenting their arguments with QuestMap, but the size of projection was not big enough for the text to be seen clearly by the whole class.

One student also reported having problems with the QuestMap notations during group discussion. The group was not sure how to put the information in the relevant icons and sometimes repeated the same statements under different icons. This indicates their confusion in creating arguments with QuestMap notations.

### **OBSERVATION OF A CSCA GROUP DISCUSSION**

The main purpose of the observation session was to gain insight into the role of a CSCA tool during a group discussion and problem solving process. It also helped to validate the responses of students in their assessment of QuestMap.

The senior author observed a group consisting of three members—designated Andrew, Bobby, and Calvin. Before the group discussion, Bobby and Calvin had a preliminary discussion and they had at that point created some argumentation using QuestMap. The purpose of having a prior discussion was not clear, and that discussion may have affected the observed discussion and some valuable information—especially on the creation of QuestMap argumentation—may have been lost.

Audio recording was used during the observation, and field notes were taken to capture some nonverbal behaviors. In the analysis of the data, the audio recording was first transcribed into text and then entered into a word processor. The text was then segmented into message units, each carrying one of the following communicative acts: Claim (statement of the problem), Grounds (the facts of the situation), Modifier (the extent of certainty by which the grounds justify the claim), Warrant (general rules or principles), Backing (justification for why the warrants are applicable in the specific case), Rebuttal (conditions under which the grounds may not justify the claim), Planning, QuestMap, On-Task Comments, and Off-Task Comments. The message units were also classified into the following interactive moves: Making Argument, Opposition, Counter-Opposition, Continuation, and Comments. This method of discourse analysis is similar to those reported by Resnick et al. (1993) and Kelly and Crawford (1996).

### **Background to the Discussion**

The focus of discussion was the case of the Number 4 green on the Gary Player Golf Course at Sun City in South Africa. Layering seemed to be the main symptom of problems on this golf course. Records of soil temperature and root

depth, temperature and rainfall, as well as cultural practices for the Number 4 green were also available to the students. The students were asked to create two argumentation diagrams using QuestMap—one on the analysis of the problem and the other on the solutions.

### Using QuestMap

The survey revealed that most students did the problem analysis and solution before transferring the information into QuestMap, but this group used QuestMap in a unique way. The group started the discussion with QuestMap argumentation prepared by Bobby and Calvin. During the group discussion, Andrew and Calvin were more involved in the problem analysis while Bobby was recording and modifying the arguments. Thus, there was a constant input of information into QuestMap throughout the discussion. However, as a group they had more extensive discussions on how to transfer the information to QuestMap toward the end of the session.

### Argumentation Pattern

Andrew contributed the most to the discussion, about 51% of the message units. Calvin contributed moderately in the discussion (32%), and Bobby participated the least in the conversation (17%). However, Bobby was solely responsible for entering and editing information into QuestMap argumentation during the discussion.

The group was task-oriented, which was evident from the dominance of on-task message units (95%) compared with off-task message units (5%). The extent of argumentation in the discussion was rather high. If simple agreement message units like *yup* or *OK* and occasional off-task comments are disregarded, argumentation contributed to 85% of the message units. Among the argumentation units, a relatively high percentage of Claims were made (45%), followed by Grounds (35%) and Warrants (15%). These correspond to the primary elements of argumentation in Toulmin's model (1958). The occurrences of the other three elements were substantially lower (Backing 5%, Rebuttal 0.4%, Modifier 0%).

By a simple comparison of the percentages of the argumentation components, it is evident that the students did not always support their Claims with Grounds and Warrants, much less with the other components of argumentation. A more detailed examination of the transcript showed that this weakness in argumentation did exist, but the percentage of Claims was partly inflated because the participants sometimes restated or rephrased their Claims.

Among the other components of argumentation, the students demonstrated their strength in presenting and clarifying supporting evidence. They frequently referred to the printout of the case description and information. They also appealed to the accuracy of the Grounds, as is evident from the high percentage of clarification related to Grounds (45%). However, they were weaker in presenting Warrants, which means the relationships between the Grounds and Claims were not always explained using rules or principles.

The poor performance in stating backing and modifier could be due to the fact that these components were not directly supported by the use of QuestMap in this study, but the major weakness of the students lay in their infrequent use of

rebuttal. It indicated a low emphasis on assessing or evaluating the solutions they proposed.

### Interaction Pattern

In terms of interaction modes, making arguments had the highest occurrence (32%). There was a moderate amount of making comments (20%), seeking clarification (19%), and continuing or elaborating an argument (26%). However, opposition (2%) and counter-opposition (1%) occurred minimally.

The results show a much stronger tendency among the students to present their arguments than to oppose and counter-oppose arguments made by others. Evidently, heated debates did not occur during the discussion; instead, challenging of ideas occurred in the more subtle form of seeking clarifications. About 45% of the clarifications focused on Grounds or evidence. This is an indication that the participants appealed to the Grounds for support of arguments.

### Guiding Discussion

There was some evidence that QuestMap may play a part in shaping the discussion. First, Bobby was evidently assigned the role of transferring the discussion into QuestMap as he was working on it throughout the process. Andrew and Calvin, while heavily engaged in problem analysis and solution, talked with Bobby about the QuestMap argumentation at various points in the discussion, more so toward the end of the discussion. Thus, the group shared a common goal and the discussion was geared toward construction of the QuestMap argumentation.

The visual representation provided by QuestMap may have some influence on the students. This was evident when Andrew started drawing his argumentation map on paper. However, the simple map drawn by Andrew resembled something more like a concept map. The paper-based argumentation map became a visual representation of problem analysis for Andrew. He constantly referred to it while accounting for the problems they had discussed.

QuestMap might also help to promote depth of thought in encouraging students to revisit their ideas. While recalling their analysis for QuestMap argumentation, the students also reviewed and elaborated their analysis. For instance, Andrew suggested the new idea of using ammonium sulfate to overcome a low N rate. The students also extended their discussion on the type of topdressing to be used while discussing QuestMap arguments.

### IMPLICATIONS FOR INSTRUCTIONAL DESIGN

The study showed that many students faced technical difficulties in using the CSCA tool. To facilitate efficient use of QuestMap in the future, we could conduct more training on the use of the program before its application by the students and provide support to students who face difficulties with the program.

To overcome confusion in using the notations of the CSCA tool, a simple approach would be to give more elaborate instructions on the use of the notations in the program so that the students could use it effectively in problem solving instead of being hindered by them. The instructor could also allocate

more time in class for discussions on the QuestMap arguments created by the students and on issues concerning the use of the program.

However, part of the problem could be due to the use of QuestMap notations to represent Toulmin's model of argument. A survey of some of the QuestMap arguments produced by the students showed that, despite being instructed in the tutorial to use the + icon for Warrant, intuitively some students used this symbol to represent advantages of a solution. Even though the students were not instructed to include backings in their arguments, a couple of students use the *note* icon to describe backings rather than evidence. This becomes an issue of graphical interface design.

Mountford (1990) suggests that interpretation of a graphical user interface depends on the user's prior knowledge and experience. In this study, the students have poor prior knowledge of argumentation, as indicated by the low pretest argumentation scores; it is likely that the students will interpret the iconic representations of the CSCA tool using their everyday experience. Furthermore, the terms *Pro* and *Con* were used in the pull-down menu of the program. As a result, there could be a mismatch between the instructor's intended use of the notations and the students' interpretation of the notations. Cocklin (1988) argues that if a software system's model is incongruent with the user's mental model of a task, the user will face the double task of working the system and accomplishing their primary goals. This is in agreement with the findings of Buckingham Shum et al. (1997), that cognitive overhead could hinder rather than facilitate user performance. Thus, a more radical solution to the problem of cognitive overhead is either to adopt the argumentation structure of the program or to design a new program that uses the desired argumentation model.

## CONCLUSIONS AND RECOMMENDATIONS

The students' feedback on the benefits of the CSCA tool was consistent with the theoretical contentions of a number of researchers (Brown, 1986; Buckingham Shum et al., 1997). Students indicated that QuestMap increased clarity of thought, enhanced organization of ideas, enabled in-depth analysis and solutions, facilitated sharing of multiple ideas and perspectives, allowed visualization of arguments and discussions, and promoted teamwork and on-task behaviors.

Observation of a CSCA discussion group was also consistent with feedback obtained in the survey. It revealed the students' tendency to make more Claims and Grounds than Warrants in their arguments, and rarely to formulate other components of arguments. An important finding was that the CSCA tool played a peripheral role rather than being the central focus during the discussion, an arrangement that might weaken the effect of the CSCA tool. This is because the CSCA tool exerts its effects through scaffolding. To achieve this effect, the students have to follow the structure provided, internalize the argumentation structure, and be able to apply it later without the support of the CSCA tool. Thus, it would be more effective to mediate the discussion using the CSCA tool through a computer network, rather than allowing students to first hold a face-to-face discussion and transform their arguments using the program.

To be more successful in using the CSCA tool, we need to overcome the problems faced by the students, which are the technical difficulties and cognitive overhead in using the program. Although more extensive training, support, and guidance could be given to the students, a more radical approach is to adopt the argumentation structure of the program or to design a new program for intended argumentation model, rather than adapting the notations of an existing program for another argumentation model.

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# The Euphrates–Tigris Basin: A Case Study in Surface Water Conflict Resolution

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## ABSTRACT

Historically, the Euphrates and Tigris waters have been a major source of freshwater conflict in the Middle East. Originating in Turkey, both rivers flow southwestward through Syria and Iraq, to discharge into the Persian Gulf. The irregularity in their seasonal flow necessitates the development of efficient storage and diversion systems to ensure adequate irrigation to the area's dominant agricultural sector. Consequently, water utilization projects undertaken by upstream riparian countries trigger confrontation, leading to hostilities and strained relations. These water development projects are best exemplified by the Turkish GAP project, which provides Turkey extensive control over the Euphrates water, through the construction of 22 dams and 19 hydropower plants. Located upstream, Turkey regards the Euphrates and Tigris Rivers as Turkish waters; the downstream countries, Syria and Iraq, view them as international rivers whose waters are to be mutually regulated. International politics, the typical East–West rivalry, and the continuous competition for leadership in the area further aggravates the conflict. This paper presents a decision case to be taken by an international committee composed of UN representatives, nongovernmental organization (NGO) mediators, and ministers of the involved riparian states. The committee (i.e., the participants) should set strategies for the resolution of the water conflict through the harmonious utilization of the Euphrates–Tigris waters. This case study targets a course of education at the graduate or senior undergraduate level based on water resources issues impacting stability in the Middle East.

WATER SCARCITY is evident in the Middle East, where inhabitants receive <math>1000\text{ m}^3</math> of water precipitation per year, and where the entire region is water-short. Currently, 9 out of 14 Middle Eastern countries experience water scarcity, with the others rapidly approaching this status, especially with potential global climate change and increased desertification (Samson and Charrier, 1997; Darwish, 1994). In the Middle East, water withdrawal as a percentage of renewable water supplies falls within the highest in the world, although the renewal rate is rather low because the region is arid (Darwish, 1994).

The incapability of current Middle Eastern water resources to meet growing demand is expected to continue in the future due to increases in population and consumption (Turkish Ministry of Foreign Affairs, 2001). Moreover, the sensitive water shortage issue is further complicated by the sharing of water among several, generally water-deficient, riparian states, which instigates political pressure and tensions over water

rights (Haddad and Mizyed, 1996). This, coupled with drying oases and shrinking aquifers, is likely to cause water to replace oil as the traditional driver of conflict in the Middle East (Mideast News, 1998).

In the context presented above, the Euphrates–Tigris Basin represents one of the critical water conflict issues in the Middle East. Turkey, Syria, and Iraq presently share the waters of this basin. There has been a history of disagreements among these countries concerning the nature of these waters, their fair and optimal distribution, and the rights of each nation to utilize these water resources.

While the conflict among the riparian countries is basically posed in the context of water, it is inevitably linked with international politics, the typical east–west rivalry, and the continuous competition for leadership in the area. Turkey regards the Euphrates and Tigris Rivers as Turkish waters, whereas Syria and Iraq view them as international rivers whose waters are to be shared. Turkey emphasizes the rational utilization of the Euphrates waters and demands the inclusion of the Orontes (Asi) river in the negotiations, a notion strictly opposed by Syria, due to the historical dispute over the Hatay province (Arab Iskanderun). Turkey's internal problem with the Kurds is further accentuated by Syria's continuous support to the Kurdish Workers' Party (PKK). Such Syrian action antagonizes Iraq as well because Iraq has similar problems with the Kurds. Furthermore, recent development projects on the Euphrates have revived animosities dating back to World Wars I and II. This paper presents a case study that focuses on the Turkish–Syrian–Iraqi conflict over the shared water resources of the Euphrates–Tigris Basin and considers the decision to be taken by an international committee<sup>1</sup> for the equitable distribution of these waters among the riparian states. The case can be used by graduate or senior undergraduate students to play roles as opponents, supporters, and/or mediators in a conflict resolution situation.

## Historical Background

In the early 1900s, Turkey, then governing the Ottoman Empire, controlled present day Saudi Arabia, Jordan, Iraq, Lebanon, Syria, and Palestine. Although Turks and Arabs share the same Islamic religion, they are the descendents of two distinct ethnic groups, speaking different languages. Following the outbreak of World War I in 1914, Turkey aligned itself with Germany against France and Britain. Meanwhile, Syrian groups protested against their suppression by Ottoman governors and demanded complete Arab independence. At the

<sup>1</sup> Composed of top-level ministers, in coordination with the foreign ministers of the three riparian countries (Turkey, Syria, and Iraq), United Nations' (UN) representatives, and several NGO mediators.

**Abbreviations:** NGO, nongovernmental organization; PKK, Kurdish Workers' Party; UN, United Nations; NATO, North Atlantic Treaty Organization; BCM, billion cubic meters; MCM, million cubic meters; GAP, Southeastern Anatolia Project; ECE, Economic Commission for Europe; ILA, International Law Association.

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same time, Britain had early interests in limiting Russian influence in northern Mesopotamia and in protecting its oil interests in the region (Library of Congress, 2001).

In 1915, Britain sought control over the Middle East and resorted to the Arabs to weaken Ottoman control in the region by instigating Arab revolts against the Turks, first in Palestine and then Hijaz, while promising to support Arab independence (Thornton, 2000). At the time, the Arabs were not aware that Britain and France had agreed to subdivide Middle Eastern states between them in the secret Sykes–Picot Agreement (16 May 1916), whereby France was to control Lebanon and Syria, and Britain was to control what became Iraq and Transjordan (Library of Congress, 2001; Thornton, 2000). These events later triggered feelings of Arab betrayal among the Turks and left the Arabs with long-term feelings of resentment for the West.

During the French Mandate, Syria was divided into five areas: Jabal ed Druze, Aleppo, Latakia, Damascus, and Alexandretta (Arab Iskenderun), in an attempt to weaken a burgeoning Arab nationalist movement. The latter district of Alexandretta, located at the border between Syria and Turkey, housed a Turkish minority and had a separate government. During the Syrian–French treaty negotiations of 1936, Turkey demanded reconsideration of the Syrian province of Alexandretta based on the large Turkish minority residing there and its particular administrative system implemented under the Franco–Turkish agreement (Franklin–Bouillon Agreement) of 1921. In 1939, France agreed to Turkish demands; Alexandretta has evolved since then into the long-disputed Hatay province between Syria and Turkey (Library of Congress, 2001).

It is also worth mentioning that under French rule, Syria became a shelter for groups persecuted from neighboring countries, mainly Kurds, Armenians, and Assyrians. The Kurds, who were promised a motherland in the 1920 Treaty of Sevres, fled from Turkey (to Syria and Iraq) between 1924 and 1938 when Mustapha Kemal (Ataturk) attempted to force his reform programs on them (Library of Congress, 2001; Thornton, 2000).

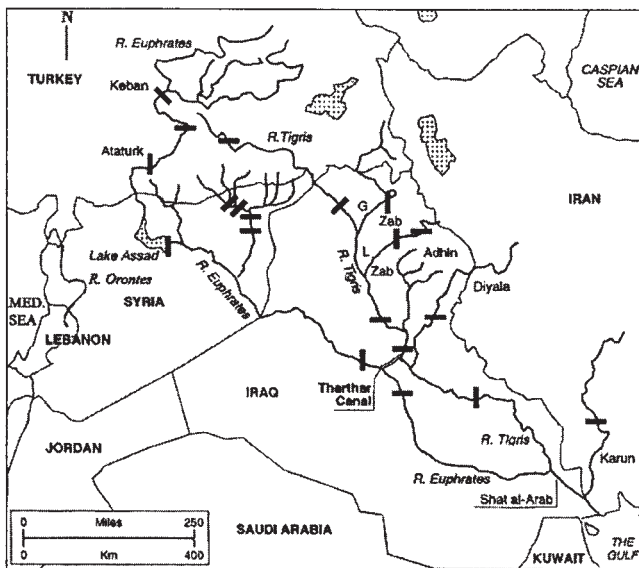


Fig. 1. The Euphrates–Tigris Basin (Dolatyar and Gray, 2000).

In summary, there is a long historical conflict between Turkey, Syria, and Iraq, starting with the Ottoman reign, and including the Arab rebellion, Syrian resentment for what they perceived as the arbitrary transfer of the province of Alexandretta to Turkey by the French, and finally the unwelcome immigration of Kurds to the neighboring Syrian state.

## THE CASE

The Euphrates–Tigris Basin, shared by Turkey, Syria and Iraq, represents a typical case of historical conflict related to water issues in the Middle East. At the root of the conflict lie the increasing population and the respective rising demand for water, accompanied by the desire for long-term food security and self-sufficiency. Political and historical animosities between the countries further amplify the problem.

### The Euphrates–Tigris Basin

The Euphrates River, at 2700 km, is the largest river in western Asia. It originates in the Armenian Plateau in Turkey and flows southeastward entering Syria at Karkamis, downstream from the Turkish town of Birecik, and southern Iraq near Qusaybah, where it joins the Tigris River near Qurna in Iraq to form the 193 km long Shatt al-Arab, which eventually discharges into the Persian Gulf (Fig. 1). Upon reaching the plains of Iraq, the Euphrates decreases in both volume and velocity (Chalabi and Majzoub, 1995; Britannica, 2001; Kaya, 1998). There is a clear imbalance in the supply of the river's waters (Table 1). It is worth mentioning that Saudi Arabia is usually excluded from the riparian states since its Euphrates stretch generally dries out in the summer (Kaya, 1998).

The 1900 km long Tigris River, on the other hand, is a typical mountain stream that rises from the Southeastern Taurus Mountains and other tributaries, some of which originate in Iran (Chalabi and Majzoub, 1995). It flows for 450 km through Turkey to the border city of Cizre, where it delineates the border between Turkey and Syria for 32 km, then crosses into Iraq at Faysh Khabur. Although Iran includes a large part of the catchment area, the main river does not flow through it (UNEP, 2001); hence, the country is generally ignored in studies of the Tigris Basin.

The economic life of the Euphrates–Tigris Basin remains reliant on the rivers' waters. Historically, the agriculture of southeastern Anatolia, as well as of northern Iraq and Syria, has been entirely dependent on rainfall, with some minor mechanical irrigation systems particularly in Syria. Another feature common to both rivers is the heavy concentration of suspended sediment in their waters, especially at the time of seasonal floods (Britannica, 2001; Dolatyar and Gray, 2000). Agricultural and hydropower potential of the rivers are disproportionately concentrated in Turkey (Table 2; similar data for Iraq are unavailable). There are considerable discrepancies among data pertaining to the basins' hydrologic configuration, depending on the reporting source. This is clearly depicted in Table 3, which compares data collected from several sources.

### History of Treaties and Conflicts

Along the Euphrates and Tigris Rivers, Turkey, Syria, and Iraq have experienced numerous confrontations over water resources. Strained relations and growing tensions have brought

**Table 1. River characteristics.**

	Euphrates				Tigris			
Length, † km	2 940				1 900			
Basin area, ‡ km <sup>2</sup>	579 314				371 562			
Annual average flow, BCM § yr <sup>-1</sup>	32 ¶				42 ¶			
Highest flow (April), ¶ % of average river flow	28.7–30.5 #				43–52.6 #			
Lowest flow (September), ¶ % of average river flow	275				260			
	33				23			
Country shares								
	Euphrates				Tigris			
Turkey	Syria	Iraq	Saudi Arabia	Turkey	Syria	Iraq	Iran	
Basin fraction, † %	21.0	16.5	48.8	13.3	14.0	0.3	38	47.2
Length, † km	1 176	604	1 160	--	440	44	1 400	--
Basin area, ‡ km <sup>2</sup>	1 21.8	95.4	282.5	77.1	53.0	0.9	1 42.2	175.4
Annual flow contribution, † ‡ %	89	11	--	--	51	--	39	10
† UNEP, 2000.	¶ Bagis, 1997.							
‡ UNEP, 2001.	# Kaya, 1998.							
§ BCM, billion cubic meters.	†† Chalabi and Majzoub, 1995.							

the riparian countries to the verge of war on several occasions. These tensions are due to a number of different variables, including the East–West rivalry characteristic of the area that fed political resentments and animosities (Berman and Wihbey, 1999). With regard to water management, however, Turkey did not disagree with either Syria or Iraq until the late 1980s, due to Turkey's unilateral minimum flow guarantees, which were kept to ensure international financing for building its dams. Besides, until the mid-1980s, hydroelectric developments actually benefitted the downstream states by regulating the river flow. Thus, as long as Turkey's projects were restricted to covering its energy requirements, the protests of the downstream countries remained limited to the period of dam filling (Çarkođlu and Eder, 1998).

The three countries have experienced various alliances in the past, forming a geopolitical approach to the conflict. Syria was loosely aligned with the former Soviet Union in the Cold War while Turkey was part of the North Atlantic Treaty Organization (NATO), a membership strongly opposed by Syria and Iraq (The Estimate, 1998). Next, Syria and Turkey opposed the Iraqi military actions of the 1970s against the Kurdish groups, which were receiving aid from Iran. During the 1980s, Turkey and Iraq joined forces against the Syrian military mobilization along the Syrian border; finally, Turkey and Syria sided with the allied forces against Iraq during the Persian Gulf War in the early 1990s (Kjeilen, 2001; Scheumann, 1998). Moreover, the Turkish–Israeli strategic military and commercial alliance, which has long been considered aimed directly at Damascus, has brought about an improvement in the relations between Syria and Iraq (Kor, 1997; The Estimate, 1998).

The first modern international agreement related to the use of water in Mesopotamia was the Franco–British convention of 1920 (also known as Luzon's Treaty, Paris), where the signatory powers agreed to establish a committee to examine and coordinate water utilization of the Euphrates and Tigris. In 1946, a Turkish–Iraqi Protocol was signed, the main purpose of which was the construction of protection and observation posts on Turkish territory to prevent downriver flooding and, thus, benefit Iraq.

The question of the Euphrates also stirred up tensions between Syria and Iraq. In 1975, the quantity of water entering Iraq fell by 25%, from 28 billion cubic meters (BCM) per

annum to approximately 21 BCM due to the filling of the Syrian Tabqa Dam. Baghdad responded by mobilizing its troops at the Syrian border (Chalabi and Majzoub, 1995).

Two phases can be distinguished in the exploitation of the Euphrates. During the first phase, from 1946 to 1960, no far-reaching projects were undertaken. In contrast, the second phase, from 1960 until now, has been marked by a series of projects, all of which were characterized by an almost complete lack of cooperation among the three riparian states. Table 4 highlights major events, as well as the agreed upon and still disputed issues among Turkey, Syria, and Iraq since 1946. The most controversial disputes are discussed individually below. It can be noted that each of the riparian countries has tended to develop its water use plans unilaterally, irrespective

**Table 2. Agricultural and hydropower potential of Turkey and Syria.**

State	River	Active reservoir storage capacity †	Irrigated area ‡	Annual hydro-power potential §
		BCM §	10 <sup>6</sup> ha ¶	GWh §
Turkey	Euphrates	42	1.74	38 940
	Tigris	15.5	0.65	16 880
Syria	Euphrates	16.1	0.31	
	Tigris		0.21	

† Bagis, 1997.

‡ Bayazit and Arci, 1997.

§ BCM = billion cubic meters, GWh = gigawatt hours.

¶ Values should be multiplied by 10<sup>6</sup> for the actual values.

**Table 3. Comparative hydrology of the Euphrates and Tigris Rivers.**

River	Length	Total discharge	Drainage area
	km	BCM yr <sup>-1</sup> †	km <sup>2</sup>
Euphrates	2 320–2 330 ‡ §	31.8 ‡	444 000 § ¶ #
	2 700 † †	33 ¶	
	2 940 ‡ ‡		
Tigris	1 658	42 #	
	1 840 ‡	49.2 ‡	378 850 ¶
	1 900 † †	47 ¶	471 606 ‡

† BCM yr<sup>-1</sup> = billion cubic meters per year.

‡ Lowi, 1993.

§ Anderson, 1991.

¶ Gleik, 1994.

# Starr and Stroll, 1988.

†† Hillel, 1994.

‡‡ UNEP, 2000.

**Table 4. Agreed and conflicting issues between the three riparian states.**

Year	Agreed issues	Conflicting issues	Parties
1911–1914†	Iraq was the first riparian to develop engineering projects in the basin (Hindiya barrage) for flood control and irrigation		
1946‡§	Flood control structures Turkey monitored flow of both rivers and shared obtained data		Turkey and Iraq Turkey, Syria and Iraq
Early 1950s†	Second Iraqi Euphrates barrage		
1956§		Syrian dam on Orontes river	Turkey vs. Syria
Late 1950s†	Russians researched Syrian reach of the Euphrates and proposed a dam at Tabqa		
1964§	Minimum release of 350 m <sup>3</sup> s <sup>-1</sup> (during the filling period of Keban Dam in Turkey)		Turkey and Iraq
1966†		Keban Dam	Syria and Turkey
1966†	Syrian–Soviet agreement started the construction of the High (al-Thawrah) Dam		Syria and the former Soviet Union
1973†	Syrian Tabqa dam completed		
1974–1975†§		Filling period Keban dam	Iraq vs. Syria mediated by the Soviet Union and Arab countries
1975–1976†§		Filling period Tabqa dam • Iraq threatened to bomb the dam • Troops massed on mutual borders	
1976‡	Unofficial deal reached with intervention of Saudi Arabia. Syria will keep 40% of water and allow 60% to flow to Iraq		Iraq and Syria
1980‡	Establishment of the Joint Technical Committee on Regional Waters		Turkey and Iraq
1983‡	Syria's inclusion into the committee¶		Turkey, Syria, and Iraq
1986§	Minimum release of 500 m <sup>3</sup> s <sup>-1</sup> (filling period Karakaya Dam in Turkey)		Turkey and Iraq
1987§	Minimum release of 500 m <sup>3</sup> s <sup>-1</sup> at Turkish–Syrian border (during the filling period of Ataturk Dam in Turkey)		Turkey and Syria
1990§	Proportional shares for Syria (42%) and Iraq (58%) from Turkish release		Syria and Iraq
1991§		700 m <sup>3</sup> s <sup>-1</sup> instead of 500 m <sup>3</sup> s <sup>-1</sup> Date and duration time of filling period Ataturk dam; minimum release not ensured	Syria/Iraq vs. Turkey Iraq/Syria vs. Turkey
1995–1996§		Birecik dam	Syria/Iraq, Arab League vs. Turkey

† Kaya, 1998.

‡ Larko'lu and Eder, 1998.

§ Scheumann, 1998.

¶ The JWC faced difficulties handling issues on its held meetings in Ankara, Baghdad, and Damascus. The completion of the Ataturk Dam led to conflicts and the eventual dismissal of the committee.

of the needs of other involved parties, the environment, or actual basin capacity (Chalabi and Majzoub, 1995).

### *Conflict over the Orontes (Asi) River*

The first conflict between Turkey and Syria was over the Orontes River (Asi in Arabic and Asi Nehri in Turkish) that arose when Syria applied for World Bank loans to build its Ghab Valley Project in the 1950s. Despite Syria's subsequent withdrawal of its request, the Orontes River remained a sensitive issue between the two countries (Çarkođlu and Eder, 1998).

The Orontes (Asi) River rises in Lebanon, and flows northward through Syria and Turkey through the Hatay Province<sup>2</sup> to discharge into the Mediterranean Sea. It flows 40 km in Lebanon, 120 km in Syria, and 88 km in Turkey. Its annual runoff at the boundary between Turkey and Syria is estimated to be about 1.2 BCM (Turkish Ministry of Foreign Affairs, 2001). To obtain water for irrigation, two water regulators have been placed in Lebanon on the Orontes and one regulator in the Syrian town of Jisr-Al-Sughur. There are also two Syrian dams on the Asi, the Destan and Maherde (Turkish Embassy, 2001).

Syria, the upstream country in this case, started with the construction of a dam in 1956 to provide water for irrigation. Turkey blames Syria for using up to 90% of the Orontes' flow, leaving none for Turkish farmers (Chalabi and Majzoub, 1995; Dolatyar and Gray, 2000). Turkey states that the Orontes

<sup>2</sup> Also known as Arab Iskanderun to the Arabs. Located at the Syrian–Turkish border, there has long been a territorial dispute between the two countries over this area.

water that actually enters Turkey is reduced to a mere 120 million cubic meters (MCM), due to excessive Syrian extraction, and that the construction of another two planned reservoirs threatens to further reduce this value to 25 MCM per year (Turkish Ministry of Foreign Affairs, 2001). Turkey also blames Syria for being cooperative only with Lebanon<sup>3</sup> on the issue of the Orontes river, although Syria claims to have continually negotiated with both Lebanon and Turkey (Kor, 1997).

The Orontes' issue remains disputed: Turkey wants it to be part of the Euphrates' negotiations, while Syria strictly refuses, since Syria still denies Turkey's right to the Hatay province, through which the Orontes passes (Çarkođlu and Eder, 1998).

### *Conflict over the Southeastern Anatolia Project (GAP)*

Syria and Iraq initiated a financial campaign against the upstream Turkish projects by securing an international financial blockade on the Southeastern Anatolia Project<sup>4</sup> (GAP). They managed to make Turkey bear the huge cost of its major projects without external funding (\$32 billion (U.S.) to date) by convincing the World Bank that it should not finance GAP

<sup>3</sup> Syria and Lebanon made an agreement on 20 Sept. 1994, according to which Lebanon is allowed to use 80 MCM of water from the Orontes River (Turkish Embassy, 2001).

<sup>4</sup> The Southeastern Anatolia Project (GAP), initiated in 1977, is the largest multisectoral integrated regional development complex in Turkey, lying at the lower reaches of the Euphrates and the Tigris Rivers. It involves the construction of 22 dams and 19 hydropower plants on the Euphrates and Tigris Rivers and an irrigation network for 1 693 027 ha of land. Out of the planned dams on the Euphrates, three are currently in operation, namely the Keban, Karakaya, and Attaturk dams (Altinbilek and Akcakoca, 1997; Bagis, 1997).



until Turkey works out a riparian treaty. This reflected negatively on the Turkish national economy and forced Turkey to postpone the implementation of the full project for at least 30 yr (Dolatyar and Gray, 2000).

The GAP Project provides the best example of Turkish developments that have increasingly threatened to diminish and even eliminate water access to its neighbors, despite the signed protocol of 1987 that ensures Syrian access to Euphrates water. Once fully operational, the GAP project would reduce the Euphrates water flow to Syria by 40% and to Iraq by up to 80% (Berman and Wihbey, 1999). This reduction threatens the continuity of Syria's irrigation programs and sufficiency of water levels in the Assad Lake that are necessary for the sustainable production of hydroelectricity (Kor, 1997).

Turkey stepped up the development of the GAP project in the 1980s. Turkey also shifted the emphasis of the project from mere hydroelectric use of water to integrated regional development, encompassing other economic and social improvements such as transportation, industrial employment opportunities, and improved education and health services. These new dimensions enlarged the scope and heightened the intensity of the conflict (Kaya, 1998; Çarkođlu and Eder, 1998).

Syria regards the GAP project as a threat to its agricultural and energy projects, while Iraq accuses Turkey of infringing on its acquired historical rights by utilizing more water than it is entitled to use (Newspot, 1997). In response, Turkey asserts that it has increased the flow before the filling of the dam, whereby the total amount released—when averaged over a period of a few weeks—exceeded the minimum water obligation to Syria. Turkey also claims that the cutoff did not affect the flow from tributaries entering the Euphrates below the dam (The Estimate, 1998).

### ***Conflict over the Kurdish Workers' Party***

Syrian vulnerability to Turkish control of upstream resources is further complicated by Syria's sustained support of the uprising Kurdish Workers' Party (PKK), a fact that has recently led Turkey to threaten a blockage of water (Berman and Wihbey, 1999). The conflict over the Kurds is the latest outstanding conflict dimension, whose stirring may be attributed either to the Syrian attempt to offset Turkish supremacy in other domains or to Syria's frustration at Turkey's unwillingness to commit to a written minimum flow commitment (The Estimate, 1998; Turkey Update, 1998). This conflict dimension is critical since >30 000 Turks have died in pursuit of an independent Kurdish state (The Wall Street Journal Europe, 1998).

While Iraq has also been involved in the past in supporting the PKK, it is Syria's involvement with the Kurdish group that infuriates and threatens the Turks (The Estimate, 1998). In this context, Turkey and Syria argue over three major points. First is Syria's support for the Kurdish rebels of the PKK in general. Second is the fact that the PKK leader Abdallah Ocalan<sup>5</sup> has long resided in Damascus, although Turkey insists he should be handed over for trial. Finally, Turkey demands the immediate closure of all training camps and sus-

<sup>5</sup> Finally, Abdallah Ocalan was apprehended by the Turks in Nairobi, Kenya on 15 Feb. 1999 and sentenced to death in a Turkish court. The Turkish government agreed to postpone carrying out the death sentence pending a ruling by the European Court of Human Rights on the appeal of Ocalan.

pension of all logistical and/or financial support for the guerillas (Turkey Update, 1998). It is worth mentioning, however, that there have been few if any clear instances of Kurdish operations occurring over the Syrian-Turkish border; almost all strikes originated in Iraq (The Estimate, 1998).

Syria denies Turkey's accusations of being a key source of support for the PKK; Turkey insists that Syria plays a vital role in financing and equipping the party and that it houses training camps in Syria as well as in the Lebanese Beqa'a Valley, over which Syria has effective control. In an agreement signed by both parties in October 1998, Syria agreed to close the Lebanese and Syrian training camps, prevent Ocalan from returning to Syria from his stay in Moscow, prevent all cross-border operations, and stop all forms of support to the PKK. However, Turkey remains skeptical of Syria's adherence to the treaty (The Estimate, 1998).

### **International or Turkish Waters?**

In short, the Arab-Turkish dispute over the legal status of the Euphrates' and Tigris' waters revolves around the following: Syria and Iraq regard these rivers as international, and thus, claim a share of their waters. Turkey, in contrast, refuses to concede the international character of these two rivers and only speaks of the rational utilization of trans-boundary waters. Furthermore, Turkey considers the unlimited use of these waters according to its needs as its natural right.

### ***The Syrian Perspective***

Syria claims historical rights to the rivers' waters based on ancient use (Kor, 1997). Syria declares that the Tigris and Euphrates Rivers are international watercourses that must be shared and proposes a simple formula<sup>6</sup> to resolve the issue (Newspot, 1997). The Syrians argue that there is a clear contradiction in Turkey's behavior in connection with settling the water question with Syria and Iraq. Sometimes Turkey regards the Tigris and Euphrates Rivers as international waters to be shared, and at other times it considers them Turkish waters. Moreover, Turkey offers technical solutions for the management of the two rivers according to its own conception of the rational usage of water. Turkey does not acknowledge the Syrian or Iraqi rights to these rivers (Arabic News, 1997). According to Syria, Turkey has violated long established international rules by disregarding the rights of other countries sharing the same river to use international river waters. Turkey has also violated the principle of "not harming others" through the construction of huge dams on both rivers, regardless of Syrian or Iraqi rights or needs in that respect. Syria also contends that Turkey misunderstood the principle of "notification," which represents the minimum level of necessary cooperation to avoid disputes (Arabic News, 1997). Further, Syria advocates a role for the UN in all negotiations and requests that the International Law Commission's studies be fi-

<sup>6</sup> Syria's mathematical formula foresees that:

- Each riparian State shall declare its demands on each river separately.
- The capacities of both rivers in each riparian State shall be calculated.
- If the total demand does not exceed the total supply, the water shall be shared according to stated figures.
- In case the total demand of water, declared by the three riparians, exceeds the water potential of a given river, the exceeding amount should be deducted proportionally from the demand of each riparian state (Kor, 1997).

**Table 5. Per capita surface water in the Euphrates–Tigris Basin.**

States	Total water/year	Population	Annual per capita water
	BCM†‡	millions§	m <sup>3</sup>
Turkey	100	65.7	1522
Syria	23	16.3	1411
Iraq	91.2	22.7	4017

† BCM = billion cubic meters.

‡ Bagis, 1997.

§ CIA, 2000.

nalized and strict rules and regulations be established (Kor, 1997).

### The Iraqi Perspective

Iraq claims that it possesses acquired historical rights to the waters of the Euphrates and Tigris that date back thousands of years (Newspot, 1997). The Iraqi attitude of the late 1990s may be characterized as somewhat calmer, due to Iraq's relative autonomy with respect to its access to the Tigris waters. This situation may not last, however, because Turkish acquisition efforts are expected to focus on the Tigris River water in the near future (Berman and Wihbey, 1999). Maintaining a low profile has, to date, served Iraq's interests in the best manner. This has been the case for three major reasons: (i) Iraq always had a Kurdish problem of its own; (ii) Iraq was engaged in an intense war with Iran in the 1980s; and finally (iii) Iraq had to remain on good terms with Turkey to market its oil to the west after the Gulf War (Dolatyar and Gray, 2000).

### The Turkish Perspective

Turkey acknowledges that it has more water than its neighboring countries, however, it claims that it will barely be able to meet its own needs in the near future. According to the Turks, the claim that Turkey is the region's richest country in water resources is greatly exaggerated; out of 186 BCM annual runoff, only 110 BCM are utilizable, due to various water losses. Turkey compares its available water per capita (1522 m<sup>3</sup> yr<sup>-1</sup>; Table 5) to that of the water-rich countries, which typically possess 8000 to 10 000 m<sup>3</sup> yr<sup>-1</sup>, to substantiate its claim of adequate vs. ample water supply. Further, Turkey focuses on its inability to fully utilize its available water whereby it uses only 25.9 of the 110 BCM available due to technological, topographical, and geological constraints (Bagis, 1997; Newspot, 1997; Tomanbay, 2000; Dolatyar and Gray, 2000).

Furthermore, to support its position, Turkey repeatedly compares its water rights to the Arab oil rights. Turkey's Minister of State, Kamran Inan, claims that Turkey possesses the same right to the waters of the Euphrates and the Tigris as the Arabs do their oil.

From the moment that Saudi Arabia stopped giving away its oil, Turkey could no longer regard its water as a present to be given away for free. The Turks do not claim Arab oil but they (the Arabs) claim our water. The Euphrates truly is a Turkish asset.

Colonel Alpasian Turkes

Turkey, in this sense, acknowledges the right of a country to a resource that originates within its territory, as in the Arab's right to their oil, and thus regards the Euphrates and Tigris Rivers, which have their sources in Turkey, as natural Turk-

ish rights. Turkey argues that it is already sharing its water with the Arabs without a legal obligation to do so (Chalabi and Majzoub, 1995).

In response to the Arabs' claim that the rivers are international, Turkey argues that the so-called *acquired rights* claimed by Syria to the *international* watercourses of the Euphrates and Tigris do not carry much weight when applied to water shared by several countries. This is due to the numerous factors influencing decisions of this nature. Turkey also rejects the use of any kind of mathematical formula for water allocation by appealing to the Report of the International Law Commission of the UN to the General Assembly on shared natural resources, which does not include phrases like "sharing common resources through a mathematical formula" (Newspot, 1997).

In contrast, Turkey recognizes the principle of *equitable utilization*, as determined by international law, for the allocation of shared water sources as the most acceptable, since it accounts for socioeconomic, geopolitical, and hydrologic factors. Turkey insists that water supplies have not been used to exert pressure on Syria and Iraq, and emphasizes the necessity of common criteria for the use of water from the Euphrates and Tigris Rivers. Accordingly, Turkey proposed to both Syria and Iraq that the equitable usage of water supplies be based on inventory studies by all three countries of their land and irrigation needs, evaluation, and information sharing. These shared scientific studies, designed to assess the real needs of the involved countries, are in Turkey's opinion, the sole means to achieve *equitable* or rational utilization of regional water supplies (Newspot, 1997).

Turkey criticizes the way Iraq and Syria have mutually agreed on the volume of water that each wants to receive. With respect to the demanded flow of 700 m<sup>3</sup> s<sup>-1</sup>, Turkey claims that a 500 m<sup>3</sup> s<sup>-1</sup> flow would be more than sufficient for the irrigation needs of Syria and Iraq, especially because the Syrians, claims Turkey, are wasting much of the 500 m<sup>3</sup> s<sup>-1</sup> anyway (According to Turkey, Syria requires only 250 m<sup>3</sup> s<sup>-1</sup>). In addition, Turkey directs Iraq to settle its water problem with Syria before negotiating with Turkey, since the Euphrates comes to Iraq after flowing through Syria (Chalabi and Majzoub, 1995).

## THE LEGAL ASPECT

In theory, water conflicts may be resolved through the application of international water laws that address the basic interests of the international community. These include the maintenance of international peace and security; development of friendly relations among riparian states; achievement of international cooperation on economic, social, and cultural problems; sovereign equality of all member states; and peaceful settlement of disputes. Nonetheless, the application of international laws is limited, since they tend to lack clarity and enforceability, and thus may be rendered ineffective when a nation ignores, or is not party to, the laws in question. Historically, upstream and downstream riparian states have advocated extreme and self-interested theories as outlined below.

### International Rivers Law

#### General Principles

Despite the urgent nature of the global water problems, the international law of water resources still lacks in maturity and

**Table 6. General principles of International law, implications, and advocates.**

Principle	Statement	Characteristics/implications	Adopted by	Riparian position
Absolute territorial sovereignty (Harmon Doctrine)	A state may freely utilize waters flowing over its territory, regardless of the adverse effects on other states.	Conflicts with principles of international law pertaining to the responsibility of states for acts committed on their territory, that may be harmful to other states	Turkey	Turkey is not obliged to share the waters of the Turkish Euphrates and Tigris Rivers with its Arab neighbors.
Absolute territorial integrity	A riparian state is forbidden from utilizing its waters to alter the course, flow rate, volume, or quality of the water delivered to the downstream state(s).	Favors downstream riparian states Implies that no state has the right to change the natural flow of a river in a manner that will negatively impact the downstream state(s) Prevents development by upstream state	Syria	Syria asks for a fair allocation of the rivers' waters, referring to the catastrophes that would result if every country were to diverge the stream of rivers originating on its territory.
Limited territorial sovereignty	A watercourse state can freely utilize waters flowing through its territory, provided that this use will not be harmful to the reasonable utilization of water by other watercourse states.	Prevailing theory in international law Sanctioned by doctrines of conventional law and supported by decisions of international tribunals, state practice, and a vast majority of international jurists An agreement remains necessary since limitations on sovereignty can only be voluntary	Iraq	Iraq claims its ancient right to the Euphrates and Tigris waters.
Community of coriparian states	The development of an integrated program for the entire watercourse system without the limits of political borders is recommended.	Accounts for interests of all riparian states through ensuring optimal water utilization Not legally binding in contemporary international law		

sophistication. The determination of the specific rights and obligations of riparian states requires that general principles apply to international rivers. These would also serve to resolve the issues of apportionment, consumption, and conservation of the waters flowing in these rivers. Four basic principles regarding the utilization of international fluvial waters have been formulated and are summarized in Table 6 (Chalabi and Majzoub, 1995; Hirsch and Housen-Couriel, 1993; Dolatyar and Gray, 2000).

In 1997, the UN General Assembly approved the Convention on the Law of the Non-Navigational Uses of International Watercourses<sup>7</sup>; that Convention included provisions on their protection, preservation, and management. The Convention does not provide definitive rules for water allocation, but rather lists several factors to be considered and adapted to specific local conditions. Preservation addresses the uses that lead to the water quality degradation due to various environmental factors such as erosion and sedimentation. Syria was in favor of the principles set forth by the Convention, while Turkey rejected it because of objections to its prologue as well as specific articles which Turkey asserted created an inequality between states and did not establish the dominance of equitable and reasonable utilization over the obligation not to cause significant harm (United Nations, 1997; Shumueli and Shamir, 2001).

<sup>7</sup> This convention was concluded within the United Nations Economic Commission for Europe (ECE), signed at Helsinki on 17 Mar. 1992, and entered into force in late 1996. There is also a valuable work by the International Law Association (1967), which was published as: Helsinki Rules on the uses of the Waters of International Rivers (Dolatyar and Gray, 2000). Widely adopted principles of the Framework Convention include (Turkish Ministry of Foreign Affairs, 2001):

**Article 5:** Trans-boundary rivers should be used in an equitable, reasonable, and optimum manner.

**Article 6:** Equity does not mean equal distribution. It rather depends on a wide range of factors that have to be taken into consideration.

**Article 7:** Individual watercourse states must exercise due diligence to make sure that they do not inflict significant harm to others.

**Articles 8 and 9:** Cooperation and the regular exchange of information between riparian states is vital.

### *Allocation of the Waters of International Rivers*

Ideally, waters of international rivers are to be shared *equitably* and *reasonably* among the riparian countries. This requires the consideration of various factors relating to the international watercourse, as stipulated by the Helsinki Rules<sup>8</sup> and the 1997 UN Convention on the Law of the Non-Navigational Uses of International Watercourses. These international Laws proposed the equitable and reasonable allocation of water, taking into account various factors including: (i) natural physical factors such as climate, geographic, hydrographic, and hydrologic factors; (ii) social and economic needs and gains of each watercourse state; (iii) population; (iv) past and present utilization, existing and potential use of the water; (v) the extent to which the needs of a riparian state can be met without significant damage to others; (vi) the availability of alternatives along with their respective value and cost; (vii) practicability of compensation in case of dispute; and (viii) how the needs of one riparian state may be fulfilled with minimal injury to another riparian state (Hirsch and Housen-Couriel, 1993; Kaya, 1998). While these rules are widely accepted and have a broad scope, they are still not binding in international law. They are simply articles that have been adopted by the International Law Association (Kaya, 1998).

### **International Rivers Law in the Euphrates–Tigris Case**

Syria and Iraq argue that current utilization of water must be distributed in accordance with the second principle of the Helsinki Rules, namely that “prior use determines water rights.” Both countries call for the estimation of the total potential water supply of each river and for comparing this total to the total water quantity demanded by the riparian states. If the total demand were to exceed the total supply of a particular river, which is very likely, the surplus would be deducted proportionally from the demand of each riparian state (Kaya, 1998).

<sup>8</sup>Adopted by the International Law Association (ILA) in 1966, which proposed that international waters have to be shared equitably and reasonably (Kaya, 1998).

From a Turkish perspective, the approach adopted by Iraq and Syria allows them to determine their own water requirements without external verification, which may lead to inflated demands that aim at the gain of additional water. Moreover, Turkey regards their position as strictly reflective of the theory of territorial integrity, which is not accepted by the rule of international law. According to Turkey, it has offered, since 1984, a “three-staged plan for optimal, equitable and reasonable utilization of the transboundary watercourses of the Euphrates–Tigris Basin” (Turkish Ministry of Foreign Affairs, 2001). This plan proposes the joining of all riparian states to achieve inventory studies for water resources (Stage 1), inventory studies for land resources (Stage 2), and evaluate water and land resources (Stage 3). This would lead to the accurate compilation of data, upon which proposed projects could be evaluated on the basis of their economic and social advantages. The most beneficial projects could then be implemented. In Turkey’s view, the three-staged plan conforms to the principle of equitable utilization by considering the basin as a whole system, underlining the interdependence of its elements, as required by the UN Watercourses Convention. However, Turkey fails to acknowledge the limited resources of some riparian states, which would be placed at a disadvantage in conducting these inventories, incurring substantial economic costs.

### THE DECISION

The sensitive conflict over the equitable allocation of the Euphrates–Tigris waters represents one of the most controversial issues in the history of the Middle East. Turkey regards the Euphrates and Tigris Rivers as strictly Turkish waters, whereas Syria and Iraq view them as international rivers whose waters are to be shared, claiming historical use rights. Based on the presented information, the international committee needs to develop a set of strategies for the resolution of the water conflict issue. The negotiations are to be held at an international level, and thus, decisions—which should consider the economic, environmental, political, and technical aspects of the three involved parties as well as forecasted shortages—are to be firmly implemented and respected. What strategies would the committee suggest for the resolution of the conflict?

### TEACHING NOTE

#### Case Objectives

This case study presents a contemporary and predominant conflict issue in the Middle East, which may threaten the stability of the region. The case should allow students to:

- Gain familiarity with the water status in the Middle East, especially with respect to the Euphrates–Tigris Basin
- Understand the various underlying factors of the water-related conflict in the framework of the Turkey–Syria–Iraq historical–political quarrel
- Recognize the interrelation between natural resources and politics
- Enhance their skills and objectivity in tackling sensitive sociopolitical water resources issues
- Recognize and review international laws and regulations related to cross-boundary waters

- Identify potential approaches to be adopted in water scarcity cases
- Define and evaluate implementation strategies for cooperation among conflicting nations

### Uses of the Case

This case primarily targets senior and graduate level students in natural and water resources management and environmental engineering and science. However, other students in political sciences, social studies, agricultural sciences, or related fields may find it equally beneficial. Students will employ crucial decision-making skills to link the scientific and sociopolitical components of the case. The case, based on region-specific data and historical events, provides students with an opportunity to study and evaluate water resources management in a water-scarce region. The extensive social and political considerations play a major role in this case due to the historical and long-standing conflict among the populations involved.

### Implementation of the Case

Given the delicate sociopolitical aspects of the case, scientific objectivity is vital in the implementation of this case. It is helpful if students are briefly introduced to the history of the Turkish–Syrian–Iraqi political conflict before being exposed to the case. Numerous books have been written in this regard and much information can be found on the Internet. The case was used in a graduate-level course on environmental case studies and conflict resolution at the American University of Beirut. The class was composed primarily of environmental science students with diverse backgrounds (chemistry, geology, physics, civil engineering, ecosystem management, and environmental education). Invariably, the feedback of students was important; in fact, their input was used to improve on the case and refine certain questions.

Case studies can be used in a variety of ways in a classroom setting (Herreid, 1994),<sup>9</sup> but the implementation should be appropriate to the background of the students and the objectives of the course. This particular case lends itself to role-playing whereby students assume the role of opponents or supporters of Turkish, Syrian, or Iraqi views. An outside panel totally unfamiliar with the case could be invited to listen to the debate and make a decision based on the arguments presented by the students. Role-playing offers the advantage of developing analytical skills, practicing public speaking, and promoting awareness of socioeconomic, political, and cultural constraints.

### DISCUSSION QUESTIONS

**1. What are the common drivers of freshwater conflict?** Freshwater is vital for food security and socioeconomic de-

<sup>9</sup> Case studies can be used in a variety of ways: (i) assign the case as outside reading, followed by a general class discussion with a decision that needs to be reached with the corresponding justification; (ii) require written reports for grading purposes and after correcting the reports, discuss the answers in class in the context of actual events and what the final decision could be; (iii) read the case in class (about a 3-h class, the case would be too long for a 1-h session) and then discuss all or selected questions, either as a whole class or in small groups. Although the latter approach requires the least amount of class time, it also provides the least chance for students to reflect on the issues raised in the case.

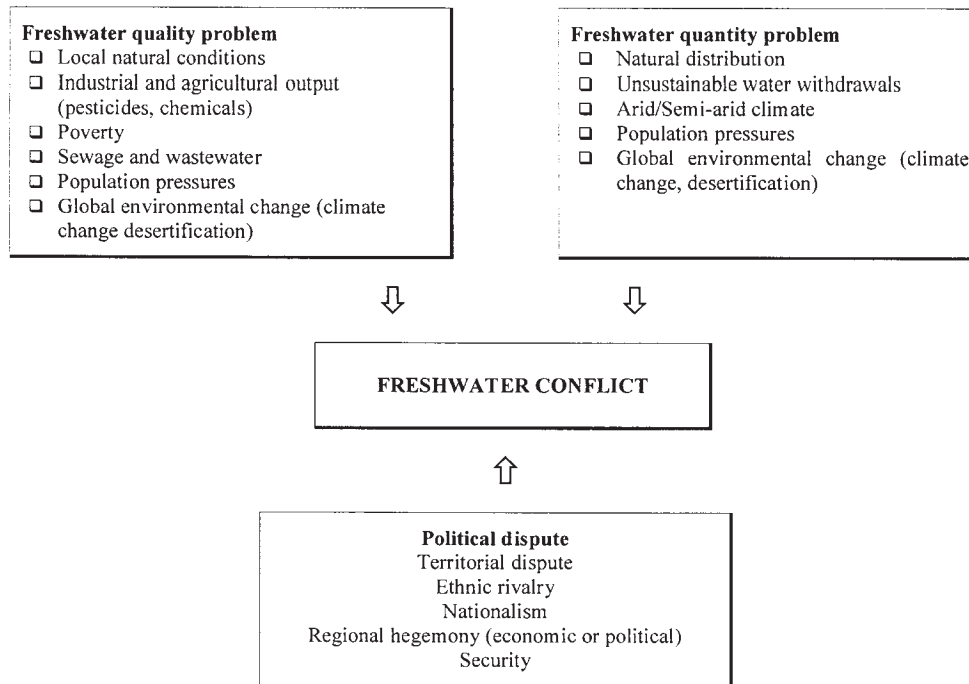


Fig. 2. Drivers of freshwater conflict (Samson and Charrier, 1997).

velopment. Due to water's uneven spatial and temporal distribution, issues of its accessibility and quality represent significant driving forces behind conflict, the type and severity of which depends on the nature of the region. International freshwater conflicts are multidimensional, including ecological, technical, economic, and political drivers as shown in Fig. 2 (Samson and Charrier, 1997).

**2. Does the Euphrates–Tigris represent international or trans-boundary waters?** According to the definition of the *international river basins* contained in Article 2B of the UN Convention, an “international watercourse means a watercourse parts of which are situated in different states.” According to the Helsinki Convention and to the Permanent Court of International Justice, an “international river is a watercourse that separates or crosses the territories of several states” (Dolatyar and Gray, 2000). The Turkish definition of an international river as one that has its opposing banks under the sovereignty of different countries renders both rivers trans-boundary rather than international (Chalabi and Majzoub, 1995). It is evident that the latter definition of an international river is not in accordance with the former two.

**3. Is Turkey (the upstream country) harming Syria and Iraq by the GAP project?** The extensive development projects undertaken by Turkey on the upstream side of the Euphrates decreased the water share of Syria and Iraq, regardless of the latter's consumption patterns. However, Turkey can argue that it was providing Syria and Iraq with more water than they required from the start. The adoption of the principle of optimal and sustainable utilization allows the upstream country additional power due to the absence of a clear definition of acceptable harm.

**4. What arguments are presented by each party in defending its water rights?** Table 7 outlines the main arguments

presented by Syria, Iraq, and Turkey with respect to defending their water rights.

**5. How should water scarcity issues in the Middle East be approached?** Water scarcity issues in the Middle East may be approached from several perspectives, at least including security, economic, legal, technological, and environmental (Dolatyar and Gray, 2000).

First, water is a natural resource that is often regarded as a source of power, since it is often linked with national security, socioeconomic development, and political influence. This perspective explains the insecurities of Syria and Iraq since they receive less water from the Euphrates than Turkey. On the other hand, this also clarifies Turkey's resort to military threats for the protection and control of its water resources.

Second, economists often argue that water scarcity is basically an economic problem, which will be alleviated if nations treat water as an economic asset (through market mechanisms). Water marketing, however, may be problematic for agricultural workers. Moreover, the establishment of markets in the near term may threaten further instability in the area since it may seem unfair to the involved riparian countries, given the different social and economic status of their peoples.

Third, the root cause of the water crisis is the absence of proper international agreements among riparian countries that clearly define the system of property rights. The situation may be resolved by establishing water rights at the national and international levels, as well as the development of a legally binding agreement.

Fourth, the technological optimists advocate that the water scarcity problems are best solved by technological management of water resources, which eliminates the whole idea of shortages of these resources. Again, this may not be applica-

**Table 7. Arguments presented by each party defending its water rights.**

Syria	Iraq	Turkey
Allocation of water should be according to a mathematical formula.	Allocation of water should be according to a mathematical formula.	Rejects the use of mathematical formulas by appealing to the International Law Commission.
Water management should not take place according to Turkey's conception of rational usage. Claims historic rights based on ancient use.	Claims historic acquired rights to the Euphrates and Tigris waters.	Claims that the acquired rights argument does not carry much weight due to the complexity of contributing factors.
Contradiction in Turkey's characterization of the water (Turkish vs. International).	Somewhat calm attitude due to its relative autonomy provided by current access to the Tigris.	Proposes equitable water use based on inventory studies by all three countries.
Turkey violated the principle of no harm by constructing its dams.	Prefers to maintain good relations with Turkey to be able to market its oil to the west.	Criticizes the manner in which Iraq and Syria have mutually agreed on the amounts of water they want to receive.
Turkey violated the international rule allowing riparian countries to share international waters.	Prefers to maintain good relations with Syria, due to its own Kurdish problem.	Justifies the decreased flow to the downstream countries by addressing their inefficient water systems, which cause losses anyway.
Turkey misunderstands the principle of notification.		The downstream countries were notified and flows were increased for 2 months before dam filling. Compares its water to the Arabs' oil, on which there is no legal obligation to share. Acknowledges its relatively ample supplies, but claims it is not water rich and will face water scarcity in the near future. Claims its water seems ample due to incomplete utilization.

ble due to discrepancies in agricultural practices and irrigation techniques adopted by Turkey, Syria, and especially Iraq, which is unable to apply advanced water resources management techniques due to economic damages ensuing from the Gulf War.

Finally, water crisis is viewed as part of the whole environmental crisis, where the notions of limits to growth, sustainable development, and environmental security are introduced. From this perspective, water scarcity is an environmental problem that emanates from misguided conduct toward nature and unsustainable policies for exploitation of this resource.

Resorting to military, economic, legal, or technological solutions not only cannot solve the problem but also exacerbates the predicament. The solution is to understand the limits to growth of the eco-geographical regions to create sustainable societies.

**6. What is the effect of political factors on the water conflict?** The water conflict in the Euphrates–Tigris Basin is not an autonomous issue; rather, it is the product of different causes that are not directly related to water scarcity in the strict sense.

The three riparian states are at odds with each other for various reasons including:

- The historical territorial disputes between Turkey and Syria over the Hatay province (Arab Iskenderun).
- Internal problems of Turkey and Iraq concerning the Kurdish conflict with the respective governments.
- The typical East–West rivalry, whereby Syria was historically backed by the Soviets and Turkey by the Americans.
- External influences and international politics (Israeli–Turkish vs. Syrian–Iranian alliances).
- The continuous competition for leadership in the area (Iraq, Syria, Turkey, Israel, and Egypt).
- National safety and border protection.
- The historical friction resulting from Turkey's oppressive rule of the Arab world under the Ottoman regime.

- The perceived betrayal during World War I, whereby the Arabs sided with the allies against Turkey and the Central powers.
- Differences in religious sects, which constitute another source of friction, are often exploited by the riparian states. Sunnites are predominant in Turkey, Shiites are becoming predominant in Iraq, although the Sunnites are presently in power, and Sunnites are predominant in Syria; however, the minority Alawites are presently in power.

In conclusion, the lack of cooperation and trust between these riparian countries in their hydro policies is not necessarily the outcome of water shortages only. There is no acute water shortage and there remains a high potential for water savings within the agricultural sectors of all riparian states. This may ease the pressure on the resource but definitely not the tensions.

**7. An important dimension of the problem that is not adequately addressed in water conflicts is the environmental damage that may occur due to dam construction. Discuss these implications further.** Major environmental impacts associated with the construction of dams and increased drainage schemes are presented in Table 8. In less than a decade, one of the world's largest and most significant wetland ecosystems has completely collapsed and turned into fragmented parcels surrounded by drained spaces and barren land. Unless urgent remedial action is taken, the remaining traces of the marshlands are likely to dry up. This has far-reaching implications since the Euphrates–Tigris Basin is the largest river system draining into the Persian Gulf; reducing discharge and changing river flow patterns and quality will also impact the marine environment in the northwestern Gulf (UNEP, 2001).

**8. How may the conflict be resolved?** Resolving the Euphrates–Tigris Basin conflict is best promoted through a comprehensive and integrated regional plan for cooperation concerning water resources. This plan should involve negotiations among the involved parties to reach an agreement on equitable

**Table 8. Environmental impacts due to increased dam construction and drainage schemes.**

Impact	Description
Regional climate change	Potential sharp decrease in evaporation and humidity rates, which will modify rainfall patterns. Increase in temperature, particularly during the summer. Wind-blown dust laced with salt crusts, exposed soils, and impurities will increase, affecting large areas and resulting in environmental degradation. Negative impacts on human health will occur due to water scarcity and pollution, as well as increased exposure to thermal extremes and potentially toxic dust storms.
Habitat loss	Arable lands surrounding the former marshlands are expected to suffer from land degradation and desertification due to wind erosion and sand encroachment. Comparative analysis of Landsat imagery from 1973 to 1976 and 2000 showed that a total of 7600 km <sup>2</sup> of primary wetlands, excluding the seasonal and temporary flooded areas, have disappeared.
Wildlife decline and extinction	Destruction of the wetlands would lead to the global extinction of several species including the smooth coated otter, the bandicoot rat, and the endemic Babel. The marshlands serve as a staging and wintering area for migratory birds on the Western Siberia–Caspian–Nile flyway. Hence, the effects of desiccation are being felt from the Arctic to southern Africa; 66 species of birds that occurred in the marshlands in internationally significant numbers are at risk. Coastal fisheries in the northern Persian Gulf will be affected with potentially serious consequences; for example, 40% of Kuwait's shrimp catch originates from the marshes.
Refugees	Marsh Arabs were forced to flee from their homes as the marshlands began to rapidly dry out in the beginning of the 1990s. An estimated 200 000 to 250 000 Iraqis were internally displaced.

utilization and protection of the Basin's water resources. Due to the complexity of the intervening factors, any solution would require the establishment of an independent party—preferably a legal institution—to encourage the riparian countries to abide by its decisions. This committee should comprise various members representing all involved states and would optimally include the states' foreign ministers, members of the UN, scientists, and NGO intermediaries to ensure objectivity in decision-making. Furthermore, each riparian state would have to reinforce its legislation on water issues to ensure the implementation of the remaining components of the regional plan, including public awareness campaigns on regional water issues. In this context, several cooperative measures may be taken:

- Awareness building through an easily accessible interactive medium, which reports accurate, unbiased, and informed details. This would aid in expanding the knowledge base of decision-makers for achieving wise natural resources management, stressing the water scarcity issue, and exposing the population to the cost of producing, treating, and distributing water to achieve wise water utilization. The resulting regional database also would aid in responding to emerging water conditions and changes.
- Promotion of multisectoral partnerships among governments, international organizations, NGOs, local groups, business, industry, and academic institutions. This would aid in the formation of a specialized institution for the joint management of water resources and allow for the consideration of all perspectives on the issue.
- Rationalization of water sharing by the UN through the development of more flexible allocation mechanisms. This would encourage the development of cooperative water management plans, promote regional water security, and alleviate fears among the riparian states.
- Integrated assessment or management programs that are sociotechnical in nature and which target not only humans, but also the ecosystem in general.
- Implementation of strategies and formal agreements by making them legally binding. These strategies may include altering the types of crops grown and/or irrigation systems, inspecting the water losses of the different systems, ensuring efficiency of technical and managerial interventions, and

confirming the riparian states' abidance by their allocated share through direct systematic monitoring.

- Exchange of demand management practices among the riparian countries for the optimization of water use. Reducing water demand in turn reduces water scarcity and thus the potential for water conflicts. Practices involve the conservation and appropriate utilization of water supplies through monitoring for leakage to minimize water losses in distribution systems and improving the efficiency of existing irrigation systems (i.e., drip, sprinkler, and automation). Other measures that may be adopted consist of reclaiming domestic and industrial effluents for irrigation purposes, adopting water saving efforts (cascading changes, cooling methods, and conserving water at the municipal level through decreasing losses due to unaccounted-for-water), and utilizing demand reducing kits (Arlosoroff, 1996).

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# Decision Case: The Carbon County Ball Fields<sup>1</sup>

Paul G. Johnson\* and Marlon B. Winger

## ABSTRACT

**Poor soil conditions, poor construction techniques, intense foot traffic, and limited budget often make it difficult to maintain a quality turfgrass cover on many municipal athletic fields. The Carbon County Ball Field complex was built in 1978 in Price, UT. During construction, the highly saline and shallow soil was severely compacted. By 1998, the turfgrass quality had deteriorated to the point where two of the fields were unplayable. Those responsible for the maintenance of the field tried numerous remedies, all of which failed. Roy Phillips, the county extension educator, was consulted about the condition of the fields. Mr. Phillips sought advice from Dr. Jeff Andersen, the Utah state extension turf specialist. Dr. Andersen agreed that the fields needed improvement and focused on the issues of salinity, compaction, drainage, and proper irrigation. This case was designed for use in an advanced turfgrass management course, and has proven to be useful in applying management options for an athletic field, especially when considering the typically high pH, saline conditions, and soils of the arid West. The students are asked to make recommendations that Dr. Andersen should present to the county commissioner and city officials. Recommendations should involve agronomic solutions that take into account the physical, economic, and social realities of the situation.**

SOILS IN URBAN AREAS often present many challenges to turf managers, especially athletic field managers trying to provide athletes with a safe, wear-resistant playing surface. Building and landscape construction procedures often result in poor quality soil indicated by compaction, high soluble salt levels, low organic matter content, and nutrient deficiencies. Yet the users of the landscapes still expect top quality turf, even on areas that experience intensive use such as athletic fields. The Carbon County Ball Field softball complex in Price, UT, was no exception.

Price (pop. 21 000) is located in central Utah, approximately 165 km southeast of Salt Lake City. Coal mining and its associated support are the primary industries. The region is becoming urbanized and recreational facilities have been lacking. One of the more popular activities is softball as evidenced by numerous city and county leagues. Because existing facilities had been overused and limited the growth of the

leagues, Carbon Recreation decided to use a portion of the Carbon County Fairgrounds for a new, four-field softball complex. The land was already owned by the county, was close to town, and would be near county maintenance facilities, making field maintenance more convenient.

## THE CASE

Construction of the Carbon County Ball Field began in 1978 and consisted of moving soil from the west half of the site to the east half and regrading the area flat to create a relatively level terrace. Topsoil was not replaced after the grading. Road-building equipment was available from the county, and used for the earthmoving and shaping process. The fields were laid out with each field occupying one-fourth of a circle. Buildings and backstops were all at the center of the circle with the fields radiating out from the center. This created four fields designated as northwest (NW), northeast (NE), southwest (SW), and southeast (SE). Before sodding the outfield areas, a mixture 2.5 cm thick of horse manure and sawdust from the fairgrounds was applied and incorporated into the NW and SW fields because topsoil had been removed. None was applied to the east half. An irrigation system was installed by county crews consisting of an irrigation zone for each field and using gear-drive rotor heads (Toro 640). Drainage in the complex consisted of a trench filled with gravel and a drainage pipe around the perimeter of the complex. In addition, three drainage lines were installed in the NW field, one in center field, one in right field, and one in left field. Each drainage line emptied into the perimeter drainage system. The drainage system emptied into an adjacent irrigation water canal. Kentucky bluegrass (*Poa pratensis* L.) sod was purchased locally and transplanted to the fields. The soil layer on the sod was approximately 1.5 cm thick, and was similar in texture to the soil on-site. Ball games started a few weeks after the fields were sodded.

Approximately 48 games were played at the complex each week, plus practices, for 23 wk of the year. Over time, the turfgrass quality of the west half of the complex had declined steadily. The Kentucky bluegrass turf thinned, became severely stunted, and much of it died. Water began to pond, and a white crust on the soil surface became visible, especially in the outfield area of the NW field. Players began complaining about the poor quality fields and unsafe playing conditions.

## Management of the Area

Since 1978, the Carbon County Ball Field has had several turf managers, including the fairgrounds manager and several directors from the city and county softball program. None had prior turfgrass management experience. Each one attempted to improve the irrigation system (to deal with uniformity problems and increase water output) and each had a different management program for the turf. Most of the past field managers felt many of the problems could be solved by simply laying new sod; poor areas were frequently resodded, but the problems never disappeared.

<sup>1</sup> This journal uses SI units, according to the ASA-CSSA-SSSA style. Due to the circumstances of this case study, however, English units are used, either alone or along with SI units.

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Each year between 1978 and 1996, about \$10 000 was put into the complex. In any given year, little money was available for improvements, upgrades, and so forth. Most of the money was put into trying to fix the problems that were occurring. In 1996, the county decided they needed to try to fix the situation and further upgrade the facility.

Between 1996 and 2000, approximately \$50 000 per year was spent, again for mainly trying to improve the field conditions, but also for maintenance such as upgrading shelters and concrete walkways. Typically, \$20 000 has gone toward general maintenance, \$20 000 for equipment, and \$10 000 for repairs, according to Denise Nelson, assistant manager of the field.

Between 1996 and 2000, Roy Phillips, the Utah State University county extension educator for Carbon County was asked for assistance. Roy is the only extension educator serving Carbon County, and his expertise is in cropping systems and agricultural soils. He is also responsible for Master Gardener training, 4-H, and other extension programs conducted in his county. Like most county educators, Roy's time was spread very thin and he could not spend as much time as he would have liked working with the maintenance crews for the softball fields.

### The Problem

By 1997, turfgrass quality of the NW and SW fields had declined to the point where the fields were unplayable. Based on the symptoms of the white crust forming on the soil surface, declining turf quality, knowledge that drainage was poor in the site, and background knowledge that soils in the region are typically high in soluble salts, Roy collected soil samples (Exhibit 1) and made fertilizer and other management recommendations. Roy felt the soils were low in P and K so he recommended four applications of fertilizer (equal ratios of N-P<sub>2</sub>O<sub>5</sub>-K<sub>2</sub>O) each year and to apply them with small equipment rather than large truck-type spreaders, as had been done in the past. Roy recommended increasing aeration frequency to four times per year, increasing irrigation to leach salts, and to *rip* the NW field to reduce compaction. *Ripping* is a deep tillage technique to break up hard pan layers deep in the soil and is a practice most commonly done in crop production. Roy

recommended applications of gypsum for the NW and SW fields at rates of 8967 kg ha<sup>-1</sup> in the most affected sites and 4483 kg ha<sup>-1</sup> in the rest of the NW and SW fields. He also suggested checking the working condition of the field drainage and adding laterals to the existing system. Finally, Roy recommended planting only tall fescue (*Festuca arundinacea* Schreb.), perennial ryegrass (*Lolium perenne* L.), or both in the NW and SW fields, or any place the salinity measurement was above 4 dS m<sup>-1</sup> (mmhos cm<sup>-1</sup>).

The fertilizer recommendations were followed for 1998 and 1999, but as the next field manager came in, Roy's recommendations were ignored. By 2001, Roy was becoming increasingly frustrated. The field managers continued to ask for recommendations but failed to follow his suggestions. In the meantime, turfgrass quality declined further. At this point, Roy decided to contact the Utah State University turfgrass extension specialist, Dr. Jeff Andersen, for assistance. Roy arranged a site visit that included an opportunity for Dr. Andersen to inspect the site, address the problems at the site, make recommendations for the field, and to make a presentation to the city and county officials. Roy thought that bringing in a turf or soils expert from a university may help convince the maintenance crews to follow appropriate recommendations.

Before Dr. Andersen's visit, Roy provided him with the following information:

1. Soil test results from samples taken in 1997, 1998, and 2000 (Exhibit 1). At some point between 1998 and 2000, sand was applied to the field in hopes of improving drainage. The addition of sand is evidenced by the change in soil texture from loam to sandy loam.
2. The soils in this area are classified as a Persayo-Chipeta complex. The Persayo soil is a loamy, mixed, active, calcareous, mesic, shallow Typic Torriorthent. The Chipeta soil is a clayey, mixed, active, calcareous, mesic, shallow Typic Torriorthent. The parent material of these soils is Mancos shale, a type of shale high in soluble salts. Characteristics and use limitations as presented in the Carbon Area, Utah Natural Resources Conservation Service soil survey description (Jensen and Borchert, 1988) are summarized in Exhibit 2.
3. The Mancos shale is unique in that salts are probably being liberated from the shale when irrigation is applied and

Exhibit 1. Soil test result summaries from 1997, 1998, and 2000.

	1997 (Univ. lab test)				1998 (Univ. lab test)				2000 (Private lab test)			
	SE	SW	NW	NE	SE	SW	NW	NE	SE	SW	NW	NE
Soil texture	--†	--	--	--	loam	silt loam	loam	loam	silt loam	sandy loam	sandy loam	sandy loam
pH	--	--	--	--	8.1	7.9	8.0	7.9	8.0	8.2	8.2	8.1
salinity, dS m <sup>-1</sup>	1.3	7.4	19	1.3	0.7	2.4	8.7	1.6	6.9	5.9	2.0	1.4
P, mg kg <sup>-1</sup>	2.5	3.8	29	3.7	18	24	38	15	9	32	13	10
K mg kg <sup>-1</sup>	109	174	400	124	182	191	>400	174	120	230	105	105
SAR	1.0	7.2	18	1.0	--	--	--	--	--	--	--	--
Na, cmol <sub>c</sub> kg <sup>-1</sup>	--	--	--	--	--	--	--	--	1.1	1.9	0.3	0.2
Organic matter, g kg <sup>-1</sup>	--	--	--	--	--	--	--	--	14.5	21.0	17.0	17.0
Ca, cmol <sub>c</sub> kg <sup>-1</sup>	--	--	--	--	--	--	--	--	14.9	10.3	9.4	10.0
Mg, cmol <sub>c</sub> kg <sup>-1</sup>	--	--	--	--	--	--	--	--	3.7	4.2	2.4	2.4
Sulfate-S, mg kg <sup>-1</sup>	--	--	--	--	--	--	--	--	99	99	99	99
Fe, mg kg <sup>-1</sup>	--	--	--	--	--	--	--	--	19.3	37.2	17.7	18.3

† Data not available or determined.

drainage is poor. Irrigation may therefore increase the salinity and allow the salts to migrate up (through water evaporation) into the plant rootzone. As a result, salinity levels might be higher than those typically found in the surrounding unirrigated rangelands.

4. When Dr. Andersen asked Dr. Steven Moser, soil extension specialist, about the soil type and the situation at the Carbon County Ball Field, Dr. Moser responded with an email (Exhibit 3).
5. Roy had a difficult time getting information on the actual fertilization and irrigation program used. However, he was told that N was applied only in one spring application each year and estimated that the irrigation system was run 5 to 10 min, twice a day. Short, frequent watering times were used because water puddled at the surface during and after irrigations, especially in the NW and SW fields.
6. Realizing that the soils were high in salinity, Roy recommended the use of alkaligrass (*Puccinellia distans* [L.]

Parl.), a salt-tolerant, cool-season grass species that has been used with some success on golf courses and some low-maintenance athletic fields in the Intermountain West. The areas were overseeded, but the resulting stand was somewhat thin and clumpy, due in part to the bunch-type habit of growth. The Kentucky bluegrass exhibited a bunchy and stunted habit as well. The condition of the turf resulted in a safety hazard to the players. The softball organizers and others in the county demanded a better playing surface and insisted that Kentucky bluegrass be used. This is the grass with which they were most familiar and is locally available as sod.

7. Another consultant/sales representative, Mr. George Tonneson, advised watering the area heavily to leach the salts; however, he was concerned that the water table was coming to the surface when the area was watered. He asked to have several monitoring wells drilled in the west half of the complex to check the movement of the water table. In

#### Exhibit 2. Summary of soil survey information for the site.

**80 – Persayo–Chipeta complex.** This map unit is on shale hills near Helper, Price, and Wellington. Slopes are 3 to 20%, 100 to 200 feet long, and concave to convex. Elevation is 5300 to 6100 feet. The average annual precipitation is 6 to 8 inches, the average annual air temperature is 48 to 50°F, and the freeze-free period is 115 to 140 days.

This unit is 55% Persayo loam, 3 to 20% slopes; 35% Chipeta silty clay loam, 3 to 20% slopes, eroded; and 10% other soils.† The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are about 5% Killpack clay loam near washes and 5% Saltair silty clay loam in swales.‡

The Persayo soil is shallow and well drained. It formed in residuum and alluvium derived dominantly from shale. The present vegetation in most areas is mainly galleta and shadscale. Typically, the surface layer is light brownish gray loam 3 inches thick. The underlying material to a depth of 12 inches is light brownish gray silty clay loam over weathered shale. Depth to weathered shale ranges from 10 to 20 inches. The lower part of the underlying material has few to common gypsum crystals.

Permeability of the Persayo soil is moderately slow. Available water capacity is 2 to 3 inches. Effective rooting depth is 10 to 20 inches. The organic matter content of the surface layer is 0.5 to 1.0%. Runoff is medium, and the hazard of water erosion is moderate. Sheet erosion is active, and in many places shallow gullies are cut into the weathered shale. The hazard of soil blowing is moderate.

The Chipeta soil is shallow and well drained. It formed in residuum derived dominantly from shale. The present vegetation in most areas is mainly mat saltbush, Nuttall saltbush, and shadscale.‡ Typically, the surface layer is light brownish gray

† Persayo, loamy, mixed, active, calcareous, mesic, shallow Typic Torriorthent; Chipeta, clayey, mixed, active, calcareous, mesic, shallow Typic Torriorthent; Killpack, fine-silty, mixed (calcareous), mesic Typic Torriorthent; Saltair, fine-silty, mixed, mesic Typic Salorthid.

‡ Mat saltbush, *Atriplex corrugata* S. Wats.; nuttall saltbush, *Atriplex gurdneri* (Moq.) D. Dietr.; shadscale, *Atriplex confertifolia* (Torr. & Frem.) S. Wats.; galleta, *Pleuraphis jamesii* Torr.; deserttrumpet, *Eriogonum inflatum* Torrey & Frémont var. *inflatum*; bud sagebrush, *Picrothamnus desertorum* Nutt.

silty clay loam 5 inches thick. The underlying material to a depth of 17 inches is light brownish gray silty clay over weathered shale. Depth to weathered shale ranges from 10 to 20 inches.

Permeability of the Chipeta soil is slow. Available water capacity is about 1.5 to 3.0 inches. Water supplying capacity is 2 to 3 inches. Effective rooting depth is 10 to 20 inches. The organic matter content of the surface layer is 1 to 2 percent. Runoff is rapid, and the hazard of water erosion is high. Rill and gully erosion is active. The hazard of soil blowing is moderate.

Most areas of this unit are used as rangeland in spring and fall. A few areas are used for urban development.

The potential plant community on the Persayo soil is 35 percent grasses, 15 percent forbs, and 50 percent shrubs. Among the important plants are shadscale, galleta, Indian ricegrass, and bud sagebrush.

Management practices that maintain or improve the rangeland vegetation include proper grazing use, a planned grazing system, and proper location of water developments.

It is not practical to revegetate large areas of this soil because of the low precipitation and fine texture of the soil. For critical erosion control, small areas can be mechanically treated and seeded. Plants that may be suitable for critical area seedlings are those native to the unit and prostrate kochia.

The potential plant community on the Chipeta soil is 15 percent grasses, 15 percent forbs, and 70 percent shrubs. among the important plants are mat saltbush, galleta, deserttrumpet, and bud sagebrush.‡

The suitability of this soil for grazing is limited because of the low precipitation and the relative unpalatability of the dominant plants.

Management practices that maintain or improve the rangeland vegetation include proper grazing use, a planned grazing system, and proper location of water developments.

It is not practical to revegetate large areas of this soil because of the low annual precipitation and the shallow depth to bedrock. For critical erosion control, small areas can be mechanically treated and seeded. Plants that may be suitable for critical area seedlings are native plants and prostrate kochia.

This map unit is in capability subclass VIIe, nonirrigated. The Persayo soil is in the Desert Loamy Clay range site. The Chipeta soil is in the Desert Shallow Clay range site.

(continued)

most of these wells, the level stayed at about 150 cm below the surface, while two had water at 75 cm. Neither level was affected by irrigation.

8. While the monitoring wells were being drilled, Roy noticed a severe compaction layer from a depth of 10 to 30 cm. Previously, this compaction layer was thought to be shale (see comments by Dr. Moser in Exhibit 3).
9. Water did flow out of the drainage system, but slowly. The salt content of this water was measured at 7.5 dS m<sup>-1</sup> during spring of 2000.

Dr. Andersen visited Price and the Carbon County Ball Field early in March 2001 and met with the renovation committee consisting of Roy, the current grounds manager (recently hired and superintendent at the nearby Carbon Country Club), city and county parks maintenance employees, and George Tonneson, the consultant–sales representative. As Dr. Andersen walked the site, he found he could easily push a soil probe down 30 cm on the east end of the fields. But when he used the soil probe in the west side, where salt crusts were present and the turf was struggling, he hit a very hard layer about 5 to 10 cm below the surface. The layer actually made a hollow sound when tapped with a soil probe. This was the compacted layer noted earlier by Roy. To address the drainage issue, a civil engineer and friend of the current field manager recommended blasting or fracturing the underlying layer with explosives to improve drainage. (The town is at the heart of a large coal mining region so the use of dynamite is not unusual to its citizens.) Various recommendations came from the par-

ticipants in the renovation committee including: application of gypsum to relieve compaction, topdressing with sand, deep tine aerification, the use of biostimulants, use of a sulfur burner, putting in additional drainage lines filled with gravel, and the use of organic fertilizers.

When Dr. Andersen asked the renovation committee what the quality expectations for this field might be, they all responded: “very high.” The facility is used by a large number of people during the summer. The complex becomes a community meeting place. Citizens want to see and play on a nice field and they expect it to be safe for themselves and their children to play on. When the committee was asked about the period for improvements, the answer was less clear. The county has been trying to improve the fields for a few years and spending considerable sums of money in recent years. One person described it as a “money pit.” With the large cost overruns on the project, closing the entire facility for significant amounts of time is politically difficult because the fields are tightly booked and players would be upset if the fields were closed again, especially since league season had just started for the 2000 season.

Obviously, everyone wanted a high quality and safe field. However, the county commissioner did not want to spend more money than necessary. The county was already significantly over budget on the project. What should Dr. Andersen recommend in his presentation to the group, and how should he present those recommendations while considering the economic and social realities of the situation?

**Exhibit 2. Continued.**

**Limitations for recreation and reason for limitations.**

Soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails
Persayo	Severe: depth to rock	Severe: depth to rock	Severe: slope, depth to rock	Severe: erodes easily
Chipeta	Severe: depth to rock, excess salt	Severe: excess salt, depth to rock	Severe: slope, depth to rock	Severe: erodes easily

**Limitations for wildlife habitat.**

Soil name	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Coniferous plants	Shrubs	Wetland plants	Shallow water areas
Persayo	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor
Chipeta	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor

**Limitations for building site development.**

Soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
Persayo	Severe: depth to rock	Moderate: shrink-swell, slope, depth to rock	Severe: depth to rock	Severe: slope	Moderate: depth to rock, low strength, slope	Severe: thin layer
Chipeta	Severe: depth to rock	Moderate: shrink-swell, slope, depth to rock	Severe: depth to rock	Severe: slope	Severe: slope	Severe: excess salt, thin layer

**Physical and chemical properties of the soils.**

Soil name	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Salinity
	cm	g kg <sup>-1</sup>	Mg m <sup>-3</sup>	cm h <sup>-1</sup>	cm cm <sup>-1</sup>	pH	dS m <sup>-1</sup>
Persayo	0–7.6	180–270	1.20–1.30	1.5–5.1	0.15–0.17	8.5–9.0	<8
	7.6–30.5	200–300	1.10–1.20	0.5–1.5	0.16–0.18	8.5–9.0	<8
	30.5+	--	--	--	--	--	--
Chipeta	0–12.7	280–470	1.15–1.25	0.2–0.5	0.11–0.16	7.4–8.4	8–16
	12.7–43.2	350–450	1.15–1.25	0.2–0.5	0.11–0.16	7.4–9.0	8–16
	43.2+	--	--	--	--	--	--

**Exhibit 3. Email response from Dr. Steven Moser, Utah State University extension soil specialist, regarding soil conditions at the Carbon County Ball Field.**

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Subject: Re: Softball fields  
Date: Thu, 08 Feb 2001 08:28:10 -0700  
From: Steven Moser stevenm@usu.edu  
To: "Jeff Andersen" <jandersen@usu.edu>

Jeff:

I am somewhat familiar with the Price ball field issue. Roy and I have talked about it a few times. It is a difficult situation. This Manco shale shows up in many areas of eastern Utah and is a problem wherever it is close to the surface. The shale is very salty and I do not think it is possible to leach the salt out of it over time. Also, in some areas the shale is solid enough to be a barrier to rooting and water movement (leaching).

A drainage system would help channel the water off if the shale is a barrier to leaching. In some areas, though, the shale is fractured enough to allow drainage. Ask Roy if the site has been irrigated and whether water ponds on the surface or seems to drain well under current irrigation or rainfall.

Since the shale is so close to the surface (only 4 inches of topsoil) the salt will migrate back into the topsoil very quickly. I think this is why they have not been successful to date in keeping the salinity level down. There are a few options short of installing the drainage system if drainage is not happening now, and bringing in some additional topsoil to increase rooting depth (probably a minimum of 12 inches of topsoil total to allow rooting and leaching). Water management would also be important if they go this route. Even with these measures I believe they would still need a salt tolerant grass since the problem will not be completely solved.

As I recall this is a typical situation. They built the field without first considering the shale/salinity issue, then started looking for an easy/cheap solution. There is no easy/cheap solution.

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Steven Moser, Assoc. Prof.  
Extension Soil Specialist  
Utah State University

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### TEACHING NOTES

This decision case describes an agronomic situation not atypical of those encountered when maintaining turfgrass in the Intermountain West. Salts, high pH, low organic matter, relatively little topsoil, and other soils issues are common due to the arid climate. While the site was originally deemed unsuitable for other uses, it is asked to support a high quality, intensively used turfgrass surface. These are the main agronomic challenges of this site. The field must also be safe for those playing softball because the city or county is potentially liable for injuries, if they are due to the condition of the turf. The case also involves economic, social, and political factors that are encountered when dealing with municipally owned facilities: the need to consider on-going events scheduled on the facility, the economic realities of the situation, and potential conflict of interest where the sales representative/consultant is a friend and neighbor of many people on the renovation committee. Also, most of the people involved did not have the agronomic background to understand what maintenance an athletic field requires, although they think they did.

This real life case is intended to illustrate decision-making processes that are involved with managing publicly owned athletic fields with highly saline soil conditions. The case allows students to use agronomic or horticultural knowledge to address the problems while considering limitations imposed by economics. The situation also will require the decision maker

to educate and prioritize the turfgrass management options to the city and county officials.

When discussing this case, agronomic factors to be considered include: field drainage, saline and sodic soil conditions, the effects of underlying soil parent material, turfgrass species choice, on-going maintenance, alternatives for renovation or rebuilding, and impacts of construction methods. Other factors that should also be discussed include quality expectations and a timeline for making corrections. Obviously, the county commissioner wants the fields to be playable immediately, but various solutions to the problem may take different lengths of time. For example, a complete tile installation to the field at needed spacing may take a field out of play for an entire season. In comparison, the use of slit drainage may allow play to resume in a matter of a few days, but it is more costly. The students should include arguments for why various procedures are important. The instructor should present relevant background information before introducing the case and have references available to students on the topics involved. Some suggested references are listed in the references section.

### Discussion Questions

**1. What is Dr. Andersen's objective in this dilemma? What about the county commissioner?** This question is meant to illustrate that various decision makers and others in-

volved may have different perspectives, which influence the final decisions. Dr. Andersen would hopefully be objective and base his recommendations on science with consideration for economics. He has no monetary stake in the decision. The commissioner may, however, be most concerned about economics and may overestimate the ability of the field to respond to inadequate management. One might call this the *it's just grass* viewpoint, meaning all grasses are the same and intensive management is not important. If Dr. Andersen senses this viewpoint from the commissioner and others, how should Dr. Andersen respond or present his recommendations?

**2. How important is it to maintain the appearance and playability at the Carbon County Ball Field?** In turfgrass management, decisions are sometimes based on appearance alone. Agronomic issues are sometimes ignored or not known. Athletic fields and other kinds of turf areas may have the additional expectations of providing a safe place for a game. Liability concerns may play a significant role in determining turfgrass quality expectations.

**3. Does the Carbon County Recreation Department have public image issues that must be considered?** Public image often plays a role in quality expectations. Especially in small communities, a softball complex can be a source of community pride or embarrassment. A quality complex, or a poor one, can also influence local tourist income for the city.

**4. You may want more information to make a decision. Is this unusual? How would you deal with the lack of information? Demand more? Work with what you have? Is the information trustworthy?** In consulting situations, it is common that information may be incomplete or unreliable. Decision makers need to act using the information available and adjust their plan as new information becomes available.

**5. Is the city/county able to afford the changes?** This question requires the student to evaluate economic factors that may affect the feasibility of their recommendations. Most students are not familiar with the Price, UT, area; therefore, a discussion using economic restraints in their particular area may be more appropriate. (Students can be asked to prioritize actions to address the problems and obtain cost estimates for each activity. Students can also be asked to construct a timeline for the recommended activities.)

**6. Could this situation have been avoided by more careful construction? If so, how?** This question is included to have students consider how the current problems may have been prevented during construction and/or in management since, but still consider the minimal budget that was provided in the first 18 yr.

### Recommendations Given and Outcome

A benefit of using decision cases in the classroom is that a number of potential solutions along with their respective advantages and disadvantages are discussed. Yet it may be useful at some point in the discussion for the instructor to report what recommendations were provided to the Carbon County renovation committee and what those outcomes were. It must be stressed, however, that Dr. Andersen's response is not necessarily the correct answer, especially in light of new technology that may have been introduced.

In Dr. Andersen's presentation, he focused mainly on drainage at the site, because of its importance to getting any-

thing to grow satisfactorily on the site. If drainage is not improved, salt levels will only continue to increase, especially in the most affected areas. Tile drains could be installed if the field(s) is to be rebuilt or slit drains could be used to minimize disruption in the field. He recommended working with an irrigation-drainage engineer (one was on staff in the Price City Public Works Department) to design the system properly. Cultivation was also stressed, especially to break up the compacted layer that exists several inches below the surface. Deep tine aerification, especially those that fracture the soil, such as a VertiDrain unit, were recommended. These drainage solutions are somewhat costly, but were argued as necessary to have a field at all. The managers were recommended to do the worst affected areas first, followed by other areas to spread out costs.

Once drainage issues are addressed, irrigations to leach salts were recommended and less frequent irrigation to encourage deep root growth. Species choice was also discussed. Since Kentucky bluegrass is one of the least salt-tolerant turfgrass species, perennial ryegrass or tall fescue were recommended as better choices, both of which are significantly more salt tolerant, especially ryegrass. Alkaligrass might still be an option in those areas where salt content remains high. Applications of gypsum were recommended to address the high sodium levels in some parts of the field, if the drainage could also be improved.

After Dr. Andersen's visit, the county followed some of the recommendations from Roy Phillips and Dr. Andersen, but did not follow others. Two years after the visit, the NW field was tilled and reseeded with mixed success. Fertilizer recommendations were followed, as were those for irrigation, specifically to leach salts; however, the drainage system was not expanded. A plugged drain was observed in 2002, which when fixed resulted in a significantly increased flow. Water infiltration remained a problem in some parts of the fields. The irrigation system was improved by replacing irrigation heads and more labor was hired for field maintenance.

### Use of the Case

When this case is used in a turfgrass science class, students should be given the case and supplemental readings (Carrow and Duncan, 1998; Carrow et al., 2001a, 2001b; Kotudy-Amacher et al., 2000; McCarty and Camberato, 2001; McIntyre and Jakobsen, 2000; Pace and Johnson, 2002) one or more weeks before class time. The instructor should assign a written report or an oral report, outlining a presentation to city officials on what needs to be done with the softball complex. In that report the student should also provide reaction to the solutions offered by the renovation committee. This report might also ask students to obtain cost estimates for their solutions such as the cost of drainage, deep tine aeration, amendments, and so forth. The students should also prioritize their recommendations in light of the economic situation of the city. The instructor should consider to what depth the answers should be written; the instructor could require general recommendations to the described problems or require the students to design drainage systems that are needed and details of other modifications to the site.

Our recommendation is that the instructor lead an in-class discussion using small groups, and start the discussion with

one or more questions. Later, other questions can be discussed in small groups or as a whole class. There are probably several ways of dealing with the situation, so a consensus among the class may not be appropriate. The instructor could lead the discussion to possible solutions or could suspend the discussion and assign students to revise their reports based on the in-class discussion.

When this case has been used in classes, it has been especially helpful in learning to apply information on salt- and sodium-related issues. This case is also useful to those students who have not had experience managing turf or other crops in high pH (>7.8) and saline soils that are widespread throughout the western USA. The case also identifies the importance of up-front planning, proper construction, and use of soil survey information. Finally, this case has been especially useful to teach students how to educate people involved in a turf site about important agronomic issues, and to teach others how to address those situations.

#### ACKNOWLEDGMENTS

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# The Nile River Basin: A Case Study in Surface Water Conflict Resolution

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## ABSTRACT

The Nile, shared by 10 river basin countries, is the main vital water artery in the North Eastern region of Africa. The river has two main tributaries: the White Nile originating in Burundi, and the Blue Nile rising in Ethiopia. These are joined by the Atbara River north of Khartoum, Sudan. To date, the prevailing water policy regulating the distribution of water among the countries of the Nile basin is a bilateral 1959 agreement attributing the largest share of the river's flow to Egypt, the downstream, noncontributing country, with the rest allocated to Sudan, leaving other countries in the Nile watershed without specific shares. The high rate of population growth in the region propels governments to continuously seek food, and thus water security, to match increasing demand. Agricultural development in other basin countries could be enhanced with a more adequate distribution of water resources. Measures have been proposed to alleviate potential water shortages, including improved utilization of water in Egypt, and construction of numerous dams and canals. There are, however, disagreements with particular countries rejecting or accepting these plans depending on which country will benefit most. The objective of this paper is to present a decision case study to be taken by an international committee that should set strategies for the resolution of the water conflict through the harmonious exploitation of the Nile. The case study targets a course of education at the graduate or senior undergraduate level based on water resources issues impacting stability in the region.

A SUFFICIENT AND RELIABLE FRESHWATER SUPPLY is essential for protecting human health, supporting food production, preserving ecosystems, sustaining economic development, and providing vital goods and services such as hydroelectric power. However, water security is constantly threatened with increases in population, the misuse and contamination of water resources, inefficient irrigation, as well as the heightened intensity and frequency of natural disasters, such as droughts and floods. Perhaps continued population growth represents the most serious threat to water adequacy, whereby a larger population leads to a higher water demand for food production and for domestic, municipal, and industrial uses. Not only does the amount of available freshwater per capita decrease as a country's population increases, but so does the amount received by other states sharing that resource. The latter situation is the result of dam construction or altering a watercourse for additional irrigation systems in a particular country, hence redistributing water allotments among sharing countries (Gleick,

2000). The drive to exploit shared water supplies triggers animosities among countries and has been noted as one of the most urgent political issues on the United Nations global agenda (Gardiner, 2000; Nileriver.com, 2001; Population Action Int., 2001).

The risk of conflict is aggravated in the Middle East and North Africa (MENA) region, where rapid population growth is coupled with an arid climate (Population Action Int., 2001). In Africa, where poverty is a common phenomenon, 14 countries are currently experiencing water stress (their people receive the total equivalent of <math>1500\text{m}^3/\text{yr}</math> per capita), with another 11 expected to face a similar fate by the year 2025, causing about 16% of the continent's population (the equivalent of 230 million people) to suffer from water shortages. In addition, the continent possesses 19 of the 25 countries in the world with the highest percentage of population without access to safe drinking water. Furthermore, the heavy reliance on agriculture, which accounts for 88% of the total water use, coupled with a lack of regional basin level planning, exacerbate the uneven distribution of water resources among countries (BBC, 1999; Gardiner, 2000; Karyabwite, 2000).

In this context, the vast Nile basin represents one of the critical, and perhaps the most important, shared water basins in Africa. Ten countries presently share its waters: Burundi, the Democratic Republic of Congo (DRC), Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda, of which the DRC and Eritrea lie to a lesser extent in the basin. Although these 10 countries represent 10% of Africa's landmass, they house 40% of the continent's population, of whom 70% reside in the Nile basin. Egypt, the most downstream country, has been the traditional user of the Nile, exploiting its waters almost exclusively. However, upstream countries have begun to consider controlling more of the Nile waters, in an attempt to initiate economic development and sustain their growing populations. Yet, the economic development sought by most countries of the Nile basin has been hindered by unresolved conflicts: Sudan and Burundi are enduring civil wars, Tanzania is threatened by famine, while volatility and internal and regional discord has limited the abilities of the DRC, Eritrea, Ethiopia, Rwanda, and Uganda to devise water development schemes (Varis, 2000; Nileriver.com, 2001; Nile Basin Initiative, 2002).

This article focuses on the conflict over the shared water resources of the Nile River and considers the decision of an international committee for its equitable distribution among the countries in the river's watershed. Based on the presented information, the committee (to be composed of top-level ministers) in coordination with the foreign ministers of all 10 countries (representatives from the United Nations and several NGO mediators) needs to develop a set of strategies for the

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**Exhibit 1. Map of the Nile River basin (Nile Basin Initiative, 2002) and status of water in 2025 (Karyabwite, 2000).**

resolution of the water conflict issue and the development of an integrated water plan that allows for an equitable and efficient exploitation of the Nile. The article represents a case study that can be used by graduate or senior undergraduate students to role-play as opponents, supporters, and/or mediators in a conflict resolution situation.

### THE CASE

Following the independence from colonialism, disputes between countries in the Nile River basin became inter-state and assumed internationally debatable dimensions. Agreements regulating the Nile River divided water between Egypt and Sudan, disregarding the needs of the remaining countries that are in increasing need for water to sustain their growing populations. These disadvantaged countries claim their right to equitable water distribution because the Nile represents the only renewable water resource in the region, hence leading to an ongoing debate regarding the most appropriate and efficient management strategy of its waters. Regional political instability and internal armed conflicts within the majority of the involved countries further amplify the problem. However, as the Nile basin countries recognize the dynamics of the population–water relationship, there remains ample opportunity to advance planning and diplomacy to overcome the conflict potential.

**Exhibit 2. Nile basin repartition (Karyabwite, 2000).**

Country	Percentage of country in Nile basin	Percentage of total Nile basin
Burundi	47.6	0.4
DRC†	0.9	0.7
Egypt	32.6	10.5
Eritria	20.5	0.8
Ethiopia	32.4	11.7
Kenya	7.9	1.5
Rwanda	75.5	0.7
Sudan	79	63.6
Tanzania	8.9	2.7
Uganda	98	7.4

† DRC = Democratic Republic of Congo.

### The Nile River Basin

The 6850-km long Nile is the world's longest river, and flows from south to north with a catchment basin covering approximately 10% of the African continent (Exhibit 1). The river spreads across 10 countries with an area of  $3 \times 10^6$  km<sup>2</sup> (Exhibit 2). Although all the waters in Burundi and Rwanda and more than half the waters in Uganda are produced within their boundaries, most of the water resources of Sudan and Egypt originate outside their borders: 77 and 97%, respectively (FAO, 1997). About 94 billion cubic meters (BCM) flow annually to Lake Aswan, Egypt, yet only 0.4 BCM are released into the Mediterranean through the Rosetta, Damietta, and other main branches along its 40-km wide delta (Karyabwite, 2000; Varis, 2000; Nile Basin Initiative, 2002).

The river has three tributaries: the White Nile, the Blue Nile, and the Atbara. The upper White Nile<sup>1</sup> originates in the East African highlands of Burundi (Exhibit 3), flows through the now submerged Owen Falls, Lake Kyoya, Kabalega (Murchisson), and Lake Mobuttu to drain into Lake Victoria. At least 50% of Lake Victoria's annual discharge (27 BCM) is lost to evaporation in the Sudd swamplands of Southern Sudan. The 1529 km long Blue Nile rises at a spring site upstream of Lake Tana in Ethiopia and provides more than 53% of the Nile's water. The Blue Nile flows west and then north to merge with the White Nile at Khartoum from where it flows 322 km northeast to join with the Nile's most northerly tributary, Atbara, which also originates on the Ethiopian highlands. From the Atbara confluence, the river flows through the Nubian Desert northward through Egypt and drains into the Mediterranean (Beschoner, 1992; Howell and Allan, 1994; Inventory of Conflict and Environ., 1997; Nile Basin Initiative, 2002).

A distinguishing feature of the Nile is that half of its course flows through countries with no effective rainfall (Exhibit 4). Nearly all of the river's water is generated on an area covering 20% of the basin, while the remainder is arid or semiarid regions with minimal water supplies and very large evaporation losses (Karyabwite, 2000).

### Socio-Economics of Nile Basin Countries

Almost 40% of Africa's population (equivalent to approximately 300 million people), lives in the Nile basin and is projected to at least double by 2025. Exhibit 5 presents popula-

<sup>1</sup> The Ruvyironza is considered to be the main source of the Nile River and is one of the higher branches of the Kagera River that flows northward from the Rwandan border before eventually becoming the White Nile (Nile Basin Initiative, 2002).

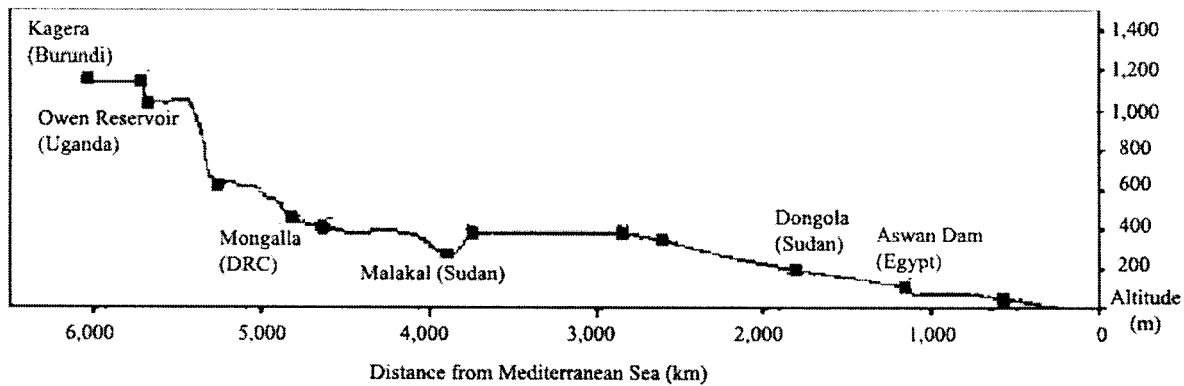


Exhibit 3. Nile river profile from Kagera to the Mediterranean Sea (adapted from Karyabwite, 2000).

tion and water use in the 10 countries for the year 2000. Due to the limited availability of renewable sources of water, population growth will decrease the available per capita water. Population distribution in the basin is dominated by a shift toward greater urbanization. For instance, the urban population in Burundi, Ethiopia, Rwanda, and Uganda is projected to more than double as a percentage of the total population. This redistribution presents implications for water management as urban populations generally consume more water per capita for domestic and industrial use than rural populations. Moreover, although urbanization can open opportunities for taking advantage of economies of scale in water delivery and sanitation, it also poses challenges of delivering water in remote areas, such as ensuring drinking water sanitation and appropriate wastewater treatment (Baecher et al., 2000).

The growth rates of gross domestic and gross national products (GDP and GNP)<sup>2</sup> are uneven in the Nile basin (Exhibit 6). The GDP is considered a rough indicator of water demand because, with other things being equal, higher per capita GDP is associated with greater water demand. The sectoral composition of GDP is also an indicator of demand. Agricultural production consumes the largest amount of water per unit of GDP, followed by the midrange industrial sector and the least consumptive services sector. The relative growth of the sectors will influence future water demands and increased industrial activity may adversely impact water quality if pollution control measures are not implemented, monitored, and enforced. The GDP of basin countries exhibited a growth in the various sectors during the 1990s except in Burundi, Rwanda, and the DRC (Exhibit 7). This may indicate that, if and when the political situation stabilizes, the war-torn areas are likely to experience rapid economic recovery. Another important fact is that Uganda's high rate of industrial growth could eventually pose adverse effects on the water quality of the upper basin (Baecher et al., 2000).

Additional development projects along the Nile are postulated to help the countries meet their growing food supply demands. Such progress may be achieved through the expansion of agriculture as most of the countries are not yet operating at their full irrigation potential (Exhibit 8). However, this will

<sup>2</sup> Gross domestic product (GDP) is the value of total final outputs produced with labor or capital located in a country during a given year, whereas gross national product (GNP) is the value of all final goods and services produced in a year with labor or capital owned by the residents of a particular country (Samuelson and Nordhaus, 1998).

Exhibit 4. Water resources and availability per person (Karabywite, 2000).

Country	IRWR <sup>†</sup>	ARWR <sup>‡</sup>	Dependency ratio <sup>§</sup>	Per capita IRWR in 1994	Per capita ARWR in 1994
	— km <sup>3</sup> /yr —		%	— m <sup>3</sup> /inhabitant —	
Burundi	3.6	3.6	0	579	563
DRC <sup>¶</sup>	935	1019	8.2	21 973	23 211
Egypt	1.7	58.3	96.9	29	926
Eritria	2.8	8.8	68.2	815	2492
Ethiopia	110	110	0	2 059	1 998
Kenya	20.2	30.2	33.1	739	1 069
Rwanda	6.3	6.3	0	833	792
Sudan	35	88.5	77.3	1 279	3 150
Tanzania	80	89	10.1	2 773	2 998
Uganda	39.2	66	40.9	1 891	3 099

<sup>†</sup> IRWR, Internal renewable water resources.

<sup>‡</sup> ARWR, Actual renewable water resources.

<sup>§</sup> Dependency ratio represents the extent to which the supply of a country's renewable water resources is dependent on sources external to its political boundaries and can be calculated using the equation (ARWR – IRWR)/ARWR × 100.

<sup>¶</sup> DRC, Democratic Republic of Congo.

only be realized if water allocation is managed equitably and efficiently.

### Conflicts in the Nile Basin

The Nile basin has experienced a long period of conflict spanning the ancient Egyptian civilizations, the colonial reign, and continuing to the modern day. Historically, the river provided the Egyptians with almost all their fresh water, and has long been regarded as the cultural symbol of Egypt dating back to the times of the Pharaohs. The Egyptians were always concerned that the Nile's waters may stop reaching them and, as a result, have tried to bring the entire Nile valley under their rule, invading Sudan during the reign of Queen Sheba, the Roman rule of Nero, and at numerous other instances (Inventory of Conflict and Environ., 1997; Nileriver.com, 2001).

Colonialism marked the beginning of the modern history of the Nile conflict in the 20th century (Exhibit 9) by realizing the significance of the Nile water for the prosperity of the colonies, particularly Egypt. Upon reconquering Sudan in 1898, the British removed vegetation that was obstructing navigation along the river, creating alternative drainage paths to divert and improve the flow. Signing an agreement with Ethiopia in 1902 was necessary to ensure the security of the water supply, since Ethiopia provides 80% of the Nile water and the British had no control over the Ethiopian portion. Britain also had to negotiate with France and Italy to prevent

**Exhibit 5. Population and water use in the Nile basin countries for the year 2000 (FAO, 2000).**

Country	Total population	Rural population	Urban population	Agricultural water use		Domestic water use		Industrial water use		Total water use
	million			km <sup>3</sup> /yr	%	km <sup>3</sup> /yr	%	km <sup>3</sup> /yr	%	km <sup>3</sup> /yr
Burundi	6.356	5.787	0.570	0.19	82	0.04	17	0.00	1	0.23
DRC†	50.948	35.521	15.427	0.11	31	0.19	52	0.06	16	0.36
Egypt	67.884	37.195	30.690	53.85	78	5.23	8	9.57	14	68.65
Eritrea	3.659	2.973	0.686	0.29	95	0.01	4	0.00	1	0.30
Ethiopia	62.908	51.805	11.102	2.47	93	0.03	1	0.15	6	2.65
Kenya	30.669	20.517	10.152	1.01	64	0.47	30	0.10	6	1.58
Rwanda	7.609	7.141	0.468	0.03	39	0.04	48	0.01	14	0.08
Sudan	31.095	19.863	11.232	36.07	97	0.99	3	0.26	1	37.31
Tanzania	35.119	23.571	11.548	1.85	93	0.12	6	0.03	1	2.00
Uganda	23.300	20.002	3.298	0.12	39	0.13	45	0.05	15	0.30

† DRC, Democratic Republic of Congo.

**Exhibit 6. The GDP and GNP growth in riparian countries (Baecher et al., 2000).**

Country	GDP 1998	Avg. annual GDP growth from 1994 to 1998	GNP per capita, 1998
	million \$	%	\$
Burundi	859	-2.5	173
DRC†	6 101	-5.6	110
Egypt	68 743	4.1	1250
Eritria	681	5.2	198
Ethiopia	6 716	4.1	100
Kenya	9 791	1.7	350
Rwanda	1 813	-3.6	230
Sudan	8 383	7.3	290
Tanzania	5 552	2.9	210
Uganda	6 944	7.1	310

† DRC, Democratic Republic of Congo.

**Exhibit 7. Composition of the GDP and sectoral growth rates during 1990–1998 (Baecher et al., 2000).**

Country	Agriculture		Industry		Services	
	% of GDP	Growth rate	% of GDP	Growth rate	% of GDP	Growth rate
Burundi	52.4	-1.8	17.1	-6.3	30	-1.9
DRC†	60.4	2.8	17.3	-13.3	20.9	-14.6
Egypt	14.9	2.8	30.4	4.2	47.1	4
Eritria	NA‡	NA	NA	NA	NA	NA
Ethiopia	NA	NA	NA	NA	NA	NA
Kenya	26.1	1.1	13.4	2	45.7	3.6
Rwanda	35.2	-5.0	23.6	-1.8	39.2	-3.1
Sudan	NA	NA	NA	NA	NA	NA
Tanzania	42.4	3.6	14.2	1.9	35.2	2.3
Uganda	40.3	3.6	15.7	12.1	33.7	8.2

† DRC, Democratic Republic of Congo.

‡ NA, not available.

their intervention with its dominance over the Nile basin. In 1929, Britain sponsored the Nile Water Agreement for water allocation to support Egyptian planned developments on the river. The bilateral agreement divided the Nile's water between the two most downstream countries, without consulting any of the other involved parties. Egypt was provided with the monopoly over the resource and Sudan was allocated a mere 4 BCM, approximately 5% of the river's flow (allAfrica.com, 1999; Inventory of Conflict and Environ., 1997).

The most comprehensive treaty that addresses sharing the Nile's water remains the 1959 Water Agreement on "the full utilization of the Nile water" between Egypt and Sudan. The treaty established the average annual Nile flow at about 84 BCM, measured at Aswan high dam in Egypt, and estimated annual water loss due to evaporation and other factors at 10 BCM. The losses were deducted from the Nile yield of 84

**Exhibit 8. Irrigation potential and water requirements in selected Nile basin countries (FAO, 1997).**

Country	Area irrigated	Irrigation potential†	Water requirements
	km <sup>2</sup>		
Burundi	NA‡	1 050	Improving the drainage network in part of the swamp areas, combined where possible with an irrigation network, would allow year-round cultivation in the two countries
Rwanda	NA	1 500	
Ethiopia	250	22 200	Requires regulation of surface runoff and the construction of dams
Kenya	60	1 800	Dams and water transfers to other (sub) basins are proposed
Lake Victoria Basin			
Tanzania	NA	300	Requires the construction of considerable water conveyance works
Uganda	55.5	2 020	Necessitates major works such as storage, river regulation, and large-scale drainage

† Irrigation potential is the area that can potentially be irrigated as determined by the physical resources, soil and water, combined with the irrigation water requirements as determined by the cropping patterns and climate.

‡ NA, not available.

BCM and the remaining water was divided among Egypt and Sudan as 55.5 and 18.5 BCM, respectively. Sudan was to construct projects to contribute to the Nile's flow by preventing evaporation losses in the Sudd swamps of the White Nile, with costs and benefits divided equally between the two countries. The projects included the Roseires Dam<sup>3</sup> on the Blue Nile, the Jonglei canal, and other irrigation and hydroelectric power generation projects. Egypt was entitled to construct the Aswan High Dam to manage the yearly floods of the river, reduce sediment deposition in the delta area, and reap its hydroelectric power. The parties decided to handle claims over the Nile by other basin countries by removing any amount that these countries may be entitled to in equal parts from both Egypt's and Sudan's shares (Whittington and Guariso, 1983; Inventory of Conflict and Environ., 1997; Nile Basin Initiative, 2002).

The DRC, the East African countries, and Ethiopia were not consulted over the final terms of the 1959 agreement and their water rights have not been explicitly mentioned (Howell and Allan, 1994). As a result, these countries have been invalidating the agreement and requesting the renegotiation of its contents to take their own interests into account (George,

<sup>3</sup> Eighty percent of Sudan's electricity is currently produced by hydroelectric schemes at Roseires and Sennar, where the dams supply irrigation water for more than 10 000 km<sup>2</sup> of the Gezira plain (Nile Basin Initiative, 2002).

**Exhibit 9. Summary of major events and agreed upon or conflicting issues in the Nile basin.**

Year	Parties	Agreed issues	Conflicting issues
1704 <sup>†</sup>	Ethiopia and Egypt		King of Ethiopia threatens Egyptian Pasha to cut off the Nile.
1898 <sup>‡</sup>	Egypt, France, and Britain		A French expedition attempted to gain control of the headwaters of the White Nile. Military conflict nearly ensued between Britain and France. The incident "dramatized Egypt's vulnerable dependence on the Nile, and fixed the attitude of Egyptian policy-makers ever since." The parties ultimately negotiated a settlement of the dispute.
1902 <sup>†</sup>	Britain and Ethiopia	Agreement was signed to limit Ethiopian intervention with the Nile waters.	
1929 <sup>†§</sup>	Britain and (newly independent) Egypt	Nile Water Treaty: Britain provided Egypt with the monopoly over the river, allocating only 4 billion cubic meters to Sudan.	
1958 <sup>‡</sup>	Egypt and Sudan		Egypt sends an unsuccessful military expedition into disputed territory amidst pending negotiations over the Nile waters.
1958 <sup>†</sup>	Report on the Nile Valley Plan issued. A 50-yr hydrological study made on the non-Ethiopian portions of the Nile basin that suggests different alternatives to increase the amount of water reaching Egypt, such as the Jonglei Canal (conflicts with Ethiopia prevented the inclusion of the Ethiopian section).		
1959 <sup>§¶#</sup>	Egypt and Sudan	Nile Water Treaty signed when pro-Egyptian government elected in Sudan. Water Agreement on "the full utilization of the Nile water."	
1959 <sup>†</sup>	Construction of the Aswan High Dam commenced (funded by the Soviet Union after the USA and the World Bank refused to fund the project). <sup>†</sup>		
1960s <sup>†</sup>	More than 100 000 Nubians forced to move from northern Sudan and southern Egypt due to development projects of the 1959 treaty.		
1968 <sup>††</sup>	Aswan High Dam completed. The dam is 100 m high, 1 km thick, and stretches 4 km across the Nile's trajectory. The reservoir formed behind it, named Lake Nasser, is the second largest man-made lake in the world, reaching 600 km long and 50 km wide in some parts. <sup>†</sup>		
1970s <sup>†</sup>	Sudan and Egypt began the joint construction of the Jonglei canal (funded by the World Bank).		
1978 <sup>‡</sup>	Egypt and Ethiopia		Ethiopia's proposed construction of dams on the headwaters of the Blue Nile rekindles Egyptian animosities.
1979 <sup>‡</sup>	Egypt and Ethiopia		Anwar Sadat declared: "The only matter that could take Egypt to war again is water" (concerning Ethiopia's proposed water development projects).
1983 <sup>†</sup>	Construction of the Jonglei Canal ceased (100 km short of completion) due to acts of rebellion in Sudan, foregoing more than \$100 million.		
1990s <sup>†</sup>	Egypt blocked an African Development Bank loan to Ethiopia for a project, which might have reduced the flow into Egypt.		
1992 <sup>‡‡</sup>	The Technical Cooperation Committee for the Promotion of the Development and Environmental Protection of the basin (TECCONILE) was established. It was intended to promote the development of infrastructure, capacity building, techniques for water resources management and the formulation of national master plans in the short term, and the development of the basin in an integrated and sustainable manner through basin-wide cooperation and the determination of equitable water allocation in the long run.		
1994 <sup>†</sup>	Egypt and Sudan		Egypt planned and then cancelled an air raid on Khartoum, where a dam was being built.
1995 <sup>†</sup>	Egypt and Sudan		Increased tensions over the attempted assassination of President Mubarak. Border clashes became common, threatening serious conflict.
1997 <sup>§</sup>	Nile 2002 Conference held in Addis Ababa, Ethiopia. The need to hold fresh negotiations and fair agreements was stressed to enable all basin countries to benefit from the Nile.		
1999 <sup>§</sup>	Nile 2002 Conference held in Cairo. Emphasis was placed on the allocation and conservation of water resources in the basin. The status quo was not challenged, Ethiopia was under-represented, with majority of papers presented by Egyptians.		
2001 <sup>§§</sup>	Egypt, Sudan, and Ethiopia established the Eastern Nile Subsidiary Action Plan (ENSAP), coordinating their efforts to execute joint and independent irrigation, hydroelectric power, and water management projects in the basin.		

<sup>†</sup> Inventory of Conflict and Environ., 1997

<sup>‡</sup> Gleick, 2000

<sup>§</sup> allAfrica.com, 1999

<sup>¶</sup> The Reporter, 1999

<sup>#</sup> Stratfor, 2001

<sup>††</sup> Varis, 2000

<sup>‡‡</sup> Karyabwite, 2000

<sup>§§</sup> Addis Tribune, 2001

1998). Although Ethiopia possesses a population nearly the size of Egypt's, the latter continues to argue that the bilateral agreement is irrevocable since its population growth is likely to double by 2025, and access to this volume of water is vital to its ability to support the growing population (George, 1998).

Furthermore, Ethiopia has been left out of negotiations because the two lower basin countries have traditionally claimed that the country can sustain itself solely through rain-fed agriculture. However, successive drought-induced famines in the last three decades have proven otherwise. Despite its substantial natural resources and potential for agricultural production, Ethiopia is one of the poorest countries in the world with food insecurity as a major problem. It has so far been able to develop only 0.04 and 2% of its irrigation and hydropower potential through its share of the Nile system. One avenue for moving toward poverty reduction and increased food security may be through developing the country's vast

arable land, which requires more water. Egypt feels threatened by the potential demands for more water. In this context, even the construction of small dams using only 0.5 BCM of the river's annual flow triggered Egypt to use its diplomatic influence in the 1990s to block an African Development Bank loan to Ethiopia (Inventory of Conflict and Environ., 1997).

Inevitably, the political relations between the countries in the basin influence the water negotiations to a large extent. Egypt is particularly interested in promoting Sudanese stability as internal conflicts in Sudan represent the main threat to the Nile basin water utilization patterns. Also, the Blue Nile represents the source of the Egyptian-Ethiopian dispute, as Ethiopia demands its natural rights to exploit its waters, over which Egypt has assumed total control.

Recent efforts toward cooperation were portrayed in 1998 when all countries, except Eritrea, joined in a dialogue to create a regional partnership to facilitate the common pursuit of

**Exhibit 10. Selected projects under the Nile Basin Initiative (Nile Basin Initiative, 2002).**

Projects	Objectives	Major components	Proposed outputs
Nile Trans-boundary Environmental Action	<ul style="list-style-type: none"> <li>• Provide a strategic framework for environmentally sustainable development of the Nile River basin.</li> <li>• Support basin-wide environmental action linked to trans-boundary issues in the context of the Nile Basin Initiative strategic action program.</li> </ul>	<ul style="list-style-type: none"> <li>• Institutional strengthening to facilitate regional cooperation.</li> <li>• Community-level land and water conservation.</li> <li>• Environmental education and awareness.</li> <li>• Wetlands and biodiversity conservation.</li> <li>• Basin-wide water quality monitoring.</li> </ul>	<ul style="list-style-type: none"> <li>• Enhanced regional cooperation on trans-boundary environmental and natural resource management issues.</li> <li>• Capacity and support for local-level action on land, forest, and water conservation.</li> <li>• Awareness of civil society through environmental education programs and networking of universities and research institutions.</li> <li>• Sustainable management of wetlands and establishment of wetlands management programs.</li> <li>• Standard basin-wide analytical methods for water quality measurements established and monitoring of trans-boundary relevant hotspots initiated. Enhanced capacity for monitoring efforts and pollution prevention.</li> </ul>
Efficient Water Use for Agricultural Production	<ul style="list-style-type: none"> <li>• Provide a sound conceptual and practical basis to increase availability and efficient use of water for agricultural production.</li> </ul>	<ul style="list-style-type: none"> <li>• Regional consultations and training.</li> <li>• Demonstrations/pilots and basin-wide exchange of experience.</li> </ul>	<ul style="list-style-type: none"> <li>• Improved enabling environment for sustainable watershed management and increased productivity.</li> <li>• Improved enabling environment for community managed irrigation development and increased agricultural production.</li> <li>• Options for reforms in public managed irrigation reviewed and appropriate pilot projects that demonstrate improved system performance implemented. Options for irrigation development explored.</li> </ul>
Water Resources Planning and Management	<ul style="list-style-type: none"> <li>• Enhance the analytical capacity for basin-wide perspective to support the development, management, and protection of Nile basin waters.</li> </ul>	<ul style="list-style-type: none"> <li>• Water policy good practice guides and support.</li> <li>• Project planning and management good practice guides and support.</li> <li>• Development of a decision support system (DSS) for the Nile basin.</li> </ul>	<ul style="list-style-type: none"> <li>• Support for water policy development and implementation and strengthening national capacities.</li> <li>• Building and enhancing human capacity and institutional support to facilitate water resources planning and management on regional, sub-regional, and national levels.</li> </ul>

sustainable development and management of the Nile's waters. They jointly adopted an inclusive transitional mechanism for cooperation until a permanent cooperative framework is established. In May 1999 the overall process was officially named the Nile Basin Initiative (NBI) (Nile Basin Initiative, 2002). Exhibit 10 provides examples of current activities and projects supervised by the NBI to create an enabling environment of cooperation, action, and investments with respect to the management of the Nile's waters.

**THE LEGAL ASPECT**

International water laws address the basic interests of the international community to maintain global peace and security. Their application nevertheless remains limited, since

they still lack maturity, sophistication, clarity, and enforceability, and hence are rendered powerless when a country chooses to ignore the laws in question.

In theory, international waters are to be distributed fairly and rationally among countries within the river's watershed. The Helsinki Rules on the Uses of the Waters of International Rivers, adopted by the International Law Association in 1966, provide a guideline for the proper utilization and administration of international rivers in cases where no specific agreements or traditional understanding prevail (Int. Law Assoc., 1967). It sets equitable allotments to countries in a basin not by equal shares but according to specific variables that help prioritize their various needs (Exhibits 11 and 12) such as: (i) topography of the basin, particularly the size of the river's

**Exhibit 11. Country data with respect to selected priority variables under the Helsinki Rules.**

Country	Climate	Rainfall mm/yr	Present utilization		Social and economic needs†				Dependence on agriculture		Availability of other resources
			BCM	% of flow	Population growth %	Agricultural growth	Life expectancy yr	Infant mortality infant deaths/ 1000 live births	% of food imports	Agriculture as % of GDP	
Burundi	tropical	1000–1500	NA‡	NA	2.9	1.7	49.5	110	18	56	none
DRC§	tropical	1500–2000	NA	NA	1.9	2.7	61.6	57	20	30	minerals, hydropower, oil
Egypt	desert	<200	59–60	79	1.9	2.7	61.6	57	31	17	Suez Canal industry
Ethiopia	NA	NA	<0.6	0.5	2.9	-2.1	47	122	17	41	gas, hydropower
Kenya	60% tropical, 30% savannah, 30% semi-arid	NA	NA	NA	3.8	3.4	61	64	10	28	hydropower, tourism
Rwanda	tropical	1000–1500	NA	NA	3.4	-1.1	52	112	9	38	none
Sudan	desert/savannah	400–1500	16	20	2.8	0.8	51.8	99	18	37	oil
Tanzania	savannah/desert	NA	NA	NA	3.6	3.8	55	97	7	59	pydropower
Uganda	tropical	1000–1500	NA	NA	3.4	-0.5	53	94	8	67	hydropower

† Refer to Exhibit 6 for further information related to GDP and GNP.

‡ NA, not available.

§ DRC, Democratic Republic of Congo.

**Exhibit 12. The relative ranking of the Nile riparian countries according to the Helsinki Rules.**

Indicator	Burundi	DRC†	Egypt	Ethiopia	Kenya	Rwanda	Sudan	Tanzania	Uganda
Country share in area of Nile basin, %	9	7	1	3	6	8	2	5	4
Country water in contribution to the Nile	2	6	8	1	3	2	7	4	5
Climate	9	7	1	3	4	8	2	5	6
Utilization									
Past	5	5	1	4	5	5	2	5	3
Present	4	4	1	3	4	4	2	4	4
Social needs									
Life expectancy	8	4	1	9	2	7	6	3	5
Infant mortality	6	3	1	8	2	7	5	5	4
Economic needs									
Income	6	7	1	9	3	4	2	8	5
Total debt	5	3	2	6	6	8	4	1	7
Total population 1990	9	3	1	2	6	8	5	4	7
Average annual growth of population 1987-2000	5	6	8	6	1	2	7	3	4
Average annual growth of agriculture 1980-7	5	3	4	9	2	6	7	1	8
Cereal imports	9	4	1	2	5	8	3	6	7
Food production per capita, index, 1985-1988	3	4	2	5	5	6	5	5	1
Percentage of labor force in agriculture, 1985-1988	1	7	9	6	5	2	8	4	3
Agriculture as percentage of GDP 1988	3	7	8	4	7	5	6	2	1

† DRC, Democratic Republic of Congo.

Key:

Country share, 1 = largest

Country water contribution, 1 = greatest

Climate, 1 = dry, 9 = wet

Past use, 1 = oldest, 5 = newest

Present use, 1 = greatest, 4 = least

Life expectancy, 1 = longest, 9 = shortest

Infant mortality, 1 = lowest, 9 = highest

Income, 1 = highest, 9 = lowest

Total debt (% GDP), 1 = largest debt, 8 = smallest

Total population, 1 = largest, 9 = smallest

Average annual population growth, 1 = highest

Average annual growth in agriculture, 1 = highest

Cereal imports, 1 = largest importer

Food production index, 1 = highest

drainage area in each country; (ii) climatic conditions governing the basin; (iii) history of water utilization, up to present-day usages; (iv) economic and social needs for each basin country; (v) population; (vi) comparative costs of alternative means of satisfying the economic and social needs of each country; (vii) availability of other water resources to each basin country; and (viii) the avoidance of undue waste and unnecessary damage to other countries. Although these rules are generally accepted, they are nonbinding in international law. If applied to the Nile basin case, there is no doubt that Ethiopia, Sudan, and practically all the equatorial countries rank higher than Egypt on almost all variables, entitling them to a larger portion of the Nile water. This emphasizes the strong interrelation between politics and international water conflicts, whereby the politically and economically dominant country generally prevails and controls an international water resource. As such, the country that enjoys the largest percentage of the water does not necessarily have to be the most deserving, thus sacrificing the economic advancement, social development, and political stability of other countries in the basin.

### THE DECISION

A delicate conflict over the equitable allocation of the Nile waters represents one of the most critical issues in the African continent. The relatively powerful and progressive Egypt has managed to dominate the basin by asserting its historical rights to exploit the Nile waters. The other countries remain politically unstable and suffer from famine and chronic malnutrition, limiting their ability toward social and economic development, as well as to devise comprehensive water schemes, and adopt water efficient technologies. Students are expected to research the topic through the set of questions in the Teaching Note. Then students must form a panel representing involved countries (advocating the positions of the different countries) and third-party mediators to hold negotiations. These negotiations should (i) alleviate tension through the for-

mulation of a specific set of strategies catering for the economic, environmental, socio-political, and technical aspects of all countries within the watershed and (ii) take into consideration the countries' water demands and shortages.

### TEACHING NOTE

#### Case Objectives

This case study presents an important issue in Africa, which may threaten the availability of even the most basic physical needs of water and food in the region. The case should allow students to:

- Become familiar with the water status in the Nile basin
- Understand the various underlying factors of the water-related conflict in the framework of historical quarrel, political instability, and proposed water development projects
- Recognize the interrelation between natural resources and political interplay
- Enhance their objectivity in tackling sensitive socio-political water resources issues
- Recognize international laws and regulations related to cross-boundary waters
- Define and evaluate implementation strategies for cooperation between conflicting countries in international river basin management

#### Uses of the Case

This case targets senior and graduate level students in natural and water resources management and environmental engineering and science; however, students in political sciences, social studies, agricultural sciences, or related fields may find the case equally beneficial. Students will utilize crucial decision-making skills to tie the scientific, social, and political components of the issue. The case—based on region-specific data, socio-economics, politics, and historical events—also provides students with an opportunity to evaluate water resources management in a water-scarce region.

## Implementation of the Case

Given the complex socio-political aspects of the region, it is helpful if students are introduced to the history of the Nile basin political conflict before being exposed to the case. Numerous books have been written in this regard and a great deal of information can be found on the Internet (Murakami, 1995; FAO, 1997; Inventory of Conflict and Environ., 1997; Karyabwite, 2000; Nile Basin Initiative, 2002). The case was used in a graduate-level course on environmental case studies and conflict resolution at the American University of Beirut. The class was composed primarily of environmental science students with diverse backgrounds (chemistry, geology, physics, civil engineering, ecosystem management, and environmental health). Invariably, the feedback of students was important and their input was used to improve on the case and refine certain questions.<sup>4</sup>

Case studies can be used in a variety of ways in a classroom setting (Herreid, 1994)<sup>5</sup>; however, the implementation should be appropriate to the background of the students and the objectives of the course. This particular case lends itself in role playing and should be first assigned as an outside reading (without the Teaching Note) before being discussed in class. After students become familiar with the case, they are divided into groups, each designated with the task of acquiring further information with respect to a particular country within the basin and to respond to the questions outlined in the Teaching Note. The case can then be analyzed over another 1 or 2 wk whereby students assume the role of opponents or supporters of the various views of each of the Nile basin countries. The Teaching Note would be shared with the students during or after the case discussion. An outside panel not as familiar with the case could be invited to listen to the debate and make a decision based on the arguments presented by the students. Role-playing offers the advantage of developing analytical skills, practicing public speaking, enhancing spontaneity, and promoting awareness of socio-economic, political, and cultural constraints.

<sup>4</sup> Our experience with the case spans over two semesters (in 2 yr). In the first semester, a group of students initiated the development of the case as part of their project assignment in a course on conflict resolution. During that semester, an initial draft was submitted to the instructor, who corrected the paper and introduced major changes to its content and structure. The group presented and tested the case with the rest of the class. The case was then modified by the instructor based on the class feedback and was used again the following year. In the second application, the case was distributed to the students as an outside reading with a set of well-defined questions to be answered, which allowed the students to further research the topic. The students were then divided into groups representing the various countries involved. The students' answers to the predefined questions as well as the class debate were used as another level of feedback to refine the case. In their evaluation of the case, the students felt that the case was highly informative and appropriate for the course; however, they concurred in both semesters that the case is complex and should be given more than 2 wk.

<sup>5</sup> (i) Assigned as outside reading followed by a general class discussion with a decision that needs to be reached with the corresponding justification.

(ii) Written reports could be required for grading purposes; after correction of the reports, answers can be discussed in class in the context of actual events and what the final decision could be.

(iii) The case can be read in class (which would take about 3 h; the case would be too long for a 1-h session) followed by either small group or whole class discussion of all or selected questions.

The latter approach requires the least amount of class time, but it also provides the least chance for students to reflect on the issues of the case.

## DISCUSSION QUESTIONS AND ANSWERS

**1. Waterbury (1997) states: "If the riparians would agree that the sole criterion for resolving conflicting demands would be strict application of a rule that highest economic returns per unit of water determine who receives each additional unit of water, and if the infrastructure is in place to store the water, then the problem would be greatly alleviated." Do you agree with Waterbury?** Waterbury's formula is inapplicable in the case of the Nile basin because countries that are willing to pay may not be those that are in most need. This is best illustrated by Ethiopia, a country that suffers the largest water shortage and is incapable of competing with Egyptian buying power. Besides that, this rationale has its weaknesses since it overlooks basic ethical values, whereby the potable water rights of the Nile basin countries should be acknowledged, irrespective of their willingness or capability of buying water shares. This strategy if adopted will enhance the development of the richer country capable of acquiring the water, and will increase the dependence of the poorer countries on the richer ones for their basic food supply. Therefore, economic incentives should not be the only basis for allocation of water resources, largely due to the inevitable economic, social, and political discrepancies among the concerned parties.

**2. How does Egypt defend its pattern of water usage? Can it initiate measures to decrease its current consumption?** Egypt argues that it is unable to reduce its water consumption because:

- Its hydroelectric power supply will be affected
- It fears farmers' outrage, thus aims at avoiding collision with them
- It is currently doing its best by shifting from canals to underground pipes
- It needs reclaimed land to help diffuse population concentration along the Nile

On the other hand, various arguments have been put forth by the remaining countries claiming that Egypt can reduce its current use of the Nile's waters, namely by:

- Reducing the flow at the Aswan high dam and minimizing water losses
- Charging the farmers for water consumed in agriculture
- Adopting various efficiency measures such as wastewater reclamation, desalination, and shifting from water-intensive to water-extensive systems
- Stopping land reclamation, which leads to low water use efficiency

**3. What measures must Ethiopia take to improve its current food and water shortages?** Ethiopia is incapable of maintaining food production levels through the continued practice of traditional highland agricultural approaches. Therefore, Ethiopia must resort to developing alternative basins (such as the Abbay, Tekeze, and Baro Akobo) that have a promising potential for irrigation, hydropower production, and tourism. If Ethiopia manages to produce sufficient electricity, it may improve its energy base for industrial and urban development, if not sell hydroelectric power to other countries.

Ethiopia may need to exert pressure on downstream countries that may trigger their positive engagement in negotiations

that aim at changing the status quo and gaining a more reasonable and unbiased basin-wide water distribution. Most importantly, Ethiopia needs to increase the awareness of its people, make them more involved in water issues, and encourage their active participation in both governmental and nongovernmental institutions that aim at enhancing the country's socio-economic progress (allAfrica.com, 1999).

**4. What are the conflicting roles of economic growth and development with respect to water? What is the implication here?** Although the growth in the use of water as an input to agriculture and industry will have measurable effects on water quality if not appropriately planned and monitored, the lack of such development also poses other, different threats. Without economic growth and development, population growth in the area will aggravate existing problems of poverty and food insecurity resulting in watershed degradation, water pollution, and the loss of native forests, wetlands, wildlife habitat, and biodiversity. The rural poor will continue to have little choice but to cultivate the often unsuitable steep uplands and overexploitation of natural resources to meet food and energy needs. Thus, Nile basin countries must proceed by balancing resource development for human use against the needs of the ecosystem.

**5. Egypt prohibited Sudan and Ethiopia from developing water projects along the Nile within their territories and threatened to go to war with any country that will threaten the Nile water. Do you think that Egypt will initiate a war to protect its water share?** The Egyptian government has long recognized upstream development of the Nile's waters as a potential national security threat and has stated its willingness to revert to military measures to secure its water supply. In August 1994, for example, Egypt planned and subsequently aborted an air raid on Khartoum in Sudan where a dam was being built. While confrontation over the Nile water is nothing new, it may yet be resolved diplomatically. Egypt now realizes that a war over water would be too costly in terms of manpower and resources, and also that the benefits of new agreements could be enormously important for Egypt's international standing, as well as for peace in the region. In addition, international laws prevent Egypt from implementing any military action, especially since it is the most downstream country and hence generally perceived as the least deserving of the largest proportion of the Nile waters.

**6. Do you think that a comprehensive treaty that satisfies all Nile basin countries could be reached? What are the arguments that could be advanced by the countries to validate their right to more water?** Conflicting interests between countries sharing the same river have long prevented the

fair and equitable distribution of international waters. However, attempts at resolving this everlasting controversy produced comprehensive rules for addressing these pressing issues, the most common being the Helsinki and International Law Commission rules (Int. Law Assoc., 1967), which take into consideration several factors such as the history of water utilization, the availability of other water resources, in addition to the economic and social needs of countries, when distributing international waters in an equitable manner.

In real life cases, the dominant country in the basin has historically imposed a solution that best suits its interests. With no exception, this has been the case in the Nile basin, whereby Egypt, the basin's most powerful country both economically and politically, has always negotiated for settlements that best suited its own interests, often disregarding the needs of the other countries within the watershed. Egypt may have previously gotten away with its actions due to the inability of its upstream neighbors to develop major water projects on the Nile; however, with their economic development, along with an increased awareness regarding their natural water rights, Egypt is unlikely to escape the inevitable call to renegotiate the Nile water shares in a more equitable and effective manner. In this context, Exhibit 13 outlines major arguments voiced by Egypt, Ethiopia, and the other countries with respect to their right in acquiring larger shares of the Nile's flow.

**7. What are the major environmental threats implicated by increasing water withdrawal from the Nile basin through the further construction of dams?** The Aswan Dam in Egypt has provided ample evidence to portray the effects of constructing dams without adequate consideration of long-term environmental effects, for example (Miller, 1998):

- The yearly flooding that fertilized the Nile Delta with silt was ended, with silt accumulating in Lake Nasser. Moreover, since the nutrient-rich silt no longer reaches the river's mouth, Egypt's sardine, mackerel, shrimp, and lobster industries have almost disappeared, leading to the loss of nearly 30 000 jobs.
- Agricultural land in the Nile Delta basin is now treated with commercial fertilizer at an annual cost greater than \$100 million to make up for the lost nutrients.
- Salinization has increased in the Delta's soil, offsetting three quarters of the gain in food production from the new, less productive land irrigated by water from the reservoir. The country presently loses around 10% of its annual crop production due to declining soil fertility, mostly because of increased salt content.

**Exhibit 13. Main arguments voiced by countries claiming their rights to more water.**

Egypt	Ethiopia	Remaining nations
<ul style="list-style-type: none"> <li>• The Nile has long been regarded as the cultural symbol of the country</li> <li>• Argues that the 1959 agreement is irrevocable</li> <li>• Claims more rights over other countries due to its large population growth rate and corresponding agricultural expansion requirements</li> <li>• Maintains that Ethiopia can sustain itself solely through rainfed agriculture</li> </ul>	<ul style="list-style-type: none"> <li>• Demand natural right to own waters</li> <li>• Rank higher than Egypt when Helsinki Rules are applied</li> <li>• Invalidate the 1959 agreement and request its renegotiation, claiming equal shares must be distributed regardless of population and agricultural needs</li> <li>• Has a population nearly the size of Egypt's and regards the key to poverty reduction and food security is through the development of its water resources</li> <li>• Has been witnessing successive drought induced famines</li> <li>• Development projects will only use 0.5 billion cubic meters of the river's annual flow</li> </ul>	<ul style="list-style-type: none"> <li>• Require Nile waters for projects to enhance economic and agricultural development to help sustain their growing populations</li> </ul>



**Exhibit 14. Environmental threats in the Nile basin (Baechor et al., 2000).**

Land degradation	Water degradation	Biodiversity loss	Natural and man-made disasters
<ul style="list-style-type: none"> <li>• Deforestation</li> <li>• Erosion</li> <li>• Riverbank and shoreline degradation</li> <li>• Loss of fertility</li> </ul>	<ul style="list-style-type: none"> <li>• siltation</li> <li>• wetland destruction</li> <li>• nutrient loads</li> <li>• urban and industrial wastes</li> <li>• eutrophication</li> <li>• disease</li> </ul>	<ul style="list-style-type: none"> <li>• bird species</li> <li>• fish species</li> <li>• large animal species</li> <li>• exotic species and weeds</li> <li>• domesticated plant species</li> </ul>	<ul style="list-style-type: none"> <li>• flood</li> <li>• drought</li> <li>• refugee displacement</li> <li>• accidents and spills</li> </ul>

- Without the Nile's yearly sediment discharge, the Mediterranean Sea is eroding the delta and advancing inland, which further reduces agricultural productivity.
- Flooding the area of Lake Nasser uprooted 125 000 people.

The evidence shows that dam construction poses significant environmental threats with far-reaching implications for a country's population, economy, and biodiversity. Exhibit 14 categorizes the major threats anticipated to arise from further weakly planned water quantity augmentation projects with respect to the principal types of resources: land, water, biological, and human.

However, arguments are faced by the many benefits presented by increased water quantity due to the Aswan dam. For example (Miller, 1998):

- The dam supplies almost a third of Egypt's electrical power
- Lake Nasser can store at least 2 yr of the River's annual flow
- Year-round irrigation has increased food production because land that was previously cultivated once per year is capable of producing crops three times
- 4050 km<sup>2</sup> of desert land has been brought under cultivation

**8. What management measures must be promoted by the international committee to help resolve the Nile water issue?** Devising a comprehensive Integrated Water Resource Management (IWRM) plan is inevitable for cooperation over water resources, which should involve negotiations among the involved parties to reach an agreement on equitable utilization and protection of basin's water resources. The IWRM plan would integrate options for sustainable water resources use and development at the watershed level, incorporating the various rival and contradictory issues of the Nile basin. Essential components include public participation, cross-border collaboration, coordination on land use management strategies, political will, and provision for financial, technical, and human support. In short, such a plan is to integrate environmental, technical, social, financial, and legal aspects, pertaining to the specific needs of the Nile basin countries. These measures can be translated into specific actions including (Gardiner, 2000):

- Increased emphasis on the roles of governments, NGOs, and local authorities in monitoring and enforcing both national and international regulations regarding water quality and equitable allocation, as well as overtly supporting trans-boundary collaboration, promoting funds and awareness and capacity building, and encouraging community involvement.
- Formulation of goals by independent riparian governments for the involvement of inhabitants, defining their rights, responsibilities, and roles within an extensive institutional framework for contributive planning and management at various levels and across sectors.
- Adoption of water management strategies that promote a decrease in the demand for water and enhance opportunities

to increase its supply. For example, demand could be decreased by controlling population growth, rationing the water, increasing public awareness with respect to the scarcity of water resources, charging farmers for water, and enhancing efficient water use especially in agriculture (drip irrigation, shift to drought resistant and salinity resistant crops, shift from open drainage to closed pipes). Public-private planning should be conducted and implementation and management processes adopted in consultation with local water users to decide on the most beneficial approach, ensuring that the poorest are fully reflected in the decision making through improved communication of access rights and frameworks for community involvement. With respect to augmenting supply, efforts can focus on wastewater reclamation, saltwater desalination, as well as rainwater harvesting, where found feasible.

- Collection of independent baseline data about the physical status of surface and groundwater reservoirs in the riparian countries, promoting research, modeling and monitoring of water resources, identifying areas with threatened water supplies or where human conflict or natural pressure exist.
- Enhancement of knowledge and information exchange through education, information exchange, and training to allow the involvement of poor, disadvantaged communities, local authorities, and NGOs. Granting the residents a certain degree of responsibility allows them to be more efficient and aware users, in addition to reinforcing local monitoring and regulating of water resources.

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# A Native Landscape for Interstate 15? A Decision Case in Environmental Science<sup>1</sup>

Kendra Busse and Phil Allen\*

## ABSTRACT

Between 1996 and 2001, the section of Interstate 15 (I-15) through Salt Lake City, UT, was redesigned, rebuilt, and expanded in preparation for the 2002 Winter Olympics. The aesthetic theme proposed for the freeway roadside was announced to be a natural landscape consisting of native plants. Dr. John Atwood, a local scientist and plant expert, was hired to provide recommendations for plant selections and seed mixes. In the course of planning the roadside, a conflict surfaced regarding the desirability and feasibility of a "native plant landscape." Atwood's preliminary recommendations had been submitted for review by other scientists (plant breeders not associated with the freeway project) who were highly critical of native plants. The plant breeders argued that the only successful I-15 landscape would consist of exotic species selected for superior performance under Utah's harsh environmental conditions. An all-native roadside landscape had never before been attempted in Utah. Atwood's recommendations would influence the spending of millions of dollars, and the high visibility of the project meant that failure would seriously undermine his professional reputation. The decision whether to use native plants along I-15 illustrates the kind of real-life dilemma that can occur when attempting to resolve an environmental issue. The case was developed for use in environmental science, horticulture, ecology, range management, and landscape architecture courses, and can be used as a basis for discussions about challenges faced when decisions must be made in the absence of complete data and where experts disagree.

MILLIONS OF HECTARES of roadside landscapes have traditionally been maintained through practices that rely heavily on mowing and applying herbicides. While these practices allow Departments of Transportation (DOTs) to meet functional needs, they also require tremendous investments in labor, machinery, and chemicals. The "mow and spray" philosophy of roadside vegetation management is being increasingly challenged for a number of reasons, including cost, sustainability, and a desire for improved regional aesthetics. Highly diverse native plant communities represent an appealing alternative to traditional roadsides (Johnson and Anderson, 1997; USDOT, 1999), although this change in attitude is not without controversy. In the western USA, critics of native plants for roadside landscape use argue that the highway environment is often too harsh and that native plants

are too slow to establish. In 1998, during reconstruction of Interstate 15 (I-15) through Salt Lake City, UT, the environmental consultant hired to provide recommendations on landscape plant selection had to decide whether to recommend the use of native plants to achieve the "natural" landscape appearance desired for the project.

Professionals who work in fields related to environmental science will likely encounter philosophical conflicts between traditional practices and newer approaches based on ecological principles, as well as incomplete knowledge upon which to base important decisions. This case considers the decision whether to recommend the use of native plants for roadside use or the traditional exotic species that had been used for decades.

## THE CASE

In April 1995 the Utah Department of Transportation (UDOT) announced the 1.6 billion dollar reconstruction of I-15 through Salt Lake City, UT. Plans for the 27-km (17-mile) stretch of freeway included expanding the paved surface to 12 lanes and connecting the interstate with several suburban communities through a common design theme. An ambitious timetable for project completion was necessitated by the fact that Salt Lake City would host the Winter Olympics in February 2002.

The contract for designing and building the freeway was awarded to Wasatch Constructors, who retained Sverdrup/DeLeuw (a joint venture between Sverdrup Civil Inc. and DeLeuw, Cather & Company) to design the project. The aesthetic theme chosen for the freeway and the associated right-of-way landscape emphasized the beauty of the Salt Lake Valley and the mountains that surround it. This theme was formally stated as follows:

In recognition of the significant value the Wasatch and Oquirrh Mountains provide for the Valley, the I-15 Corridor Urban Concept celebrates the quality of life and prestige these mountains bring to the Salt Lake Valley, thus supporting the UDOT Guidelines Theme—Celebration of the Native Landscape of the Salt Lake Valley  
(Wasatch Constructors, unpublished report, 1996)

Closely associated with aesthetic objectives was the recognition that these aesthetics would be accomplished within the delineation of six planting themes or ecosystems (Exhibits 1 and 2).

The aesthetic theme for the reconstruction of I-15 called for a philosophical shift from the traditional roadside management practices of UDOT, in which monocultures of crested wheatgrass (*Agropyron cristatum* R. & S.) or a mixture of crested wheatgrass and one or two other Eurasian grasses were typically seeded (Johnson and Anderson, 1997; MacMahon, 1983). Roadside maintenance practices had focused on the

<sup>1</sup> This journal uses SI units, according to the ASA-CSSA-SSSA style. Due to the circumstances of this case study, however, English units are used, either alone or along with SI units.

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**Abbreviations:** DOT, Department of Transportation; I-15, Interstate 15; UDOT, Utah Department of Transportation.

control of vegetation through spraying herbicides (especially broadleaf herbicides), grading, and mowing. This approach to landscaping did, in general, provide adequate erosion control and required minimally trained maintenance employees. However, repeatedly disturbing the roadsides by mowing and spraying prevented native plant communities from re-establishing and perpetuated the invasion by numerous species of weeds.

A natural landscape comprised of a large variety of native species would require a very different management approach. For example, herbicide applications in a diverse plant community typically focus on spot-spraying target weeds rather than broadcast coverage. This would require maintenance personnel to be able to identify a wide variety of native species as well as weeds, but would use much less herbicide. The additional cost of increased personnel training needed to maintain native plantings was estimated to be more than offset by the considerable cost savings associated with significantly reduced spraying and mowing (Johnson and Anderson, 1997). Widening the freeway to 12 lanes made the right-of-way slopes steeper than in the original I-15, so steep that mowing would be unsafe in many places.

### The Landscape Task Force

An important constraint in the I-15 reconstruction was that the project was designed and constructed simultaneously (i.e., the design was completed in a prioritized series of phases, with construction beginning in early phases of the project before design for other sections was completed). This led to a number of critical deadlines that required all professional groups involved in the reconstruction (e.g., the freeway builder, engineers, landscape architects, landscape contractor, and freeway manager) to act under significant time pressure. To facilitate communication and issue-resolution among the various entities involved in the project, Wasatch Constructors

**Exhibit 1. Six proposed ecosystems for the I-15 freeway landscape. The overall concept was for a matrix of grasses to be interspersed with small “islands” of woody plants and wildflowers. These planting themes were repeated along the 27-km (17-mile) corridor as illustrated in Exhibit 2.**

**Wasatch Front Landscape**—Plants that are indigenous and similar to those that could be found along the Wasatch Front.

**Mountain Creek Landscape**—Reflecting plantings found along the streams and creeks that flow from the mountains to the Jordan River† and the Great Salt Lake.

**Salt Marsh Landscape**—These plantings are similar to those found in wetlands and detention basins and are tolerant to high concentrations of salt. They are similar to the plantings found west of the I-15 corridor between the Great Salt Lake and Antelope Island communities.

**Alpine Landscape**—These are plantings indigenous to the foothill and mountain range areas along the Wasatch Front.

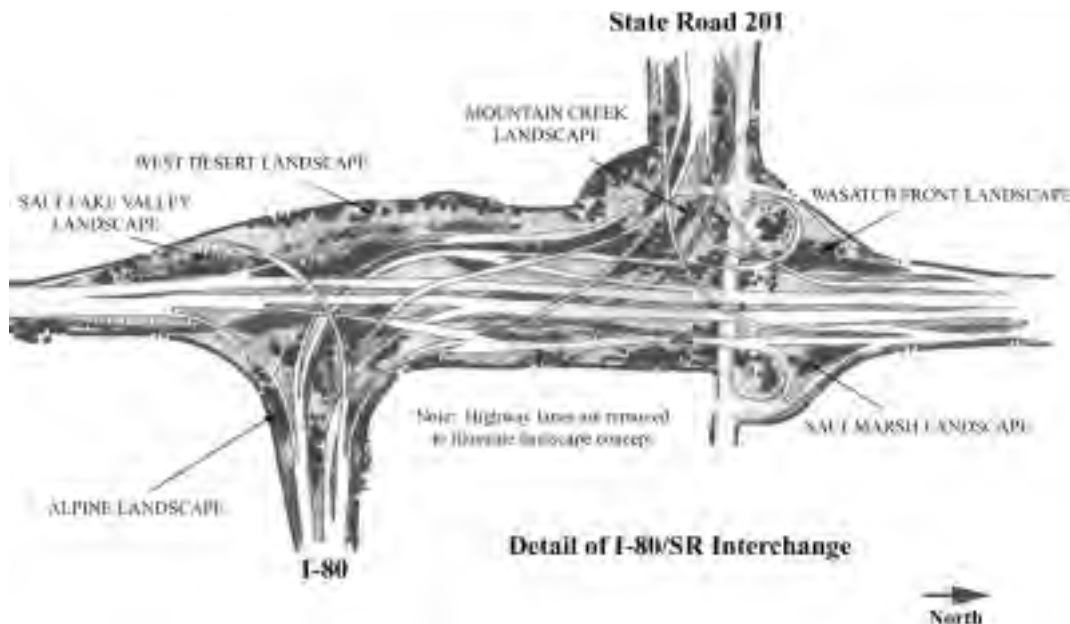
**West Desert Landscape**—The plantings will reflect the vegetation one would find as they proceed west toward Antelope Island or the Oquirrh Mountains.

**Salt Lake Valley Landscape**—These plantings reflect the meadows and grasslands similar to those the early settlers may have encountered as they came into the Salt Lake Valley.

† Note: The Jordan River roughly parallels I-15. Mountain streams discharge into the Jordan River, which empties into the south end of the Great Salt Lake.

created a “Landscape Task Force,” comprised of representatives from each professional group. A brief background summary and priorities for each Landscape Task Force participant follows.

**Builder.** Wasatch Constructors, a conglomerate of several construction companies, was created as a joint venture to build the I-15 corridor. They held the responsibility and liability for the entire project. They were motivated by significant financial incentives (millions of dollars) to complete the project according to a predetermined timetable. In addition, to assure that the ambitious timetable did not compromise



**Exhibit 2. Landscape concept for a section of the I-15 reconstruction, showing five of the six proposed ecosystems. The landscape was expected to complement the freeway design while still meeting important functional requirements such as safety and erosion control.**

**Exhibit 3. Soil test results for stockpiled topsoils and borrow pits.**

	pH	Sand	Silt	Clay	OM†
	g kg <sup>-1</sup> ‡				
Stockpiled topsoils§					
600 North (clay loam)	7.5	350	330	320	52
1500 South (sandy clay loam)	7.7	590	200	210	18
7200 South (loam)	7.4	500	300	200	22
White Hills Borrow Pit¶ (loam)	7.5	460	290	250	4
Monroc Borrow Pit¶ (loamy sand)	7.6	870	70	60	4

† Organic matter.

‡ Divide g kg<sup>-1</sup> by 10 to convert to %.

§ Topsoil existing along roadside before reconstruction was scraped off and stored at locations indicated, and respread before seeding and planting.

¶ Expanding the freeway from 8 to 12 lanes required significant amounts of fill material. Fill was obtained from borrow pits located near the north (White Hills) and south (Monroc) ends of the project. Approximately 70% of the fill came from Monroc and 30% from White Hills.

quality of the project, Wasatch Constructors was required to warranty the freeway for a period of 10 yr.

**Engineers.** Sverdrup/DeLeuw was a joint venture of two companies who designed the freeway reconstruction. In addition to overseeing the civil engineering aspects of the design, they hired the landscape architects. The engineers operated under extreme time deadlines, because construction could not proceed until their plans were completed.

**Landscape Architects.** Landscape architects came from two firms (Allred, Soffe, Wilkinson & Nichols and Gillies, Stransky, Brems & Smith Architects) who were retained by Sverdrup/DeLeuw to develop the necessary landscape plans for the project. Responsibility for the labor was divided geographically (north and south halves, respectively) between the two firms. They also faced deadline pressures and required recommendations for suitable plants and seed mixes before their designs could be completed. They were responsible to see that the objectives within the aesthetic theme were met while working within budget constraints.

**Landscape Contractor.** Nakae and Associates was a California-based landscape contractor with no previous experience in Utah. They were selected to landscape the I-15 reconstruction partly because they had just completed a similar project (i.e., “natural” landscape along a comparable stretch of freeway) in Orange County, California. Their responsibilities included installation of irrigation systems, seeding, and planting, but did not include selection of plants. Nakae was required to complete all landscaping by the project deadline (September 2001) and was required to guarantee plant survival for 1 yr following landscape installation. Therefore, Nakae was concerned that plants and seed mixes chosen for the project had the highest probability for success.

**Long-Term Freeway Manager.** Following construction and installation of the landscape, UDOT had complete responsibility for maintaining the freeway and roadside right-of-way. The UDOT’s primary concerns included safety, drainage, erosion control, weed control, and public perception of roadsides. The UDOT representatives on the Landscape Task Force included the maintenance supervisor as well as the vegetation manager.

**Environmental Scientist Consultant.** The I-15 landscape was to be installed by seeding grasses, shrubs, and wildflowers and transplanting trees and some shrubs. Because Landscape Task Force participants had limited knowledge of native plant ecosystems, Sverdrup/DeLeuw retained Dr. John At-

wood to provide recommendations regarding plants and seed mixes for the six different planting themes that would comprise the roadside. Atwood earned a Ph.D. in horticulture and taught college courses in landscape design, arboriculture, and environmental science. His scientific credentials included several publications dealing with native plants and weeds as well as considerable experience in soil science. While Atwood’s main role was to recommend plants and seed mixes, he was also asked to evaluate soils and determine which, if any, amendments were needed. Atwood was responsible for submitting recommendations to the landscape architects, and was occasionally asked to attend Landscape Task Force meetings.

The reconstruction project appealed to Atwood on several levels. As an avid outdoorsman, he spent many hours hiking, running, and biking in local mountains and deserts where he observed native plant ecosystems. Through these observations and his research projects, he learned about successful growth patterns of native plants. His interest in native plant communities led him to become involved in the Utah Native Plant Society. As a passionate volunteer, he spearheaded the restoration of foothills near the campus where he taught.

The I-15 reconstruction project also professionally appealed to Atwood. Not only was there a significant financial incentive, but he was excited by the magnitude and public impact of the decisions he would influence, and the amount of money spent based on his recommendations. Atwood also knew that good results from this consulting job would likely lead to additional consulting opportunities in the future.

Despite his enthusiasm for the project, both personally and professionally, Atwood was anxious about the demanding schedule of the project. Many of his final recommendations needed to be made within a matter of weeks, during a time in the semester when he would be very busy with giving exams and grading them.

### Related Issues

Atwood was aware of several factors that needed to be considered in order to recommend the best plants for a particular location. These included soils features (texture, nutrient levels, water holding capacity, slope, and aspect), application of de-icing salts (budgeted by UDOT at 1.14 Mg per lane per kilometer (2.0 tons per lane per mile) per year, weed competition, water requirements of native plants, plant and seed availability, water runoff from pavement, and erosion. He arranged for soil tests to be completed for each of the three types of soil that would be used in the project (Exhibit 3). His understanding was that woody plants would be irrigated at least through establishment and that all seeded areas would be completely unirrigated. Based on consideration of all these factors, Atwood prepared a preliminary set of plant lists and seed mixes for each ecosystem/planting theme. These lists included a minimum of 13 native species for each ecosystem and focused on plants that were native to the Salt Lake Valley.

Unknown to Atwood at the time he submitted preliminary recommendations, several competing priorities and strong differences of opinion existed among Landscape Task Force members. Even though the aesthetic theme had been accepted formally, the degree of support for native plants by Landscape Task Force members was highly variable. A number of con-

flicts surfaced in the form of memos and verbal communication. Atwood became increasingly aware of these issues as the deadline approached for his final set of recommendations. Several important concerns arose, all of which had potential implications for which plants he should recommend. These are highlighted below.

**1. “This is not the way we manage roadsides in Utah.”**

It became increasingly clear that UDOT employees at several levels were reluctant to change their landscape management approach. In casual conversation, Atwood overheard maintenance supervisors boasting that “it does not matter what they plant—we can kill it.” This was a concern because maintenance practices could ultimately eliminate most plants on Atwood’s preliminary list.

**2. “Canyon plants are prettier than valley plants.”** The landscape architects were supportive of native plants, but favored native canyon vegetation instead of the more rugged and drought tolerant shrubs, grasses, and flowers that were indigenous to the Salt Lake Valley. However, the average annual precipitation in the Salt Lake Valley was only 38 cm (15 inches), whereas precipitation averaged 46 to 61 cm (18–24 inches) in the lower canyons and foothills. While trees and shrubs were going to be planted in areas with an irrigation system, UDOT had no long-term irrigation management plan for I-15. Atwood was familiar with a previous UDOT project where the irrigation system had been abandoned as soon as repairs were needed. Few species had survived. Therefore, it was impossible for Atwood to know whether plants from the lower canyons and foothills would be supplied with the supplemental irrigation water they would need in the long run. Further complicating his evaluation process was the recognition that the freeway corridor would be a heat sink and that most water runoff from the freeway would be directed to drain pipes and retention basins rather than to the roadside.

**3. Nobody had clearly defined *native*.** Members of the Landscape Task Force were vague in their definition of just what a “native plant” was. Many members were more concerned that drought-tolerant plants with a “natural” look be used and did not necessarily care that such plants be indigenous to the Salt Lake Valley. Atwood was aware that many of the worst invasive plant species in Utah were exotic landscape plants that had escaped from “natural” gardens.

**4. Some outside experts argued that native plants would not work.** Exotic plant species and traditional roadside landscape practices had been used for decades. A completely native landscape had never been attempted by UDOT. While native plants had been included in some plantings and seedings, they often met with little success. In particular, many desirable native species failed to establish from seeds during dry years. Also, forbs (wildflowers) and woody plants were quickly eliminated by mowing and broadcast application of broadleaf herbicides, practices that UDOT felt needed to continue to control weeds. The UDOT vegetation manager was especially concerned that native plants might not work along the freeway, and he submitted Atwood’s preliminary lists for review by scientists whose primary expertise involved rangeland improvement through breeding of exotic grass varieties that could withstand the harsh conditions of Utah and surrounding states. These plant breeders were highly critical of Atwood’s preliminary recommendations (Exhibits 4 and 5).

**Exhibit 4. Letter solicited by the Utah Department of Transportation (UDOT) Vegetation Manager, a member of the Landscape Task Force. The letter is authored by a plant breeder who was not a member of the Landscape Task Force. (Names of individuals have been changed.)**

February 6, 1998

Thomas Child, Vegetation Manager  
Utah Department of Transportation  
4501 South 2700 West  
Salt Lake City, Utah 84119

Dear Tom:

Jonathan Carter, Ian McDonald and I have reviewed the seed mixes for the I-15 Corridor. We are convinced that proposed dryland mix would be a failure. The area that is being seeded has been drastically modified from the original native environment, and for the most part, will not support the species that are native to the undisturbed surrounding areas.

We suggest that you use a core mix in the dryland areas consisting of 20% Western wheatgrass, 30% Vavilov Siberian crested wheatgrass, 30% Tegmar intermediate wheatgrass, 10% bottlebrush squirrel tail, and 10% other species. The other species probably should not include Indian ricegrass.

We are not experts on the wild flowers, but we concur with the choice of Indian paintbrush, globemallow, and blue flax. Many of the others are probably OK.

The saline sites (not marshes), you should consider beardless wildrye and NewHy. The proposed mix for the marshes look OK to us; however, poor germination and lack of seedling vigor will be a problem.

The meadow mix #4 looks a mess. Is this a real dry meadow? How about smooth or meadow brome, tall fescue, NewHy, Tegmar intermediate wheatgrass, thickspike wheatgrass, western wheatgrass, and basin wildrye? This mix would be changed depending on the available moisture. If water is limited (25–38 cm [10–15 inches] precipitation), crested wheatgrass, Tegmar, Thickspike wheatgrass (Sodar), and western wheatgrass would be a good mix.

We really do not have enough expertise to make intelligent comments on other mixes; however, we would use greasewood only as a last resort.

Give us a call if you have any questions.

Sincerely,

D. K. Hatch  
Research Geneticist

Although Atwood was not entirely opposed to non-native plant species in natural landscapes (he had used several exotic species in landscaping projects), he was becoming increasingly concerned that the non-native grasses advocated by the plant breeders were becoming increasingly invasive in many wild habitats. For example, in the canyon restoration Atwood spearheaded, intermediate wheatgrass (*Agropyron intermedium*, recommended by the author of Exhibit 4) was the most difficult to control “weed.”

**5. Each member of the Landscape Task Force had different priorities.** For example, the landscape architects and the landscape contractor were concerned about successful aesthetics, partly because a beautiful I-15 landscape would help them compete for future projects. For engineers and builders, erosion control in the right of way was the primary vegetation issue of concern. They feared that slopes could “unravel” during the vegetation establishment phase, which would necessitate costly repairs and increase liability. Consequently, aesthetics was not a significant concern.

**Exhibit 5. Letter solicited by the Utah Department of Transportation (UDOT) Vegetation Manager, a member of the Landscape Task Force. The letter is authored by a plant breeder who was not a member of the Landscape Task Force. (Names of individuals have been changed.)**

March 19, 1998

Thomas Child  
Roadside Vegetation Manager  
Utah Department of Transportation  
4501 South 2700 West  
Salt Lake City, UT 84119

Dear Tom:

Thank you for the opportunity to review the I-15 roadside revegetation seeding recommendation of John Atwood. His seed mix recommendations are of considerable concern to me and to the team of research scientists here at USDA-Agricultural Research Service, Forage and Range Research Laboratory (FRRL). Let me explain the reason for our concerns and give a little history of our research Unit and clarify the reason for any attached modification to those recommendations.

The Forage and Range Research Laboratory is made up of 8 PhD research scientists and about the same number of support personnel. Revegetation work was initiated by the USDA here on the Utah State University Campus in 1927 shortly after congressional attention was directed to the overgrazed and degraded rangelands in the western U.S. The initial charge of our Unit was to identify plant species and develop seeding techniques to effect revegetation of semiarid rangelands in the intermountain west. During the first 50 years, a wealth of information and knowledge about the seeding of native and introduced species was assembled. For the past 15–20 years, our research efforts have been focused on the development of new and improved plant materials for use on arid and semiarid lands because few available species were found to be adapted to the altered and degraded rangeland conditions present on many areas. We have released 15 new cultivars/varieties/germplasm during that time. The process of releasing new plant material requires that they be grown with and compared side-by-side with many other known plant materials on the possible sites to which they may be adapted. Again those years of research have provided opportunities to evaluate many plant materials. That is our mandate from the Federal Government.

We have no reason to prefer either native or introduced. Our present concern is that the knowledge developed by the FRRL be considered in the highly visible and important task of revegetating I-15 right-of-ways, and that the taxpayers' money be spent with some accountability. Those areas have much in common with many degraded rangelands we have spent years of research effort on.

Several considerations must be made—some of which may easily be overlooked in an attempt to “return to the natural” or native condition. Clearly, the ecosystem that existed on the areas along I-15 in the Salt Lake Valley has been destroyed; top soils were removed, and a few inches of new (different soil) is being put in its place. However, all plant materials, organic matter, soil structure and horizons, associated microflora, and most nutrients were destroyed or are not being replaced. Furthermore, the Salt Lake Valley is a semiarid desert that receives insufficient rainfall to support many of the proposed species. A critical and germane issue is effecting a

successful seeding and the establishment of young plants under semiarid conditions.

It has been our collective experience in the seeding of over grazed and disturbed lands in those dryland areas that establishment of a planting that will effectively stabilize the soil should be a primary concern. Nevertheless, success does not come with every planting even if one uses the most vigorous, drought tolerant, and best adapted species. Year-to-year variations in the weather have profound effects on seedling establishment. Furthermore, the probability of success goes down, often to zero, if anything less than the best adapted species are planted.

One concern is that decisions relative to species recommendations for roadsides are easily driven by desires to create a floral display that may be unrealistic for the site under consideration. In this instance, these are harsh dry sites that also receive considerable salt applications each year due to snow/ice control. Another important factor is DOT's requirements to control noxious weeds. Because many of those areas suffer from repeated infestations of undesirable and noxious weeds, most areas are sprayed at least every few years. Flowers and shrubs are highly susceptible to and are killed by such sprays. Why are the current I-15 right-of-ways in the Salt Lake Valley dominated by grasses? Certainly a major reason is that the plants are adapted to the area and are resistant to chemical spraying.

It may be educational to closely observe the roadsides along Highway 89/91 between Logan and Wellsville. That road was widened and reworked several years ago. Grade cuts were made near the Little Bear River. Large amounts of money and effort were spent in an attempt to establish many flowers and other native species. Although the moisture conditions are much better in Cache Valley than along I-15 and excellent rich topsoil was used, none of those “flowers” are now present. If flowers will not survive along roads in Cache Valley, there is little chance they will even establish in Salt Lake county.

We have years of data that compares many of the species in question on side-by-side test plots. Our recommendations are based on the results of those studies.

Finally, let me restate that we are not advocates of either native or introduced plant materials. We base our plant recommendations not on origin or race, but on plant performance under the conditions in question. I close by asking, “Should we spend tax money in futile attempts by planting species that will never establish?” I would argue that our primary goal should be stabilization of the soils along I-15 at the most reasonable cost. It is a fact that we will never have floral gardens along I-15 until we modify the soil and then apply the amount of water to them that occurs in those areas that do have beautiful flowers.

We congratulate you on the excellent job you are doing and wish you well in your many endeavors.

Sincerely,

R. Nelson Young  
Research Leader

**6. Plant biases affected others' opinions.** Several Landscape Task Force members had favorite plants they wanted included; similarly, everybody seemed to have some plants they hated. These preferences and prejudices disregarded which plants were best from an ecological perspective, whether native or non-native. As an example, an early proposal called for pine trees to be planted along the corridor from the Salt Lake airport to the ski resorts for the Olympics; however, this would be impractical since the airport abuts the Great Salt Lake and surrounding soils are regularly inundated with excessive salt.

**7. Engineers wanted seed mixes to be universally successful.** It was originally envisioned that Atwood's recommendations would be tailored to a given soil, slope, and proposed ecosystem. However, near the deadline for final rec-

ommendations engineers informed Atwood that because they could not verify where a particular soil would be used on the project, they wanted a single seed mix and/or plant palette for each ecosystem (i.e., one that would work for every soil type and slope situation within an ecosystem). This concerned Atwood because soil texture and organic matter were highly variable (Exhibit 3). Few plants that tolerated 870 g kg<sup>-1</sup> (87%) sand and 4 g kg<sup>-1</sup> (0.4%) organic matter (Monroc soil) would thrive in the clay loam that had only 350 g kg<sup>-1</sup> (35%) sand and 52 g kg<sup>-1</sup> (5.2%) organic matter (600 North Topsoil).

**8. The landscape contractor wanted to seed all species at a location at the same time, and at the same depth.** Species on Atwood's preliminary lists varied with respect to optimum seeding depth. For example, with many native

species best establishment occurs with surface seeding, while others emerge best from a depth of 3 cm. Atwood was concerned that this restriction would make it difficult to create sustainable native plant communities that would thrive for several decades.

### The Decision

Atwood was faced with a dilemma. He had originally been hired to provide recommendations about which *native* plants would work best for the I-15 landscape. He valued the ecology, sustainability, and beauty that a complex, high-biodiversity landscape could accomplish, but he recognized that failure of an all-native landscape would be highly visible. Atwood had achieved good success in the ecological restoration project near his campus, but he was in charge of that project. While Atwood had observed successful native roadside plantings in Minnesota, Iowa, and Arizona (drip-irrigated in Arizona), he was well-aware that an all-native planting in the dry Salt Lake Valley had never before been attempted and therefore had never before been successful. He was uncertain that the UDOT would manage the landscape effectively in the long run, even if the design and installation were successful. He did not know if existing UDOT personnel would alter their management techniques to ensure survival of native plants, especially broadleaf species. Atwood's recommendations would directly influence the spending of several million dollars. Also, while he knew a great deal about native plants, many of the species had not been tested previously in the specific environment created by a freeway corridor. By the time Atwood learned of the issues and concerns of Landscape Task Force members, he had only 3 wk to resolve them and make his final recommendations. At this point his consulting fees would not change whether he recommended native or exotic species. What should he recommend?

### TEACHING NOTE

#### Case Objectives

After completing this case, students should have a better:

1. Understanding of the advantages and limitations of using native plant for natural landscapes.
2. Appreciation for the difficulties involved in decision-making for an environmental issue where different priorities conflict and experts disagree.
3. Awareness of the challenges involved in making important environmental decisions in the absence of complete data.

#### Use of the Case

"A Native Landscape For I-15?" presents an authentic situation that illustrates conflicts that frequently arise associated with the issue of native vs. non-native plants. (Note: The names of all individuals in this case have been changed; company names and all other information is factual). Often the question of whether/when to use native plants becomes a controversial and emotional topic. The case as presented was developed for use in an advanced landscape design course, but may also be adapted for use in environmental science, ecology, horticulture, or range management courses. While the

case specifically involves landscaping of a freeway roadside, the issue of whether to require native plants frequently arises in a number of other contexts. Some examples of situations that require decisions on whether to choose native plants include: landscaping of campgrounds in national forests, revegetation of public lands following a major disturbance such as wildfire or strip mining, legislation in communities or regions where exotic ornamental plants have become invasive species, water shortages leading to the need for drought-tolerant landscape plants, revegetation of weed-infested rangelands, and efforts to reduce maintenance costs in public parks.

Preliminary versions of the case were class-tested in a sophomore-level environmental issues course composed of students from various majors in 1999, a junior-level urban forestry course for horticulture majors in 2002, and a senior-level landscape design course with students from various majors in 2002. While the case elicited a variety of responses from the different courses, two points are worth noting here. First, the majority of students were already familiar with the term *native plant*, but few of the students had considered that deciding whether to use native plants could be an important issue before exposure to this case. Second, for students with a previous background in environmental education that included an understanding of the importance of *sustainable* landscapes, the awareness that native plants may not always be the best practical choice for a natural landscape sometimes came as a shock.

The following suggestions are offered for teaching this case.

- In addition to assigning the case for reading before class discussion, there is other valuable information that will generate a wider variety of perspectives than are presented in this case. These sources include recent journal readings or Internet searches in the areas of invasive plant species (e.g., Mullin et al., 2000), the regionally important need for water conservation in urban landscapes (numerous websites are available, often associated with Cooperative Extension in drought stricken areas), and further arguments advocating the use of native plants (e.g., Native Plant Society websites).
- The instructor may begin the in-class discussion by dividing the class into small groups (3-5 students) with each group assigned to one of the discussion questions in the next section. Each student first rapidly answers the question individually in as much detail as he/she can in 2 to 4 min, then a group answer is generated (also under time pressure). A group leader may be assigned to assure that each group member participates in developing the answer to the question (with the threat that a non-participant may be assigned to be spokesperson for the group). Depending on student enrollment, multiple groups may be assigned the same question.
- Following or during a group answer, the instructor may interject comments based on material from the author's interpretation that follows discussion questions in order to stimulate alternative thinking or liven the discussion. Additionally, students from other groups may be allowed to challenge an opinion. The instructor may wish to reserve some questions for consideration by the entire class.
- Alternatively, groups of students may be assigned to represent a particular perspective on the Landscape Task Force



in responding to the discussion questions. This approach helps assure that a variety of opinions will be represented.

### Discussion Questions

In discussing the case, factors that affect decision-making regarding the use of native plants on the I-15 landscape should be identified and evaluated. Some possible questions to accomplish this include the following.

1. Why did the decision whether to recommend native plants create a dilemma for John Atwood?
2. What is the appropriate landscape for I-15? Is Atwood obligated to use native plants in the landscape?
3. What constitutes an appropriate “native” plant along the right-of-way?
4. Would the exotic species recommended by the author of the first letter (Exhibit 4) work better than native plants? How could you be certain? (Note: The plant breeders who wrote letters in Exhibits 4 and 5 did not have soil test results and were unaware of the Aesthetic Theme for the I-15 reconstruction.)
5. Do you think a bureaucracy like UDOT could maintain a natural landscape like the one Atwood envisioned?
6. What did Atwood recommend? To what extent did Atwood’s recommendations satisfy the priorities of each Landscape Task Force participant?

(Note: Questions 1–5 can be answered before reading the *Authors’ Analysis*. Question 6, which the instructor may choose not to raise in order to help students retain ownership of the decision (See Bouda et al., 1996), can best be addressed after reading the *Authors’ Analysis*.)

### Authors’ Analysis of the Decision

Recognizing that even the best plants and seed mixes could not guarantee complete plant establishment, Atwood was determined to provide recommendations that would maximize the probability for project success. Representative recommendations are included in Exhibit 6; his complete recommendations are available from the authors.

Atwood had to consider each of the concerns described earlier. A brief description of how he dealt with each issue along with his rationale follows.

#### 1. “This is not the way we manage roadsides in Utah.”

Atwood was convinced that UDOT personnel required education and persuasion. Due to his involvement in the I-15 project, Atwood was invited to be the keynote speaker at the 2000 UDOT annual vegetation management conference. He presented a seminar on ecological principles of roadside management. In addition, he focused considerable efforts (memos and phone calls) on younger UDOT employees who were more open-minded about change.

**Exhibit 6. Recommendation for Wasatch Front Landscape, as an example of Atwood’s final recommendations. Complete recommendations are available from the authors.**

Wasatch front seed mix #2 drill seeding†		
Shrubs	Special seeding considerations	Seeding rates [kg ha <sup>-1</sup> (pounds acre <sup>-1</sup> ), PLS]
Black sagebrush ( <i>Artemisia nova</i> A. Nels.)		0.45 (0.40)
Wyoming big sagebrush ( <i>Artemisia tridentata</i> Nutt.)		0.22 (0.20)
Green ephedra ( <i>Ephedra viridis</i> Cov.)		5.60 (5.00)
	<b>Subtotal for shrubs</b>	<b>6.27 (5.60)</b>
Grasses	Rhizome or bunch	Seeding rates [kg ha <sup>-1</sup> (pounds acre <sup>-1</sup> ), PLS]
Slender wheatgrass ‘Revenue’ ( <i>Agropyron trachycaulum</i> Malte var. <i>trachycaulum</i> )	bunch, rhizome	1.68 (1.50)
Indian ricegrass [ <i>Oryzopsis hymenoides</i> (Roem. & Schult.) Ricker]	bunch	1.12 (1.00)
Crested wheatgrass ‘Vavilov’ [ <i>Agropyron cristatum</i> (L.) Gaertn.]	bunch	1.12 (1.00)
Needle-and-thread grass ( <i>Stipa comata</i> Trin. & Rupr.)	bunch	1.12 (1.00)
Streambank wheatgrass ‘Sodar’ ( <i>Agropyron riparium</i> Scribn. & Sm.)	rhizome	1.12 (1.00)
Intermediate wheatgrass ‘Tegmar’ [ <i>Agropyron intermedium</i> (Host) Beauv. var. <i>intermedium</i> ]	rhizome	0.56 (0.50)
Western wheatgrass ( <i>Agropyron smithii</i> Rydb.)	rhizome	0.56 (0.50)
Snake River wheatgrass ‘Secar’ [ <i>Pseudoroegneria spicata</i> (Pursh) Love]	bunch	2.24 (2.00)
Sand dropseed [ <i>Sporobolus cryptandrus</i> (Torr.) A. Gray]	bunch	0.28 (0.25)
	<b>Subtotal for grasses</b>	<b>9.80 (8.75)</b>
	<b>Total—Pure live seed, PLS</b>	<b>16.00 (14.35)</b>

† Notes for Seed Mix #2 Drill Seeding:

1. Recommended seeding procedure following seedbed preparation (subject to modification as needed):
  - A. Drill-seed all grasses and shrubs *except* sand dropseed, black sagebrush, and big sagebrush (1.6 cm [5/8 inch] deep). Drill shrubs in separate drop boxes, separately from grasses where possible.
  - B. Drill sand dropseed, black sagebrush, and big sagebrush at 0.3 cm (1/8 inch).
  - C. Nakae is having a rangeland drill built specifically for this project. Further refinements of seeding procedures will be likely, depending on the drill’s capacity.
2. In irrigated areas, the following can also be seeded at 2.5 cm (1 inch): Cow mex (Stansbury cliffrose) at 1.7 kg ha<sup>-1</sup> (1.5 pounds acre<sup>-1</sup>), Rhu tri (oakbrush sumac) at 5.6 kg ha<sup>-1</sup> (5 pounds acre<sup>-1</sup>), and Cer led (curl-leaf mountain mahogany) at 3.9 kg ha<sup>-1</sup> (3.5 pounds acre<sup>-1</sup>). In unirrigated areas, these will fail to establish on Monroe borrow nearly every year.

**Explanation: All native trees and shrubs listed in the Wasatch Front Landscape can be seeded, with different probabilities for success. In Utah, many of these plants naturally establish from seed only during wet years or “wet cycles” of years. Due to limited seed availability and/or low expectation for success even with the highest quality seed and best seeding procedures, certain plants that will be established as transplants (with irrigation) are not included in the above list.**

**Most drought-tolerant trees and shrubs are slow to establish, and seeded woody plants may compete poorly with grasses. Even transplanted shrubs will compete poorly with grasses where grasses are irrigated. Use of the Wasatch Front Seed Mix should probably be avoided where irrigation to transplanted shrubs occurs, or the grasses should be omitted from the mix in these areas.**

**Where the primary objective is establishment success for desired species, it is more economical to establish a few transplants than apply a sufficient amount of seed to “make it work.” In some cases, sufficient seed quantities simply do not exist commercially.**

By expanding the lanes of traffic within the same right-of-way, roadside slopes for the new freeway were almost all considerably steeper than for the old freeway. The consequence was that mowing was impractical in many areas. Atwood recommended that where mowing was necessary, it should be done only in the autumn after native species had produced seeds, and never where woody plants and wildflowers were located.

**2. “Canyon plants are prettier than hardy valley plants.”** Atwood supplied a strongly worded memo (available from authors) regarding the need for ongoing irrigation if canyon plants were to be used.

**3. Nobody had clearly defined *native*.** During a Landscape Task Force meeting Atwood explained how many introduced species had become invasive, a problem with enormous costs to private and public entities including UDOT.

**4. Some outside experts argued that native plants would not work.** Atwood concluded that a native roadside landscape was more consistent with his philosophical and professional background, even though he recognized that the I-15 project would probably not be entirely successful. He submitted his preliminary recommendations for review and refinement by five ecologists with revegetation experience and either a master’s or doctoral degree. He contacted the author of Exhibit 5 to verify that the two letters (Exhibits 4 and 5) had, in fact, been written with no knowledge of the I-15 aesthetics theme, soil test results, or irrigation systems.

However, to avoid criticism that could arise if the native plants failed to establish, Atwood made the “political” decision to include in his seeding recommendations very small amounts of traditionally advocated nonnative species (Exhibit 6). That way, if the plantings totally failed he could defend the native plant recommendations by pointing out that the nonnatives had not established either.

**5. Each member of the Landscape Task Force had different priorities.** Aside from engineering solutions to the problem of erosion control (e.g., specifications called for erosion control blankets on slopes greater than 3:1), Atwood remained convinced that high plant diversity in the seed mixes would prove to be the best strategy. His final recommendations (Exhibit 6) included three to four times the number of species typically included in roadside seed mixes, thereby increasing the probability that at least some species would establish given the wide range of conditions encountered. In all seed mixes, some highly salt-tolerant plants were included due to the unknown salt loading from de-icing.

**6. Plant biases affected others’ opinions.** Atwood provided memos and verbal arguments in Landscape Task Force meetings, explaining why each inappropriate plant proposed was unsuitable for the project. Landscape architects ultimately followed Atwood’s recommendations on tree and shrub species about 90%, and on seed mixes 100%.

**7. Engineers wanted seed mixes to be universally successful.** The number of species in each seed mix was increased.

**8. The landscape contractor wanted to seed all species at a location at the same time, and at the same depth.** Atwood introduced the landscape contractor to practitioners who specialized in seeding equipment for revegetating sloped sites. Special equipment was created that allowed for broadcast and drill seeding (at multiple depths) simultaneously. Note that steeply sloped sites had to be broadcast seeded, which requiring a higher seeding rate and resulted in poorer establishment.

### Initial Results

Areas that were drill-seeded had acceptable plant coverage on more than 90% of the roadside areas (Nakae and Associates, personal communication, May 2002). Where plant coverage was not acceptable, probable explanations include the following.

1. Several snowstorms of less than 7.6 cm (3 inches) during the winter of 2001–2002 resulted in heavy application of de-icing salts with minimal moisture for dilution. A few areas devoid of vegetation were so salty they appeared white on the surface by April 2002. Soil test results yielded sodium levels as high as 550 mg kg<sup>-1</sup> (parts per million) and sodium adsorption ratios as high as 39.2, which indicated an extreme sodium hazard.
2. Areas that were broadcast-seeded remained more compacted than areas that were drill-seeded (engineering specifications for the freeway required that fill material be compacted to 95%).

Most plants Atwood recommended grew successfully along the I-15 roadside; only two species proved unsuccessful in the short run. Interestingly, several new positions were tentatively approved within UDOT to hire employees with expertise in native plant communities. These positions were all re-allocated within UDOT to meet other needs. Thus, the jury is still out on whether the largely native I-15 landscape will prove to be successful.

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# A Case Study on Rotational Grazing and Riparian Zone Management: Implications for Producers and a Conservation Agency

Michael Popp,\* Brenda Chorney, and Terry Keisling

## ABSTRACT

**Discussions of economic benefits and costs of rotational grazing and riparian zone management are ongoing but few case studies are available that summarize issues that may be of importance to producers and wildlife agencies. In spite of non-ideal study conditions, the case study presented here demonstrated that positive annual net economic benefits can result from improved pasture management without including environmental benefits. A discussion of available and required data highlights the difficulties associated with attempting to quantify whole-farm economic benefits to changes in pasture management.**

ROTATIONAL GRAZING PASTURE SYSTEMS and reduced access to riparian zones (areas along streams or rivers) may have the potential to provide economic and environmental benefits. Economic benefits from rotational grazing are considered to occur due to improved pasture conditions that may provide for greater weight gain of herds on pasture and/or higher stocking rates in comparison to continuous grazing systems. Environmental benefits include improved wildlife habitat and reductions in soil erosion from trampling and overgrazing. Additional environmental benefits are obtained if the pasture includes a riparian zone and the rotational system controls the herd's access to the riparian area. A summary of the literature on the major impacts of livestock grazing on stream and riparian ecosystems may be found in Belsky et al. (1999).

A number of cattle producers in Manitoba, Canada<sup>1</sup> and the USA<sup>2</sup> have adopted some form of rotational grazing system and/or reduced access to riparian zones (Chorney and Josephson, 2000). Many of these producers have observed improved pasture conditions, although some controlled trials of various

rotational scenarios have found varied results. While the research results are mixed, there is interest among producers, as well as environmental and producer groups, on grazing systems that provide the greatest level of sustainability from both an economic and environmental perspective (Chorney and Josephson, 2000; Lowrance et al., 2000).

While there are publications on controlled research trials that have evaluated various aspects of pasture management, there are few formal farm case studies that have presented issues surrounding the examination of economic benefits realized by producers who have changed their grazing systems from a continuous to a rotational system. Such studies would be useful to producers in identifying and outlining what such benefits are, how they are realized (i.e., through weight gains on pasture or increased stocking rates), how soon after adoption of a rotational system the benefits can be realized, the costs of such systems in comparison to the benefits, and finally, what kind of difficulties are encountered from a record keeping perspective when trying to evaluate a system change after the fact. Environmental and wildlife agencies that provide incentives or other forms of funding to producers to adopt more environmentally sustainable forms of production also require information on the possible benefits of such systems in order to analyze the feasibility and success of their funding programs (Chorney and Josephson, 2000). To put it in simple terms using the words of Lovejoy (1999, p. 370) "Does Conservation Pay?... We hope so."

The objectives of this study are (i) to provide a brief background of some of the literature on this topic to inform case readers of some of the issues, and (ii) to introduce an educational case study that highlights the importance of and difficulties encountered in the economic evaluation of costs and benefits of adopting rotational grazing and development of riparian zones on a small sample case farm that has switched to a new production system in a nonexperimental setting.

## BACKGROUND ON ROTATIONAL GRAZING

Rotational grazing involves partitioning pasture or rangeland into a number of paddocks and grazing each paddock in rotation. The sequence of rotation through the paddock will usually vary from year to year. The numbers of paddocks and length of time in each paddock varies with the type of rotational system adopted and may be a function of the size and natural conditions of the pasture, the climatic conditions of the area, and the herd size. Various advantages have been ascribed to properly maintained rotational systems. As livestock are rotated through the system, the pasture is more uniformly grazed than if they were allowed to selectively graze

<sup>1</sup> Both Ducks Unlimited and Manitoba Habitat Heritage Corporation provide start up funds to producers for fencing off critical wildlife habitat. In 1998 there were approximately 160 producers enrolled with both agencies throughout Manitoba (L. Colpitts, personal communication, 1998). For a more detailed description of the Ducks Unlimited program in Canada, see McMillan (1998).

<sup>2</sup> In addition to wildlife agencies such as those quoted for Manitoba, in the USA the USDA-NRCS through their Grazing Lands Conservation Initiative (GLCI) is also promoting pasture and riparian buffer management through educational programs and economic incentives of the Conservation Reserve Program (CRP), Environmental Quality Incentives Program (EQIP), Wildlife Habitat Incentive Program (WHIP), Wetlands Reserve Program (WRP), and Stewardship Incentives Program (SIP) (USDA-NRCS, 1995, 1997, 1998).

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**Abbreviations:** AU, animal unit; CRP, Conservation Reserve Program; EQIP, Environmental Quality Incentives Program; GLCI, Grazing Lands Conservation Initiative; MHHC, Manitoba Habitat Heritage Corporation; SIP, Stewardship Incentives Program; WHIP, Wildlife Habitat Incentive Program; WRP, Wetlands Reserve Program.

the whole pasture. A period of rest for plant regrowth, avoidance of overgrazing, and less selective grazing by livestock results in more vigorous plant growth, reduced opportunities for undesirable plant species to invade the pasture, and reductions in trampling and soil erosion (Holechek et al., 1995).

Environmental benefits from improved pasture management and restricted access to riparian zones include increased quantity and quality of wildlife habitat areas and reduced soil degradation. For example, paddocks left to rest in spring are available to wildlife for reproductive purposes without danger of cattle trampling their nesting sites. Also, riparian zones are particularly susceptible to overgrazing, trampling of banks, and subsequent erosion problems, as cattle prefer these areas for the water supply as well as, in many cases, the shade and cover afforded by these areas (Holechek et al., 1995). By restricting access to the riparian areas, the improvement in vegetative cover and water quality may have a beneficial impact on fish and wildlife habitat.

In the "twice over" rotation grazing system, multiple paddocks are each grazed for two periods during the summer with the first paddock grazed in one summer being the one grazed last the previous summer. The initial cattle grazing period or "first pass" is timed to defoliate grassland plants at a phenological stage that will enhance tiller development and symbiotic rhizosphere activity (Manske, 1994). The rhizosphere is the narrow zone of soil around the roots of perennial grassland plants. Increased activity of symbiotic organisms in the rhizosphere ultimately results in a greater level of nutrients available to the defoliated plant (Manske, 1994). Greater tiller development and increased rhizosphere activity enhances aboveground biomass production and, therefore, the first pass of the pasture is considered the stimulation phase. The second cattle grazing pass entails harvest of the grass (Manske, 1995).

Controlled studies of rotational grazing have found mixed results. Manske (1994, 1995) identified greater weight gains per animal with rotational grazing. Others showed greater weight gain per hectare as a result of greater stocking rates that are possible with rotational grazing (Walton et al., 1981; Emmick et al., 1990; Morrow et al., 1990; Bertelsen et al., 1993). Still others maintain that there is no difference between the two systems (Hart et al., 1988; Chestnut et al., 1992) or that differences are due to travel distance to the water source (Hart et al., 1993). Hubbard (1951) in fact shows that under moderate stocking rates continuous systems may outperform the rotational system in terms of weight gain per calf. The variety of results found in the various studies makes comparing and interpreting these results difficult with respect to the benefits of rotational grazing over continuous grazing. The merit of rotational grazing may be highly dependent on the prior conditions and natural characteristics of the pasture as well as the degree of management provided under the two systems. Pastures that have critical areas or conditions that make them susceptible to damage or overgrazing may benefit most from the rest periods provided by rotational grazing.

## PROCEDURE AND DATA

The Manitoba Habitat Heritage Corporation (MHHC), a habitat agency created by the government of Manitoba, works with landowners through various habitat improvement programs. Through its programs, MHHC promotes the "twice-

over" rotational grazing system and has assisted producers in adopting such a system, both financially and through extension services. Producers, MHHC, and other agencies are interested in having the benefits of rotational grazing formally documented. With this end in mind, MHHC identified a producer who has recently adopted a twice-over rotational grazing system and obtained his agreement to participate in the current case study. Data on the cow-calf operation both before and after adoption of the rotational system were obtained through a personal interview with the producer. The producer's operation and the data he had available are described below.

The participant is a cow-calf producer who resides close to Shoal Lake, Manitoba, and joined the MHHC program with a commercial beef herd of 50 cows. Calving begins after the first week of February, with the first week of March as the average calving date. Calves are weaned by the end of October and market calves are sold the first week of November every year. Approximately 16% of the heifer calves are kept to replace culled cows.

The aerial map in Exhibit 1 provides an overview of the fence system. The western half of the section (Paddocks 1, 2, and 3) is used as the main summer pasture and is characterized by mostly native grass species interspersed with shrubs and trees. Prior to establishment of the rotation system, cattle were placed on this main pasture between mid-May and the first of June with no fencing between the paddocks (i.e., Paddocks 1, 2, and 3 were grazed continuously). Between the middle and end of September the cattle were moved from the main pasture to Paddocks 4 through 6 and 9. These latter areas are used for forage, cereal, and oilseed production as well as for fall grazing once crops are harvested. Paddocks 7 and 8 are mostly bush but do provide some grazing for the fall months.

The twice-over rotational grazing system was implemented in 1996 by establishing fence lines between Paddocks 1, 2, and 3. Cattle are placed on pasture on 1 June, rotated on a 2-week basis, and removed from pasture on 1 September. With the twice-over system and three paddocks, one pass of the entire pasture requires about 6 weeks, with each paddock receiving 4 weeks of rest. Two passes of the pasture are completed during the summer months. Cattle are kept on pasture for 92 days in the rotational system, from 1 June to 1 September. Each paddock is grazed for approximately 30 days. Once removed from this pasture, cattle are again placed in the same paddocks as in the continuous system. The producer hopes to gradually increase the second pass from 2 to as much as 4 weeks per paddock, given appropriate weather and forage conditions.

The current water source for the pasture is the Birdtail River, which runs through Paddock 10. Access to the river is now limited to one site via a gravelled ramp to the river. Prior to the establishment of the rotational system, access to the river was not limited to one site. Although the fence separating the pasture from the riparian paddock (Paddock 10) was in place, cattle were able to gain access to the river on the west side of the river. By comparison, under the rotation system, pasturing on the riparian Paddock 10 is limited to 3 to 4 days in the fall.

The only other change the producer has made for improving the pasture, other than those described above, is brush and scrub cutting. As indicated in Exhibit 1, the pasture system has some shrubs and wooded area interspersed with the grassed

area. The producer began scrub cutting in 1997 to keep down the growth of the woody vegetation and to promote grass growth around the shrub areas. The hope was that grasses would eventually crowd out the shrubs within about 4 years.

The producer was able to provide data for 1995 to 1997, inclusive, for stocking rates and average weight gains of calves

(see Exhibit 2). He did not have data available for years before 1995, but considered 1995 representative of his continuous grazing system. Since the producer does not own a scale, average weight gains are based on sale ticket weights in the fall, and therefore represent weight gains from birth to market, not just weight gain on pasture.

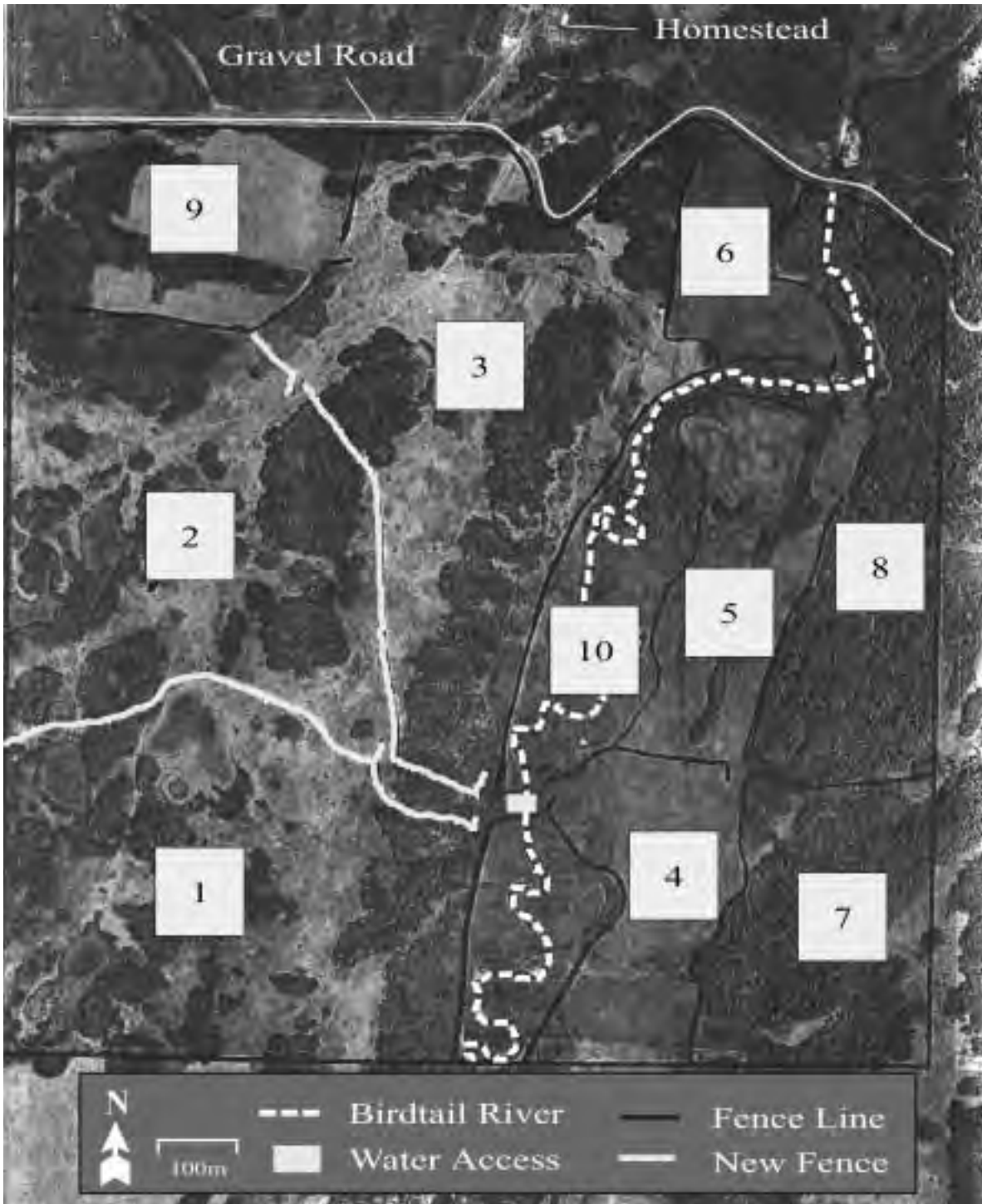


Exhibit 1. Aerial map of pasture in 1996, Shoal Lake, Manitoba. Paddocks 1, 2, and 3 were grazed continuously before 1996 and as a rotational system starting in 1996.

**Exhibit 2. Number of cattle on pasture (Paddocks 1 to 3), calf weights, beef production, and average Manitoba feeder cattle prices in Canadian currency (1995–1997).**

No. of cattle	Continuous (1995)	Rotational		
		1996	1997	1996–1997 avg.
Bred cows	50	70†	70	70
Heifer calves	29	31	36	34
Steer calves	19	37	33	35
Replacement heifers	8	0	0	0
Bulls	2	3	3	3
Weight data (in kg)				
Heifer calves	279	303	308	305
Steer calves	327	331	337	334
Avg. beef production per cow	286	309	322	315
Beef production per ha	111	168	175	171
Average 1988–1997 November Manitoba market prices (in \$ kg <sup>-1</sup> )				
Steer calves Min	1.81	Heifer calves Min		1.64
(272–363 kg) Max	2.57	(272–318 kg) Max		2.44
Avg.	2.18	Avg.		2.04

† Twenty cow–calf pairs and one additional herd sire were purchased as prices were cyclically low (assume \$800 per cow–calf pair and \$1500 per bull). Also, pasture was available from a neighbor for the replacement heifers and therefore information on those cattle are not reported here.

### Animal Unit Days Per Hectare

The producer did not have data on weights of cows, replacement heifers, or bulls, but estimated the average weight of his cows at 635 kg. Cattle weights are used to estimate stocking rate in terms of animal unit days per hectare for each year. An animal unit (AU) is defined as one 454 kg mature cow, either dry or with a calf up to 6 months of age (Holechek et al., 1995). Therefore, with an estimated average cow weight of 635 kg, cow–calf units are assigned values of 1.4 AU. Similarly, animal units for bulls and yearling heifers can be calculated using 1.5 AU for bulls and 0.75 AU for yearling heifers (Basarab and Gould, 2000). Animal unit calculations enable comparisons across systems, as the producer pastured different types and numbers of animals over time. Exhibit 3 highlights similarities and differences across the two systems.

One might further distinguish the two pasture systems by calculating differences in forage intake using standard intake values. A mature cow, either dry or with a calf up to 6 months of age, is considered to consume 2% of its body weight of forage (dry matter) per day (Holechek et al., 1995). Bull and replacement heifer intake can again be adjusted using the differential in AU values. In the absence of actual intake data, total estimated required forage production (to proxy for assumed consumption) across years and pasture systems may serve as a crude measure of comparison across the two strategies (Exhibit 3).

## ECONOMIC RETURNS

### Differences in Gross Revenue

The difference in gross value of heifer and steer calf production using various pasture systems can be calculated using average sale weights and November prices (appropriate numbers are provided in Exhibit 2). The value of production will vary substantially depending on cattle prices used to determine value as shown in the range and average of the 10-year November prices. Manitoba average prices of 272 to 318 kg

**Exhibit 3. Animal unit (AU) and forage requirement comparisons on pasture Paddocks 1 to 3.**

Statistics	Continuous (1995)	Rotational (1996 and 1997)	
		Per paddock†	Total
Days on pasture	122	31	92
Number of hectares	129	43	129
Number of AU	79	103	103
AU days	9 638	3 137	9 410
AU days ha <sup>-1</sup>	74.7	73.0	72.9
Total forage requirements (kg season <sup>-1</sup> )‡	87 636	28 582	85 745
Forage required (kg day <sup>-1</sup> )	679	933	933

† Per paddock average. Sizes of the three paddocks are 42, 43, and 44 hectares.

‡ In the North Dakota research study using the twice over system as one of the grazing strategies, cattle remained in each paddock for 15 days for the first cattle grazing pass of the pasture and 30 days for the second cattle grazing pass of the pasture (Manske, 1995). The producer in the present study hopes to slowly increase the time spent in each paddock for the second pass from the present 2 weeks up to 4 weeks, which will increase total forage requirements from the native pasture.

heifers and 272 to 363 kg steers are, therefore, also provided. All price and cost information are in Canadian currency.

### Differences in Costs of Production

Costs that were identified to differ between the two systems are (i) creep feeding, (ii) feeding and pasture costs to account for difference in days on pasture between the two systems, (iii) scrub cutting costs in 1997, and (iv) the cost of setting up and operating the new electric fence system. No attempt was made to identify and apply any differences in labor between the two systems. Installation of the fence would be a one-time event that would need to be allocated over the useful life of the fence. Other changes in labor are likely to be minor in the sense that daily cattle checking activities may be extended by several minutes to move cattle from paddock to paddock more often than previously and paying more attention to pasture condition to evaluate when to switch paddocks. No additional labor was hired and as a result, differences in returns need to be interpreted as returns to owner labor and management. Land resources and capital resources differ slightly across the systems and therefore careful attention may need to be paid to account for these changes.

### Creep Feeding of Calves

Creep feeding of calves was done on a free choice basis using a mobile creep feeder. In 1995, the producer creep fed 227 kg whole oats per calf. For 1996 and 1997, the calves used 181 and 100 kg per calf, respectively. The 1996 price of \$126 Mg<sup>-1</sup> of oats (Manitoba Agriculture, 1996) was chosen as a representative market price of feed oats for all years.

### Accounting for Differential Days on Pasture and Pasture Rental

Because the pasture season on the native pasture was shorter for the rotational grazing system, the cost of feeding the animals for the additional days has to be accounted for to make comparisons between the two systems possible. Cattle were turned out on pasture at a later date in the rotation than the continuous system and were therefore kept on feed longer in the spring. Using 1996 Manitoba Agriculture cow–calf production costs, overwintering costs of \$0.83 per cow per day (this includes feeding newborn calves and herd sires) may be

used. Replacement heifers carried an estimated cost of \$0.80 per head per day.<sup>3</sup>

The producer also took the cattle off pasture earlier in the rotational system. Costs associated with placing the cattle on the harvested fields earlier may be reduced hay yields the following year, or increased requirements for fertilizer. Since calculation of these costs is difficult, a commonly used pasture rental rate of \$0.42 per cow-calf unit per day may be used (Blawat et al., 1996). This rate breaks down to \$0.32 per cow per day and \$0.10 per calf per day.

One additional cost of the rotational system, which was not discussed above, is that of pasturing the replacement heifers on a separate pasture. The producer grazed the replacement heifers at no charge from his neighbor from 1 June to 1 September for 1996 and 1997. The replacement heifers joined the remainder of the herd on Paddocks 4 through 9 for the remainder of the pasture season.

### **Scrub Cutting**

As a further means to improve pasture condition, the producer began scrub cutting in 1997. The producer stated that he likely would have started scrub cutting even without the change to the rotational system. Further, dramatic changes in forage production due to scrub cutting would likely not have appeared the first year.

### **Fencing Cost**

Total fencing costs for separating the native pasture into three paddocks using two strand electrical wire was \$1800. A useful life of 10 years is assumed with no maintenance cost and a salvage value of \$800 at end of the fifth year. Again, no labor charges are included. The producer was refunded some of these costs.

## **SUGGESTED CASE STUDY LECTURER NOTES**

The following section exhibits the authors' calculations that were presented to the conservation agency to determine whether or not to continue subsidizing producers by paying part of the initial fencing cost. A discussion follows on shortcomings and additional data needed to fully answer the research question posed in the title of the paper: Is rotational grazing and riparian zone management profitable both from the perspective of economic returns to the producer as well as environmental benefits realized by users of the Birdtail River?

The analyst needs to make several assumptions. Since the producer changed both his pasture management and scale of operation, the returns estimated will be to a new management system and not necessarily rotational grazing alone. With this caveat in mind, one of the first decisions is to use data from either 1996, 1997, or an average of the 2 years for the rotational system as the basis for comparison with 1995 or the continuous grazing system. Since the producer has no additional data, the average of 1996 and 1997 is preferable to using either of the 2 years. This 2-year period would allow the rotational system some time to adjust to the new grazing pattern.

<sup>3</sup>Manitoba Agriculture (Blawat et al., 1996) uses a winter feeding period of 225 days for the average producer. During this time cattle are kept in corrals and fed rations made up of hay, straw, and grain. Hay costs for this period are given as \$180 per cow or herd sire.

In addition, averaging across years would remove seasonal weather differences, at least for the rotational system. Since the producer has been in the cattle business for some time, his statement regarding 1995 being a representative year is taken at face value. Second, the discussion of the case study implies that a partial budgeting approach can be used to answer this question. Rather than estimating returns to resources with the old system (e.g., \$50 per bred cow) and comparing them with those of the new system (e.g., \$75 per bred cow), only differences in revenues and costs across the systems are analyzed to estimate returns to the system change (e.g., \$25 per cow). By doing this, the analyst can calculate returns to additional resources that may be required but could not be accounted for in the analysis (i.e., added owner labor and management). Since a whole-farm comparison is envisioned across systems and a change in scale of production was also introduced (moving from 50 to 70 bred cows), partial returns above specified costs per bred cow offer a reasonable and somewhat scale independent criterion by which to judge the systematic changes. Further, only those changes that were measured can be included in the analysis.

Revenues would be increased with higher weaned calf sales due to changes in the calf weights. The split between heifer and steer calves as well as the calving rate (number of calves weaned per bred cow) changed across years; therefore, the analyst may wish to use the 3-year average calving rate (97.24%) and sex ratio (52.73% heifers) to determine the impact of heavier calves with the new system. The average gain in calf weights was 26 and 7 kg for heifers and steers, respectively. Further, price data presented in Exhibit 2 are average, minimum, and maximum prices. The 10-year average price should probably be used to present revenue changes that would not be unduly influenced by cyclically high or low cattle prices. Seasonal price fluctuations are not an issue, because both systems have cattle marketed in November. The analyst might consider looking at minimum calf prices to identify whether the system might lead to cashflow pressure during a low price year. On a per bred cow basis, additional sales are \$34.21 using average information for prices, calving rate, and sex ratio (Exhibit 4). The system change did not lead to a reduction in sales.

Exhibit 4 also outlines changes on the cost side. The system change resulted in the following: (i) Cows, calves, and replacement heifers were fed a winter ration of hay and grain for an extended period in the spring (approximately 1 week) due to delayed access to the pasture; (ii) A shortened feeding period when compared with the continuous grazing system on Paddocks 1 to 3, which in turn meant an increased stocking rate and pasture period for Paddocks 4 to 9. (Costs of this added pasturing may be estimated using pasture rental rates for the estimated 3 weeks of additional grazing by the added livestock. To determine changes in average pasture cost per bred cow, the total change in pasture costs is divided by the 70 bred cows); (iii) The replacement heifers were grazed on a neighbor's pasture for the 92 days that replacement heifers used to spend on Paddocks 1 to 3; (iv) Additional investment in fencing equipment. Scrub cutting was also introduced in 1997 but would not have been expected to result in added pasture production for the same year. Mowing expenditures are also excluded from the analysis; (v) Finally, the system change

has lead to a reduction in supplemental oats fed to the calves with a creep feeder.

The above system changes have thus lead to a total increase in returns above specified costs of \$28.65 per cow exposed. These returns are due in part to larger land resources used (replacement heifers are custom grazed) and increased owner labor and management (installation of pasture improvements and changes in annual labor requirements—moving cattle from paddock to paddock, pasture checking, and so forth). Investment per cow has also slightly increased because of pasture improvements that were partially considered (cost share in the investment is not listed and labor costs are not explained). These returns, therefore, need to be interpreted with care. A producer and/or conservation agency interested in determining whether or not to switch to the new pasture management strategy would take the return estimate of \$28.65 per bred cow, adjust prices and costs in Exhibit 4 to fit their situation, multiply by the number of bred cows in the herd, and see if the added returns would justify additional labor and management efforts. How much of these returns are attributable to rotational grazing is not quantifiable, however, because there are a large number of limitations to the study. A discussion on these issues follows.

Limiting the study to one producer is acceptable for the case study approach taken here, but does not allow for any general conclusions of the merits of rotational grazing over continuous grazing. Pasture conditions and their responses to different management techniques will vary substantially by location. Limiting the number of years to 1 year for the continuous grazing system and 2 years for the rotational system also places serious restrictions on the results. The producer felt 1995 was representative of his continuous grazing system, but formal documentation of 3 years or more would lend more weight to average weight gain expected under the continuous system. Similarly, only 2 years of data under the rotational system does not give enough indication that increased weight gains were due to the rotational system or were partially, or even entirely, the result of other unaccounted for factors. For example, pasture production is expected to change from year to year due to weather. The provincial average for tame hay yields for Manitoba was 4.2 Mg ha<sup>-1</sup> in 1996 compared with 3.0 Mg ha<sup>-1</sup> in 1995 (Manitoba Agriculture, 1996). Higher precipitation and other weather-related factors, not associated with the rotational system, could have contributed to better pasture conditions for the 2 years under rotational grazing. Paddocks 4 through 9 were also utilized to a larger extent with the rotational system compared with the continuous system. To rule out such factors, more years of data are required, a control pasture should be used during the same time period and study conditions, and more grazing data need to be collected (e.g., forage intake, paddock specific weight gains, changes in body condition, grass species composition, etc.).

As was mentioned earlier, average weight gains of calves were based on average sale ticket weights, and thus actually indicate weight gain from birth to market. This included time before cows and calves were placed on Paddocks 1 to 3 and time after they were taken off those paddocks, and therefore is not solely the weight gain realized due to rotational grazing. For example, if calves were born, on average, in the first week of March and were sold the first week of November, then they were approximately 245 days old when sold. In the con-

**Exhibit 4. Annual partial returns per bred cow for switching to new pasture management.**

<b>Added revenues</b>	<b>\$34.21†</b>
Change in average value of beef produced per bred cow after adjusting to 47/53 steer and heifer production and a 97% calving rate in \$ bred cow <sup>-1</sup>	
Avg. change in value of heifer calves produced per cow 97.24% × 52.73% × (305 kg – 279 kg) × \$2.04 kg <sup>-1</sup>	\$27.20
Avg. change in value of steer calves produced per cow 97.24% × 47.27% × (334 kg – 327 kg) × \$2.18 kg <sup>-1</sup>	\$7.01
<b>Reduced revenues</b>	<b>(\$0.00)</b>
None	
<b>Added costs</b>	<b>(\$16.16)</b>
Added feeding costs in spring for delayed release to pasture using cost of production estimates and average placement date of third week in May with the conventional system compared with the June 1 starting date with the rotational system.	
Added spring feeding costs in \$ bred cow <sup>-1</sup> 1 week @ \$0.83 day <sup>-1</sup>	\$5.81
Added replacement heifer feeding cost adjusted to 1 replacement heifer per 6.25 bred cows 1 week @ \$0.80 day <sup>-1</sup> / 6.25	\$0.90
Pasturing replacement heifers on another pasture adjusting the grazing cost by AU and adjusting for cow replacement rate. Replacement heifer pasture cost in \$ bred cow <sup>-1</sup> 92 days @ 0.75 AU heifer <sup>-1</sup> @ \$0.32 AU day <sup>-1</sup> / 6.25	\$3.53
Added pasturing (3 weeks) on Paddocks 4 through 9 adjusted for number of bred cows.	
Added cows (20 @ \$0.32 day <sup>-1</sup> )	\$134.40
Added calves (21 @ \$0.10 day <sup>-1</sup> )	\$44.10
Added herd sire (1 @ \$0.48 day <sup>-1</sup> )	\$10.08
<u>Added replacement heifers (3.2 @ \$0.24 day<sup>-1</sup>)</u>	<u>\$16.13</u>
Total added costs associated with extended grazing and additional livestock	\$204.71
Added pasture charges in \$ bred cow <sup>-1</sup> (\$204.71 / 70)	\$2.92
Initial outlay (\$1800) and salvage value (\$800) capitalized over 5 years to arrive at an annual cost of fencing system with the assumption that 70 cows can be maintained on the rotational system. The capital recovery method is used (Boehlje and Eidman, 1984). Annual capital cost @ 4% real interest per year in \$ bred cow <sup>-1</sup> [(1800 – 800) × [1 – (1 + 0.04) <sup>-5</sup> ] + 800 × 0.04] / 70	\$3.00
<b>Reduced costs</b>	<b>\$10.60</b>
Creep feeding costs are expected to decline with improvements in pasture quality. Average oats consumption savings per calf and calving rate are used with the 1996 oats price. Supplemental feed savings in \$ bred cow <sup>-1</sup> 97.24% @ [227 kg – (181 kg + 100 kg)/2] @ \$0.126 kg <sup>-1</sup> of oats	\$10.60
<b>Total difference in annual net returns in \$ bred cow<sup>-1</sup></b>	<b>\$28.65</b>

† Values are in Canadian currency.

tinuous system, cattle were on Paddocks 1 to 3 for 122 days, representing only 50% of the time from birth to market, and in the rotational system, cattle were on that section of pasture for only 92 days, representing only 38% of the time from birth to market. While the producer is confident that the entire change in weight gain is due to the change in pasturing method, a more accurate estimate of changes in weight gain could be obtained by weighing cows and calves just before and after their time on the main pasture. The reader may wish to consult the literature cited previously or find additional literature on the topic.

Also, since weight gains of heifer calves kept by the producer to replace culled cows were not available, average weight gains for market calves were extended to these calves. However, the producer kept what he considered his best heifers



as replacements and, therefore, using the average gain from market calves likely underestimates the weight gain on these replacement heifer calves.

Finally, the producer added 20 cows and 1 bull to his herd at the beginning of the rotation program. Depending on the cows and bulls added, this could have improved the genetic foundation of the herd and produced, on average, heavier calves. Since weight gain of individual calves were not provided this could not be analyzed.

As was discussed in the “Background on Rotational Grazing” section, several studies have found improved pasture conditions after adopting a rotation strategy with greater biomass production and/or improved species composition. In the present study, the producer has noticed an increase in desirable grass species, in particular, western wheatgrass (*Agropyron smithii* Rydb.) and needle and thread grass (*Stipa comata* Trin. & Rupr.), and a decrease in undesirable invader species within 2 years. Improvements have also been noticed to the riparian area since limiting cattle access to the river. No attempt was made here to quantify or even record any improvements or changes to the riparian area. Improvements in water quality and nesting opportunities are expected, however. Had additional returns to improved pasture management not been realized, the conservation agency would then need to quantify some of the environmental benefits that can be realized to determine how much they need to subsidize producers for changing their pasture management. This would be subject to further study. In the above case, positive returns are available without accounting for environmental benefits. As long as these returns are sufficient to motivate producers to change production practices, the conservation agency need not intervene with subsidization.

#### ACKNOWLEDGMENTS

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# An Alternative Method for Remediating Lead-Contaminated Soils in Residential Areas: A Decision Case Study

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## ABSTRACT

Lead (Pb) is one of the most significant environmental contaminants worldwide and has significant human health effects. Historic use of Pb in paint and gasoline, in particular, have made this contaminant ubiquitous in our environment although widespread use of Pb has declined in the USA. Unfortunately, segments of the population are still receiving unacceptable doses of Pb. In the case reported here, citizens of Joplin, MO, will have input on a critical decision regarding the method by which the USEPA will remediate the Pb-contaminated soil in their community. Soil excavation is currently being used with the possibility of switching to phosphorus (P) amendment. Phosphorus added to the soil reacts with Pb to form an insoluble solid phase that is believed to be less harmful to humans compared with untreated soil. The use of P amendment offers advantages compared with soil excavation but has not been used before in residential areas. This case can be used to introduce students to the concepts of soil remediation, toxicology, and soil chemistry as well as social issues such as the use of tax dollars to support remediation. The learning objectives of this case are to understand the most common remediation strategy for Pb-contaminated soils and an alternative to that strategy, understand the concept of bioavailability and how it relates to the physiological effects of a soil contaminant on an organism, appreciate how soil amendments can change the bioavailability of a soil constituent, and to be able to identify the primary pathways of exposure for a soil contaminant and humans.

THE CITY of Joplin, MO, is in the process of remediating soils contaminated with Pb and cadmium (Cd) in residential areas. The current remediation effort involves excavating all of the soil from around homes and replacing it with clean soil (Exhibit 1). Some 2500 homes are scheduled for remediation. The USEPA is considering the use of a new remedial technology that will eliminate the need for soil excavation. The new method would be performed in situ and would involve mixing P with the contaminated soil. The Pb would react with P and form the insoluble mineral pyromorphite  $[Pb_5(PO_4)_3OH]$ , which has a very low bioavailability (Ryan et al., 2004). Although the logistics have yet to be worked out, application of the technology would likely involve spreading P fertilizer on the soil followed by roto-tilling and then re-establishment of the turf with either seed or sod (Ryan et al., 2004).

The Jasper County Superfund Site Coalition (hereafter referred to as *Coalition*) is a citizens group that has taken an active role in representing the concerns of the public as reme-

diation efforts have been planned and implemented. They have had considerable influence on the overall process to date. The Coalition needs to decide whether they support the change to the new technology and then communicate its position and supporting information to the USEPA during the public comment period after the USEPA announces its intentions. The USEPA stated its preferred alternative is a combination excavation and P treatment (Exhibit 2) as they begin to prepare the Record of Decision for this area.

## Origin of the Contaminated Soils

Joplin is located in an area known as the Tri-State Mining Region, which encompasses southeastern Kansas, southwestern Missouri, and northeastern Oklahoma. Lead and zinc (Zn) were mined extensively in this area for nearly 100 years beginning in the mid-1800s. The process of mining the ores and producing the final products of elemental Pb or Zn involved three steps: (i) the actual mining of the ore, sphalerite (ZnS) and galena (PbS); (ii) concentrating the ores; and (iii) smelting of the concentrated ores. Early mining was generally done in shallow pits and crude concentrating and smelting techniques were used. Thousands of small operations dotted the landscape in the mining region. As mining techniques improved and the surface ore deposits were exhausted, shaft mining became the dominant method. Concentrating techniques also improved and fewer, larger smelters processed the ores. Most mining ended by the 1950s, although some smelting operations continued into the 1970s.

Environmental problems from mining are wide-spread and complex. In mining areas, the landscape is dominated by abandoned pits, shafts, smelters, and other equipment used in processing the ores. These pose direct safety threats to persons. A variety of waste materials are also evident. Chat, the first by-product produced, is present in large quantities and has high concentrations of Cd, Pb, and Zn. Chat is used as construction material and consequently has been transported throughout the region. Smelter slags are present in much lower quantities but are highly enriched in metals. Smelters that were in operation most recently had tall smokestacks that emitted metal-enriched dust that spread over large areas. One such smelter in Joplin contaminated soils sufficiently to require remediation up to 2 miles away from the stack (Exhibit 3). This area is where the majority of the remediation efforts are being focused at the present time.

## Human Health Effects from Lead

Lead causes a variety of health problems in humans (see ATSDR, 1999). Acute Pb toxicity can affect adults and children alike. Symptoms include abdominal cramping, anemia, decreased reaction time, weakness in the extremities, and

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**Abbreviations:** ATSDR, Agency for Toxic Substances and Disease Registry; IEUBK, Integrate Exposure Uptake Biokinetic Model; MDOH, Missouri Department of Health; USEPA, United States Environmental Protection Agency



**Exhibit 1. Photograph of soil excavation efforts in Joplin, MO. Photo credit Jim Mueller.**

possible damage to the male reproductive system. Young children are the most susceptible to chronic toxicity, which has been associated with subclinical effects such as reductions in IQ, hyperactivity, and attention deficit disorder. Young children, 6 to 72 months old, are more likely than adults to suffer from acute or chronic Pb toxicity because of their tendency to put nonfood items in their mouths. Acute toxicity can result from a child chewing on surfaces having deteriorated leaded paint, for example. Chronic toxicity is more common and typically is the result of hand-to-mouth activity in children who play in areas containing dust or soil with high Pb concentrations. A house surrounded by high Pb soil is particularly problematic because the children are directly exposed to the soil during their outdoor play activities and are also exposed to high Pb dust inside the home. Children living in areas with soils contaminated with Pb from smelter emissions, paint residues, or automobile emissions have been found to have elevated blood Pb levels (Steele et al., 1990).

Current health guidelines suggest that children's blood Pb concentrations should not exceed 10 micrograms per deciliter

**Exhibit 2. USEPA fact sheet describing the remediation alternatives selected from the feasibility study that will receive the greatest consideration in preparing the record of decision.**

<b>FACT SHEET</b>	USEPA Region 7
Oronogo–Duenweg Mining Belt Site (Jasper County Site) Jasper County, Missouri	May 1996

### INTRODUCTION

The U.S. Environmental Protection Agency (USEPA) has completed a study of remedial cleanup alternatives for residential yard soils in the Oronogo/Duenweg Mining Belt site in Jasper County, Missouri. The USEPA's proposed plan summarizes the remedial action alternatives evaluated in the Feasibility Study (FS), including the rationale for the USEPA's selection of the preferred alternative.

The USEPA will prepare a Record of Decision (ROD) for residential yard soils that will select the cleanup actions and prepare a responsiveness summary responding to comments from the public at the conclusion of the public comment period.

### SITE BACKGROUND

The Oronogo-Duenweg Mining Belt site is part of the Tri-State Mining District of Missouri, Kansas, and Oklahoma. The district covers hundreds of square miles in southwestern Missouri, southeastern Kansas, and northeastern Oklahoma. Mining, milling, and smelting of lead and zinc ore and concentrates date back to 1850 and continued in the district until the 1970s. Mining, milling, and smelting activities generated several types of waste material including mine wastes, mill wastes, and smelter-related materials. The wastes from mining and smelter operations contain excess metals, particularly lead, cadmium, and zinc. Approximately nine million tons of mining/milling and smelter wastes remain on the site's surface. Additionally, air releases from historic smelters resulted in soil contamination around the smelters.

The site was added to the EPA's National Priorities List in 1990. The site had been divided into 11 specified areas for investigation because of its large area. In 1991, the USEPA began remedial investigations and feasibility studies (RI/FSS) with some work being conducted by the potentially responsible parties, under USEPA oversight. The RI and a human risk assessment were completed this year, and

the feasibility study for the mine/mill waste is scheduled for completion in 1997.

The Missouri Department of Health (MDOH) conducted an exposure study to evaluate health effects on residents at the site. The study concluded that some children under the age of 7 years had elevated blood-lead concentrations. The study concluded that the most significant source of contamination resulting in elevated blood-lead levels was residential yard soils.

In 1994, the USEPA began a strategy to prioritize cleanup at the site and the adjacent Cherokee County Superfund site. Initial work consisted of identifying numerous day-care centers and residences as having soil lead concentrations at levels requiring cleanup in a time-critical manner. The USEPA began a time-critical removal action in January 1995. The removal action targeted day-care centers and residential yards.

Cleanup actions were taken at residences where children were observed with high blood-lead concentrations or where soil lead levels exceeded 2500 parts per million (ppm). More than 300 residential yards and six day-care centers were remediated under this action, which ended in January 1996. The majority of day-care centers and homes identified for cleanup were around the Eagle–Picher smelters in Joplin. Generally, these residential yards had the highest levels of lead contamination in the soil samples. The cleanup activities consisted of excavating and removing soils, replacing the soil with clean soil, and resodding the yards.

### PREFERRED ALTERNATIVES

The USEPA evaluated three alternative cleanup plans in the FS. These alternatives were developed to establish clean up goals for reducing risks by exposure to residential soils with elevated lead and cadmium concentrations resulting from historic mining and smelting activities.

( $\mu\text{g dL}^{-1}$ ). Blood Pb surveys in Joplin, as well as part of Jasper County, found approximately 14% of the children have blood Pb concentrations of more than  $10 \mu\text{g dL}^{-1}$  (MDOH, 1995).

### Soil Excavation Versus Phosphorus Amendment

The principle behind soil excavation is straightforward. The contaminant is removed to reduce or eliminate exposure. Soil excavation is currently accepted by the USEPA for remediating Pb-contaminated soil in residential areas. Soil excavation requires a repository for the soil that is removed and a source of clean replacement soil. In this case, the contaminated soil is stored at a repository constructed on an abandoned mine site. The soil is placed into piles over several hectares with a depth of 4 to 5 meters. Approximately 150 cubic meters of soil is removed from each home and the repository covers 17 hectares. After a pile is completed, vegetation is established on the surface to prevent erosion. The entire excavation process generates considerable dust and truck traffic in the community.

The goal for the remedial efforts is to have more than 95% of the children with blood Pb concentrations below  $10 \mu\text{g dL}^{-1}$

after completion (USEPA, 1996a). The Integrated Exposure Uptake Biokinetic Model (IEUBK) can be used to predict the distribution of blood Pb concentrations in children using site specific inputs (USEPA, 1994). The model has been used to determine a soil clean-up level, which is the soil Pb concentration used to determine if a given residential dwelling needs to have the soil excavated. Based on the IEUBK model, homes having soil with greater than approximately  $200 \text{ mg kg}^{-1}$  Pb will require soil excavation to meet the goal of more than 95% of the children with blood Pb concentrations below  $10 \mu\text{g dL}^{-1}$ . The USEPA has stated that this is not practical and that funds simply would not be available for such an endeavor. Therefore, part of the remediation efforts will include reliance on institutional controls to minimize Pb exposure. Institutional controls will include public education on the health effects of Pb and ways to minimize exposure of children to Pb. Suggestions will include washing hands frequently for children, house cleaning frequently to remove dust, frequently washing pets that are allowed both outside and inside the house, maintaining painted surfaces to minimize flaking of leaded paint, and eliminating all bare soil areas around the home. In some

#### Exhibit 2. Continued.

Alternative 1. No further action. This alternative required by the USEPA regulation would leave contaminated soils in place. Residents would continue to be exposed.

Alternative 2. Phosphate stabilization with institutional controls. This alternative would treat soils with phosphate to bind up the metals so they are not absorbed into the body when swallowed. Phosphate treatment would be applied to residential yards with greater than 500 ppm lead in the soil. A treatability study would be required before the treatment alternative could be implemented. This study would take about 1 year to complete. Institutional controls would also be established to regulate construction of new homes in contaminated areas.

Alternative 3. Excavation and disposal with health education and institutional controls. This alternative consists of excavation and removal of contaminated soil with concentrations greater than 800 ppm along with a public health education program. The health education program would provide information similar to the information described below. Residential yards with soil contamination greater than 800 ppm would be excavated as well as garden soils exceeding 500 ppm. Removing garden soils exceeding 500 ppm lead and 75 ppm cadmium would reduce the risk associated with eating vegetables from contaminated gardens. Cleanup activities will begin with the residential yards that present the highest risks first.

#### USEPA'S PREFERRED ALTERNATIVES

Based on the available information, the USEPA's preferred alternative for the contaminated soil is Alternative 3 (excavation and disposal with health education and institutional controls), with the option of switching to Alternative 2. The preferred alternative combines both Alternatives 2 and 3. Phosphate stabilization with institutional controls (Alternative 2) would only be started after treatability studies show phosphate effectively binds up the metals in the soil. Binding the metal would prevent the metal from being absorbed into the body through swallowing, so they cannot be absorbed into the body when ingested. If the studies show the phosphate is not effective then excavation and disposal will continue until the cleanup is complete.

USEPA feels that it is important to begin cleanup of the yards that present the highest risks as soon as possible. Cleanup of the highest risk yards should not be delayed while additional studies are ongoing. Therefore, USEPA feels that the best way to proceed is to begin

with excavation and disposal and then switch to phosphate treatment if and when the studies show that it will be effective.

This alternative, without phosphate stabilization of yards after completion of the treatability study, is expected to cost \$29 887 000. This is based on the estimate of \$10 000 per home for excavation, backfilling, and sod/seeding. The overall costs for the proposed alternative cannot be accurately determined until completion of the treatability study.

#### HEALTH EDUCATION PROGRAM

##### Reducing Child Exposure

USEPA, MDOH, and the Agency for Toxic Substances and Disease Registry (ATSDR), the federal health agency, continue to recommend limiting exposure of young children to lead-contaminated soil. This can be accomplished in the following ways:

- Children should not eat or drink in areas of known contamination.
- Children should not play in bare soil areas with known contamination.
- Wash toys periodically and encourage children not to put toys in their mouths.
- Vacuum and dust inside the home often to remove dust that may have lead in it.

##### Gardening

In general, it is most protective of health not to garden in areas with high levels of lead and cadmium. However, if you decide to have a garden, it is best to minimize the possibility of increasing exposure to lead and cadmium. Cadmium in particular is known to be taken up from soil into grains, root crops, and leafy vegetables. Lead is also taken up by these plants but not to the same degree as cadmium. USEPA and ATSDR recommend that you consider the following information if you plan on gardening in areas with lead and cadmium contamination:

- Consider a raised garden bed. This should be accomplished by bringing in soil you know is not contaminated.
- Thoroughly wash all vegetables and peel root vegetables.
- Limit exposure to young children to contaminated garden soil.
- Avoid transporting contaminated garden soil into the home on shoes, clothing, and pets.

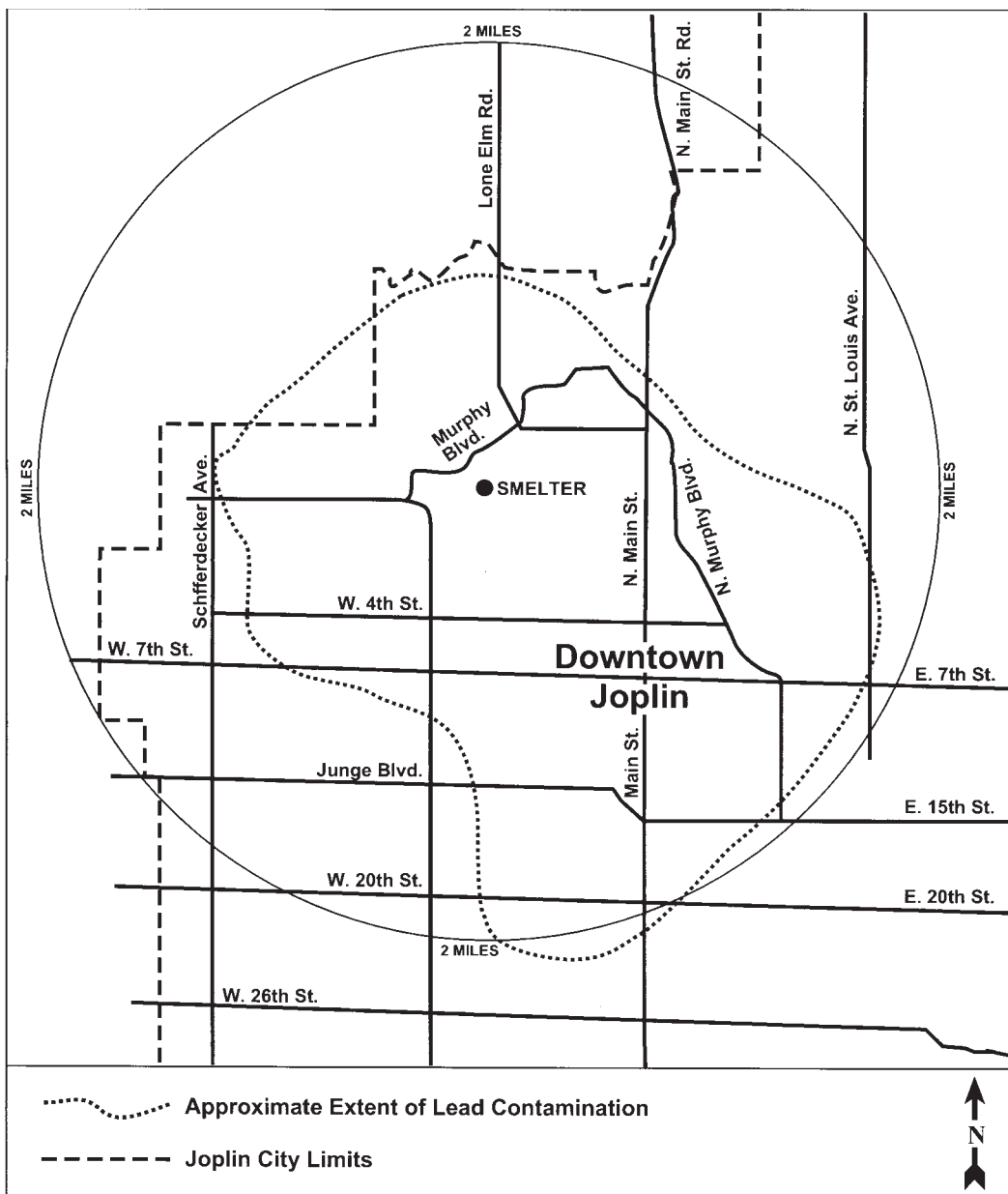


Exhibit 3. Map of western Joplin showing the extent of Pb contamination from the smelter.

communities, soil abatement has not produced the desired reduction in blood Pb concentrations in children (USEPA, 1996b). However, initial results from a nearby community with similar problems suggests that soil excavation and institutional controls could be an effective measure (Exhibit 4).

The Record of Decision for the area will likely state that soil excavation will be the preferred remediation technology with the option of changing to P amendment (Exhibit 2). Residential yards having soil Pb concentrations more than 800 mg kg<sup>-1</sup> will have the soil removed. The preferred alternative will still require some reliance on institutional controls to limit exposure to Pb.

A critical variable in the risk from soil Pb is the bioavailability of the Pb. Bioavailability is the fraction of total Pb in soil that is available for uptake by an organism. The form of Pb in soil directly influences its bioavailability as do soil

properties such as the clay mineral type and amount. Lead strongly held by clay minerals or present as insoluble solid phases would have low bioavailability. For humans, most concern stems from ingested Pb. This commonly occurs when Pb-containing soil particles are consumed. The Pb must be released as Pb<sup>2+</sup> in the digestive fluids before it can be absorbed into the body.

The fact that some of the Pb in soil will be converted to pyromorphite upon amendment with P is well established (Hettiarachchi et al., 2001), as shown in Eq. [1] below.



Pyromorphite is an extremely insoluble mineral that will not dissolve appreciably in the human digestive system. In theory, there will be less uptake of Pb by a child consuming Pb-

contaminated soil that has been amended with P compared to the same dose of Pb from soil that has not received P because the Pb in pyromorphite has low bioavailability. Feeding studies with rats and pigs have confirmed this hypothesis. The IEUBK model accounts for Pb bioavailability in soil so it is possible to model the affect of P amendment on the blood Pb distribution in a population of children. The example shown in Exhibit 5 illustrates the influence of a reduction of bioavailability from 18 to 4% on the distribution of blood Pb concentrations in children from 6- to 72-months old. These model runs were performed for illustrative purposes. At 18% bioavailability, the model predicts 24% of the children having more than 10  $\mu\text{g dL}^{-1}$  blood Pb while at 4% bioavailability it drops to 11%. Swine feeding studies have shown that the Pb bioavailability in soils from Joplin ranges from 30 to 41% and preliminary studies suggest a 50% reduction in bioavailability upon addition of P (Ryan et al., 2004).

One potential disadvantage to P amendment is the impact on local surface water. Phosphorus lost in runoff to surface water can contribute to eutrophication. The amount of P to be added for remediation far exceeds amounts typically used for agricultural or horticultural purposes. The potential loss of P in surface runoff under the conditions of the proposed remediation method has not been evaluated. In general, incorporation of soil-applied P and vegetative cover minimize runoff losses (Devlin et al., 2003).

The current remediation activities are addressing homes with more than 800  $\text{mg kg}^{-1}$  Pb and still require reliance on institutional controls to minimize exposure to Pb. Approximately 2500 homes will require remediation at a cost of \$10 000 to \$15 000 each. The estimated cost for P amendment would be \$4000 to \$5000 per home. Using P amendment, the USEPA has stated that it would be able to treat approximately 5000 homes with the funds that are available, which would allow all homes having more than 600  $\text{mg kg}^{-1}$  soil Pb to be treated.

## THE DECISION

Consider the advantages and disadvantages of each remediation method. Think about the scientific issues, which method would make you feel more protected, and the logistics of performing the necessary work. Make a list of any additional information that you feel you need. Consider the case from the viewpoint of a citizen of this area as well as from that of an objective outside observer. Would you recommend that the USEPA allow P amendment to be used?

## TEACHING NOTE

### Case Objectives

This case can be used to introduce students to the concepts of soil remediation, toxicology, and soil chemistry as well as social issues such as the use of tax dollars to support remediation and the use of institutional controls to control Pb exposure after the remediation is complete. In addition, the opportunity exists for students to compare the emotional, scientific, and practical sides of the issue by contrasting the viewpoints of citizens directly impacted by the contaminants to those of an outside objective observer. After completing this case, the students should be able to:

1. Understand the most common remediation strategy for Pb-contaminated soils and an alternative to that strategy.
2. Understand the concept of bioavailability and how it relates to the physiological effects of a soil contaminant on an organism.

**Exhibit 4. Excerpts from Joplin Globe article regarding potential benefits of soil excavation in other communities. Some names and the date have been changed to ensure anonymity of the parties involved.**

The Joplin Globe  
Sept. 16, 1997

By Gary Garton  
Globe Staff Writer

Picher, Okla. – Blood-lead levels in children living in northern Ottawa County have decreased in the months since the yards of their homes were targeted in a soil remediation by the USEPA.

“The results are not definitive by any means, but they’re very encouraging,” Mary Caldwell, with Oklahoma Department of Environmental Quality, told Picher’s City Council on Tuesday night.

“Blood-lead levels in children were what originally got this started and I think that’s where we can start to see some really good results now,” she said.

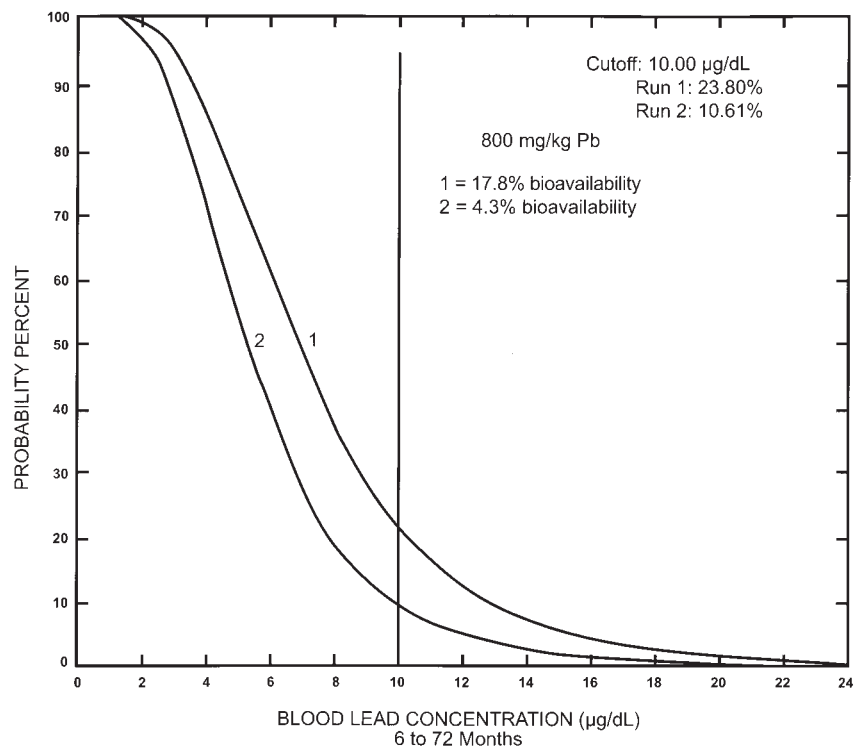
She noted blood tests of children in Picher, Quapaw, Commerce, Cardin, and North Miami that found elevated levels beyond the national health standard of 10 micrograms per deciliter in all the towns. Ms. Caldwell said later testing by the health department of children with the elevated lead levels has shown a decline in eight children living in homes where USEPA’s soil remediation work is complete.

She cited seven examples, saying an eighth child, which also posted a decline, was brought to her attention too late to be included in the examples.

In the examples she presented Tuesday night:

- A 3-year-old Picher child had a blood lead level of nearly 20 micrograms per deciliter prior to soil remediation, and five weeks after the dirt replacement, the level dropped below 15 micrograms per deciliter.
- A 4-year-old Picher child’s blood-lead level dropped from 10 to 6 micrograms per deciliter five weeks after yard work was completed.
- A Picher 5-year-old’s lead level dropped from 10 micrograms per deciliter to 7 micrograms per deciliter in seven weeks after the soil remediation.
- Another 5-year-old in Picher dropped from over 10 micrograms per deciliter to 7 micrograms per deciliter in the two months following soil work.
- A 6-year-old from Picher showed a lead-level decline from 14 micrograms per deciliter to 11 micrograms per deciliter some seven weeks after soil work.
- At Cardin, a child 4½ years old showed a drop from 11 micrograms per deciliter to 7 micrograms per deciliter in three months.
- A child of 5, who lived in North Miami but spent a substantial amount of time with a grandmother at Quapaw, showed a lead decrease from 17 micrograms per deciliter to 10 micrograms per deciliter two weeks after the North Miami home was treated.

“The fact that of all the children I was able to trace, 100 percent had shown a blood-lead decrease after the primary source of lead in their environment was removed is some very encouraging data,” Ms. Caldwell told the group.



**Exhibit 5. Example results from Integrated Exposure Uptake Biokinetic Model (IEUBK) illustrating the influence of a change in soil Pb bioavailability on the blood Pb distribution for children 6- to 72-months of age.**

3. Appreciate how soil amendments can change the bioavailability of a soil constituent.
4. Be able to identify the primary pathways of exposure for a soil contaminant and humans.

The students should receive a copy of the case study, including all exhibits, prior to classroom discussion. A quiz may be used to encourage the students to read the case study before class so that they are fully prepared to participate in the discussion. The instructor may find it useful to inform the class that they are the Coalition and the instructor is a technical advisor for the Coalition and begin the case study discussion by presenting some background information on the record of decision and the alternatives being considered. This is a realistic scenario as the USEPA often funds technical advisors for communities undergoing Superfund remediation activities (and did so for Joplin, MO). Once the stage has been set, the students generally have numerous questions and opinions on the technical aspects of P amendments, which feeds additional discussion. The discussion questions below can also be used. At the end of the class period a vote can be taken whereby the Coalition “officially” declares its support, or lack thereof, of P amendment as an alternative strategy for remediation Pb contaminated soils in Joplin. Again, this is a realistic activity because the USEPA must consider the views of the citizens when they finalize the record of decision.

For teaching purposes, this case can be used at both the undergraduate and graduate levels and can supplement coverage of a variety of topics including general environmental issues, the chemistry of trace elements, toxicology, and soil remediation techniques. The case has also been successfully used

with general audiences, provided adequate background information is given.

### Discussion Questions

Consideration of this case from both the viewpoint of the resident of this area as well as from the viewpoint of an objective outside observer is useful. This case also lends itself to short writing assignments in which students are asked to address some combination of issues including their view of the scientific issues relevant to the case, their opinion on whether P amendment should be used, and one or more of the following discussion questions.

1. Discuss the advantages and disadvantages of each remediation method.
2. Are you comfortable with the reliance on institutional controls to limit Pb exposure after the currently approved remediation effort is complete?
3. Would you be comfortable if the contaminant remained in place but supposedly was no longer harmful?
4. Do animal feeding studies that show P reduces soil Pb bioavailability represent sufficient evidence to try P amendment in Joplin?
5. Are the modeling efforts showing that a reduction in soil Pb bioavailability will reduce blood Pb concentrations in children sufficient evidence to try P amendment in Joplin?
6. What evidence would you need to be convinced that P amendment was an acceptable remediation technique?

7. Joplin would be the first community for which P amendment is used. If successful, many other communities would benefit from their experience. Should the Coalition consider this factor in their decision?
8. An estimated \$25 million will be spent on this project. Could these funds be used elsewhere with greater benefit to society?

### **The Actual Outcome**

Revealing the actual outcome of a case takes away from class discussion because the outcome may be viewed as the best solution or the correct answer when that may not necessarily be true. This situation is not an issue with this case because the decision was never actually made. Soil excavation proceeded faster than expected and the research supporting the use of P amendment proceeded slower than expected. In the end, the soil excavation process was completed before adequate data were available to use to make the decision. The overall question is still relevant, however, as there are many communities in the USA and around the world that could benefit from remediation of Pb-contaminated soils.

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# “Anybody’s Dream”: A Decision Case of Marketing Alternative Crops<sup>1</sup>

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## ABSTRACT

Decision cases have been used in the USA for both classroom and extension education within agriculture and natural resources. Use of cases has sometimes been limited by the extensive amount of time that may be required to assign and analyze conventional, text-based cases. Availability of video decision cases, which are visual and do not necessarily require reading, could foster the use of cases on “short notice” for diverse education audiences. Although “video-enhanced” cases exist, these rely on appreciable amounts of reading and can still be time-consuming to use. *Anybody’s Dream* is an entirely video-formatted decision case that considers an agricultural situation and is suitable for extension, classroom, and experiential education learners. The case presents the story of a group of farmers in central Minnesota as they attempted to diversify their cropping systems by producing buckwheat (*Fagopyrum sagittatum* Gilib). One of the challenges these farmers faced was a need to resolve questions about how to best organize for processing, storing, and marketing their buckwheat crops. The case was developed using a “documentary” format and includes interview segments with representative farmers from the Buckwheat Growers Association. These farmers describe their perspectives on the challenges they faced in producing and marketing an alternative and uncommon crop. This article describes the *Anybody’s Dream* video and considers how it can be used for classroom and extension learning situations. The article further offers perspectives on the process of developing a video case.

DECISION CASES are a “problem-based” approach for enhancing learning in agriculture, food, and natural resource sciences (Simmons et al., 1992, 2000). When teaching with cases within a course, teachers usually follow a consistent protocol (Simmons et al., 2000). They assign a case—presented in a written format—and the students are asked to read the case and analyze it over a period of time varying from several days to weeks. These instructors then facilitate a group discussion of the case during a class session. Finally, the students may be asked to prepare a post-case discussion analysis and possibly a reflective writing about what they learned

<sup>1</sup>Persons who would like to use this case for classroom or extension purposes may obtain a copy of the case video and Teaching Note (EP-6741) from the Educational Distribution Center of the Minnesota Extension Service, Univ. of Minnesota, 405 Coffey Hall, St. Paul, MN 55108-6068; phone 612-625-8173.

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from the case. The instructors’ goal is to assist their students to analyze the elements of the case, the decision objectives, and options, and to come to a reasoned decision regarding the dilemma that is presented in the case.

This approach to case teaching presumes that instructors have the opportunity to be with their students repeatedly over a period of several days or weeks. But what options exist for instructors who do not have the opportunity to assign a written case to their students and to provide time for study before discussing the case? This is often the situation faced by extension educators who only have the opportunity to engage their clientele for a period of an hour or so, not days or weeks. Similarly, some classroom instructors may desire to utilize a case on “short notice” or in advance of a field trip or other experiential learning activity. Thus, having the capability to present a decision case to students quickly would be an advantage in many educational situations.

One option for such “short notice” cases would be to use brief, text-based “mini-cases” that can be read quickly. Such cases do exist (e.g., Gamble et al., 1997); however, their brevity and lack of detail may limit their suitability for stimulating in-depth analysis and discussion.

Adult learners often differ in their level of comfort with text-based learning exercises that require extensive reading. Thus, a more visual approach to presenting a case topic, which minimizes text and reading, should prove useful. Such an approach utilizes the principle that “a picture is worth a thousand words.” Several “video-enhanced” cases have been produced within the field of business (Harvard Business School, 2002) and at least one such case has been previously developed for agriculture (Taack et al., 1997). However, these are actually paper-based cases that also include supplemental videos that provide additional background information for the case and often incorporate “stock” promotional or commercial video footage that may have little direct relationship to the case dilemma itself. There have been, to our knowledge, no previous decision cases considering agricultural topics that are entirely formatted on video and where text plays only a minor supplemental role.

This paper describes a video decision case involving an agricultural situation that is suitable for “short notice” educational situations. The case considers an important current topic—the diversification of agroecosystems—and presents the story of a group of farmers in central Minnesota as they attempted to diversify their cropping systems by producing buckwheat (*Fagopyrum sagittatum* Gilib). In addition to the agronomic considerations involved in producing this alternative crop, these farmers also faced questions about how to best organize themselves to process, store, and market their buckwheat crop. The paper also considers the process involved in producing a video decision case, particularly in comparison to conventional text-based cases. It highlights the continuing evolution of media technology in relation to future opportunities for producing more visually enriched decision cases.

## THE CASE

This video case, formatted as a “documentary,” begins with footage showing a crop of buckwheat and accompanied by brief statements from the farmers who are featured in the case story. Farmers explain how they got interested in growing buckwheat as a crop and describe some of the difficulties they faced, particularly in marketing their crop for a profit.

The principal farmers portrayed in the video, Tom and DeEtta Bilek, lived on a 88-hectare (220-acre) farm near Aldrich, MN. At the time portrayed in the video, they had been farming for about 20 years. During one cropping season about 15 years earlier, Tom had needed to identify an “emergency crop” since it had become too late in the season for him to plant his usual crops of corn (*Zea mays* L.) or oat (*Avena sativa* L.). A neighbor suggested that he grow the crop of buckwheat, which at the time was unfamiliar to him. Since that year, he had continued to produce buckwheat on as many as 12 hectares (30 acres) each cropping season.

Another farmer in the vicinity, Allen Schmitz, is then introduced and tells of having adopted buckwheat for production on some of the fields of his farm with poor soil. He notes that his grandfather had also grown buckwheat and contended that it grew well under weedy and/or poor soil conditions. A third farmer, Phill Arnold, is then introduced in the video. He also had been encouraged to grow buckwheat through a neighbor’s recommendation.

The narrator provides background information about buckwheat, including its agronomic characteristics and uses. The narrator concludes her introduction by saying:

Buckwheat has been around for a long time. It is now gaining popularity as farmers discover the benefits of growing this alternative crop... With first hand experience growing buckwheat, these farmers enjoyed the benefits of this alternative crop—but they also realized that they needed each other to make it profitable.

### A Tough Sell

Though buckwheat offered several agronomic advantages for these farmers, such as competitiveness with weeds, a capacity to utilize poor soils, and a means to add needed diversity to their crop rotations, it was not without problems. The video draws on the words of the farmers to outline these concerns. For example, Tom Bilek states:

The big problem throughout the years was always the marketing. It’s been a sort of volatile crop...

To attempt to capture a better price for their buckwheat, Tom and DeEtta began talking to other local farmers about establishing a small association that would link buckwheat producers and provide the opportunity for collective cleaning and marketing of the crop. They hoped that the association would help create more marketing opportunities than any of the farmers could have found individually. According to DeEtta Bilek:

You either had to sell it [buckwheat] to a local feed mill, or if you lined up your own buyer, you didn’t really have enough volume to fill a ‘semi’ [semi-trailer truck]. If you sold to a local feed mill, you got a low price where if you sold directly to a buyer, you got a better price, but you don’t have enough volume to fill the semi. So, those are the rea-

sons we started talking to other people about growing it and selling it collectively.

An “association” was formed and a “board of directors” made up of member farmers was established. The operation of this Buckwheat Growers Association, as it was named, depended entirely on voluntary labor. And it was not without problems, as described by Phill Arnold:

There are a lot of rules on how you do things. You know, our packaging—that sort of thing. Working with people, making sure that we get things delivered, all of those details, that’s a dilemma. How do we pull that off with a volunteer group?

From the beginning, the goals and aspirations for the Buckwheat Growers Association differed among the members. In the video each of the featured farmers is quoted as they explain their expectations and concerns. Association member Paul Friedrich offers an optimistic vision of the crop and the Association’s potential, and contributes the following from which the video derives its title:

I mean it could be anybody’s dream as to what you wanted to do with the stuff—if you wanted to continue on a larger basis or move into all the by-products that are associated with it [buckwheat].

However DeEtta Bilek, who was a particularly active member and handled most of the administrative responsibilities, offers a more tempered view:

We were trying to accomplish too much. We needed to step back and take a look at the elements that make a strong organization. So we had to look at those before we could really put ourselves into researching the [buckwheat] marketing possibilities.

Such divergence of viewpoint led some members of the Buckwheat Growers Association to consider reorganizing as a cooperative. Tom Bilek explains:

All I thought was this is going to be a small organization where we get a group of growers together and we were going to market it [buckwheat]; but down the road as far as I can see in the future is maybe we’ll have to go to a “coop”- type situation because of the liability.

After hearing from the farmers about their diverse aspirations and concerns regarding the Association, the narrator frames the principal decision facing the members, which then becomes the focus of the case for the remainder of the video’s duration. The farmers’ were unified in their goal to make buckwheat a profitable crop but they differed in their perspectives on how best to organize toward that end. The dilemma came down to whether the group’s goals could best be achieved by staying as an informal association or changing to a more structured agricultural cooperative?

### Association or Cooperative?

A text-based exhibit with the case explains some of the technical differences between a partnership (the legal name for the Association) and an agricultural cooperative. The farmers are quoted in the video as to their positions on the ‘pros’ and ‘cons’ of these two forms of organization. For example, Phill Arnold states:

There are legal advantages to being a coop, protection from liability and so forth, the ability to set or fix prices as a group and not be subject to antitrust laws. And the other big advantage is, if you're going to own equipment, or some sort of facilities, if you're a coop it's set up to do that, where if you're an association it's a lot more awkward.

However, some within the Association were reluctant to form an agricultural cooperative. As a rule, they saw this as an initial step toward creating unneeded complexity in the organization and likely relinquishing individual and localized control of the decision making that would affect their production and marketing options. Allen Schmitz comments:

Co-ops seem to have a lot more laws as far as guides, I guess guidelines that you have to follow, as far as paying dividends and things like that. I guess they each have their benefits; you know if it's a really small group it's probably less hassle, you know with just an association as opposed to being a coop. But as things grow you need a little more order, or you know, structure to the organization.

Furthermore, Paul Friedrich states:

With an association you can stay with small numbers and still probably do pretty good not getting into a lot of "after market" things. But, if we become a co-op, then pretty soon we've bumped ourselves into volume. Then you have lots of growers, so then we start moving further away from the community, further out, maybe even out-of-state. Then what happens to the control, because obviously the big grower's going to want to have a say.

Other members of the Association had positive experiences with agricultural cooperatives and associated them with times of prosperity for local communities. In the words of Ray Eiswald:

I can remember when we had our cooperatives, our communities were thriving, and as we've lost our cooperatives, we can generally see that the communities have degraded.

### The Decision

As the video concludes, the narrator summarizes the major points presented in the video and rephrases the key elements of the decision faced by the Association members:

Buckwheat has many advantages as an alternative crop for these farmers. They need to decide how they will organize themselves—as an association or a coop. They also need to determine how they will market the buckwheat—locally, nationally or internationally. Finally, they need to consider the impact that their decisions will have on other issues.

### Exhibits

There are two text-based exhibits that accompany the video. Exhibit 1 is an "Alternative Field Crops Manual" (Oplinger et al., 1989) that describes history, uses, growth habits, environmental requirements, cultural practices, yield potential and performance results, and economics of production and markets for the crop of buckwheat, as well as listing additional information sources. Some teachers may choose to not use this exhibit depending on their purposes for the case. But if deliberations of the case are to include detailed con-

siderations of production and utilization options for buckwheat, Exhibit 1 can provide good background information for these discussions.

Exhibit 2 is two pages in length and is titled "What is a Cooperative?" It provides background information on various agricultural business organization types: partnerships, limited partnerships, corporations, cooperatives, and "new generation" cooperatives. It also explains the marketing advantages for agricultural cooperatives arising from their antitrust exemptions via the Capper-Volstead legislation. Most teachers who use the case will likely choose to provide Exhibit 2 to students to add depth to discussions of the case.

## INTERPRETIVE NOTE

### Case Objectives

Through deliberation of this case, students will learn about a wide range of topics bearing on the adoption and marketing of alternative crops. The case provides a backdrop for consideration of principles and considerations faced in deciding how members of a loosely organized growers "association" might proceed to produce and market an alternative crop. Although this case considers the crop of buckwheat for a small group of growers in central Minnesota, the principles should be broadly applicable to many crop situations and localities.

Upon completing this case students should have:

- A better understanding of agronomic and economic challenges faced by farmers who choose to diversify cropping systems by growing uncommon (alternative) crops
- A better appreciation of the range of values, attitudes, and beliefs that affect choices related to diversification of cropping systems
- Gained experience deliberating a "real world" decision and considered aspects of leadership and management associated with beginning a new agricultural business
- Engaged in discussion that leads to information exchange and critical reflection

### Use of the Case

This case was developed for use on "short notice" with learners in situations such as extension, university classrooms, and experiential education within the disciplines of agronomy, agricultural business management, agroecology, and leadership studies. The case has been used in a "capstone" course (see below), as well as for extension in-service workshops. It is designed to be used within a class or extension period of 45 to 90 minutes, which includes the 14 minutes necessary to view the video. This case is intended for use with a discussion-based, active-learning process focusing on definition and resolution of the dilemma faced by the Buckwheat Growers Association. The case facilitator guides the discussion, asks clarifying and probing questions, redirects questions among the discussants, and helps facilitate transitions from point to point. The facilitator also validates the discussants' contributions and may record information and key points on a blackboard, flip chart, or overhead projector. A decision case such as this one is not intended to be a backdrop for an instructor-centered lecture, although a facilitator may provide his or her interpretations of the case as part of a "debriefing" *after* the discussion of the case itself by the participants.

The senior author has used *Anybody's Dream* as the basis for discussions about leadership in a Senior Capstone course within the agronomy major. In this context, the students have viewed the video and discussed the case within a single, 90-minute class period. Most of the discussions have considered the role of leadership within the specific situation faced by the Buckwheat Growers Association. In most years, some form of written "reflection" has been required of the students after the case discussion has been concluded. The students have been also provided with additional background readings on leadership before discussing the case to provide a conceptual framework for their comments. Averaged over 4 years of use (1999–2002), a total of 26 students rated the case as "satisfactory" to "good." Some of these university students expressed a desire to have the case presented to them in "paper" form in lieu of video. They expressed that it was difficult to remember specific information while watching the video alone, whereas they felt that a text-based case could be more readily referenced later. Although it is true that a video presentation of a case does not readily lend itself to recall of *specific* data or information, it is seldom that a decision case—either text-based or video—is intended to primarily teach specific knowledge. Decision cases are better suited as a basis for elucidating an understanding of broader concepts and principles. It is our judgment that a video-formatted case is well suited for this purpose.

This case can also be used directly with farmers. However, it should be noted that, when used with farmers or extension educators, the case is not intended only to familiarize them with buckwheat production and marketing. It is *primarily* meant to provide a basis for enhancing understanding of marketing options that can be more broadly applied. Thus, the case can be used even in geographical areas where buckwheat is not, nor is likely to become, an important crop. Before using the case, the facilitator will want to emphasize this point to the learners that the case has a broader purpose than just learning about buckwheat and challenge them to consider how the concepts elucidated from the case might transfer to other crops or situations.

When using a video case, it is assumed that many audiences will not have had prior introduction to the case before discussing it. Since the case is formatted on video, it is well-suited to be introduced quickly to the learners. It is helpful for the instructor to "frame" the video before showing it to the audience and to encourage them to take notes while viewing it, such as asking them to keep track of the principal characters portrayed in the case and their ideas about how to organize for the marketing of buckwheat. The characters in the video who represent the Board of Director decision makers in the case are Tom Bilek, DeEtta Bilek, Phill Arnold, Allen Schmitz, Ray Eiswald, and Paul Friedrich.

*Anybody's Dream* may precipitate disagreements. Just as the principal decision makers in the case differed in their perspectives on the value and implications of changing from a growers association to a cooperative, so the learners may also bring differing values to the discussion as well. It is important that the discussants be encouraged to maintain a degree of objectivity about the case and to not "choose sides" prematurely. The teacher should strive to have the students view the case dilemma from multiple perspectives.

Students may likely also want to have more information about the case than is provided in the video and associated exhibits. Instructors can handle this situation in several ways. As part of their deliberations of the case, they can have the learners list the "needed" information and discuss how that information might be obtained and used. In classroom situations, the instructor might suspend discussion of the case after generating such a list of needed information and ask the students to retrieve some of it before continuing their discussion of the case at a later class session. However, in most extension situations, and many classroom situations as well, there is not sufficient time to permit retrieval of additional information so the learners are asked to proceed without the benefit of the desired information. The facilitator can remind discussants that in the "real-world," one seldom has all the information and background that one would like to have, yet a decision still often needs to be made.

Once teachers are satisfied that their purposes for using the case have been fulfilled—and usually after the learners have reached a consensus decision and attained a sense of "closure" for the case—teachers should move into a period of "debriefing" of the case. It is important to realize that there is no single "correct" answer for decision cases such as *Anybody's Dream* and it is possible that a "split decision" may occur.

### Discussion Questions and Issues in the Case

Below are some examples of questions that might be used to facilitate a discussion of *Anybody's Dream* after viewing the video.

**1. What are the growers' motivations for growing buckwheat?** Each of the farmers in the association is seeking to enhance the profitability of their farming operation. Not all of these farmers rely solely on farming for their income; some have off-farm employment or are retired from another job. However, all sense the need to diversify their cropping systems for agronomic and economic reasons. Several in the video refer to purported agronomic advantages of buckwheat. Many of the soils in the Aldrich, MN, area are coarse-textured and lacking in inherent fertility. For some of the farmers, the idea that buckwheat absorbs phosphorus from the soil and then releases it to a subsequent crop is an attractive feature. Some also cited the competitiveness of buckwheat with weeds as favorable. Buckwheat is also distinctive for its short growth cycle, which permits farmers in northern climates to plant the crop later in the growing season and still have it mature before frost.

But for all of the farmers in the association, a key motivation for participating is to gain access to a new "niche" market that may be more lucrative and stable than conventional ones like those for corn, soybean [*Glycine max* (L.) Merr.], and small grains. At the time of this case, there was a high demand for buckwheat hulls as filler for therapeutic pillows, as well as an interest in marketing buckwheat "value-added" products directly to Asia, Europe, and other regions of the USA. One of the growers on the video noted the importance of establishing new industry in rural communities as a stimulus to their economies.

In contrast to some alternative crop situations, the production of buckwheat itself does not pose a particularly difficult challenge to these growers. Management of weeds, diseases, and insects had not yet become a production constraint

for this crop. The material in Exhibit 1 could be used to provide additional background for discussing production aspects and for projecting possible “weak links” in the production of buckwheat in the future. For example it is often observed that biological and ecological problems become more prevalent once the land area of a crop increases and the crop is produced in shorter rotations (i.e., fewer seasons between successive buckwheat crops).

**2. What is the dilemma faced by the Buckwheat Grower’s Association?** This question is addressed directly by several of the principals in the video. DeEtta Bilek summarizes the dilemma faced individually by growers of small-acreage alternative crops: “. . .if you sold to a local feed mill, you got a low price where if you sold directly to a buyer, you got a better price, but you don’t have enough volume to fill the semi.” However, discussants should also move to a deeper level of the dilemma by recognizing that the farmers do not all see the organizational strategy for collective marketing of buckwheat in the same way. Similarly, one can see a myriad of obstacles facing a small “start-up” organization such as the Buckwheat Grower’s Association in areas such as leadership and administrative support.

**3. What issues do you think are important in affecting this dilemma?** This question provides the opportunity to explore the various issues bearing on the choice of organizational structure to be followed by the buckwheat growers in the future. There is a rich array of business philosophies and personal values portrayed by the farmers in the video.

Some, such as Phill Arnold, see the cooperative as having a number of clear advantages, particularly from a business and legal/liability perspective. It is important to note that Arnold acquired some of his perspective by attending a workshop on “new wave” cooperatives, an experience shared by none of the other growers within the association. Some, like Paul Friedrich, articulated a more skeptical viewpoint. Friedrich is critical of the longer-term implications of forming a cooperative and notes several limitations such as loss of localized control, dominance by large-acreage growers, and creation of a large “corporate” infrastructure where “decision makers” would be separated from actual production of the commodity. Implicit in this argument is the thought that continuing with a smaller, less structured association would help assure the opportunity to directly participate in its operation. But even those who were skeptical acknowledged that more “structure” was needed if the association was to attain its goals.

Students should be encouraged by the instructor to list and discuss the various “pros and cons” of moving toward a cooperative structure. One of the most compelling arguments for forming a cooperative is the legal protection that it affords to the individual members of the cooperative and its governing officers. Another is the opportunity it provides for collective marketing in accordance with the Capper-Volstead Act and the Cooperative Marketing Act, which provide antitrust exemption for farmer-owned cooperatives. Perhaps the most compelling argument against forming the cooperative is that it could lead to a more diffuse, less producer-focused leadership structure. However, it should be noted that to qualify for the antitrust exemptions in cooperative-specific legislation, a cooperative’s membership must be limited to producers and it must engage only in marketing of products produced by them.

**4. Why is the decision about how and where to market buckwheat also a dilemma?** There is another critical question faced by the association, whether it chooses to become a cooperative or not. This involves the strategy that should be used to market their buckwheat. In their quest to make buckwheat more profitable and to find more stable markets, they have acknowledged the necessity to move beyond marketing raw buckwheat commodity to “value-added” products. But it is unclear to them how far this should proceed at this point in their organization’s history since creating additional products increases the level of risk and expense for the association. For example, although the market for therapeutic pillows seemed attractive at the time of this case, it proved to be a short-lived consumer “demand.” Had the association chosen to create such value-added product, it and its members would likely have incurred a significant economic loss. This dilemma of how and where to market is a recurring matter for any alternative crops without an established track record.

**5. What principles of “leadership” and “management” apply to the dilemma of the Buckwheat Growers Association?** One possible application of this case is in courses and situations where principles of management and leadership are considered. This question offers learners an opportunity to distinguish between the concepts of leadership and management, as well as to develop an understanding of how important strong leadership can be when an organization such as the Buckwheat Growers Association is in its “formative” stages. The comments by members of the association provide some basis for considering elements of leadership at both an individual and collective level.

**6. What objectives should the association growers have in making a decision about how to proceed?** This question asks students to put themselves in the place of the buckwheat growers portrayed in the case. They can collectively define the objectives that they would seek to attain through their decision regarding the future organization.

**7. What options do the growers have in resolving their dilemmas?** To the extent possible, the learners should brainstorm options they feel the growers should consider in responding to their dilemma. These could include, but are not limited to:

- Retain the current association structure and seek to increase production capacity (e.g., recruit more growers and acreage) that could make their association more attractive to potential buyers and handlers.
- Establish one (or more) cooperative to market their buckwheat seed and/or to produce and market value-added buckwheat products.
- Seek additional counsel and obtain additional information to make a better decision. If the discussants settle on this option, it is important that they be asked to list the specific kinds of additional information that they will need to make a decision.

The instructor may also choose to guide the discussion into consideration of the additional dilemma regarding how to specifically market buckwheat in the future. As noted above, this dilemma applies whether or not the association members choose to become a cooperative.

**8. What should the growers do?** It is customary to conclude a case discussion by asking the participants to make a decision based on the information and options that have been generated. However, this may not always be necessary, depending on your purposes for the case. Since groups often do not reach a consensus regarding what should be done, a teacher may find it helpful to divide the group into subgroups of three or four individuals each, and then have each subgroup make a decision. Finally, the facilitator might have each discussant decide individually and to share their response to the dilemma and their rationale orally or in writing.

**9. What did we learn from this case?** After closing the discussion of the case, it is very helpful for the teacher to lead a “debriefing” of the case discussion. Again, it is important that learners who discuss this case understand that the purpose for considering it is not just to resolve the buckwheat growers’ dilemma. It is also to examine how the “lessons learned” might be applied to other situations, some of which may be “closer to home.” The teacher might ask, “What did the students learn from the case experience”?

### Video Production Considerations

Before producing a video case, one should consider whether their prospective case topic lends itself to a video format. We believe that the number of video-compatible topics is large, but we also know that not every case topic is equally suited for development as a video. Clearly, a producer must have access to and trust of the case protagonists and that they will permit themselves to be visually portrayed on video rather than merely quoted using text as in a conventional paper-based case. Having existing “stock” footage related to the topic of the case available is an asset, although it is important to note that no such footage existed for *Anybody’s Dream*.

One should also ask how well a case topic would lend itself to a visual portrayal. For a case where most of the interest is internal, such as for a case involving a moral dilemma of the decision maker, there might not be enough of visual interest in the case to favor using a video format. Such cases might be better portrayed using a conventional text-based approach. We felt that there were a number of visually attractive features with the *Anybody’s Dream* topic and dilemma such as the visually interesting and articulate qualities of the decision makers and their community setting, as well as the novelty of the buckwheat crop itself. We used a “documentary” approach for this video. This helped us to convey, in the farmers’ own words, their analysis of the problems and their aspirations for the Buckwheat Growers Association.

### Scripting Process

We began by traveling to Aldrich, MN, and interviewing each farmer on audiotape. This one-on-one interview without the video camera team present gave the farmers a chance to talk freely and express their viewpoints. We interviewed six members of the association in one day. We also scouted locations that would be appropriate for videotaping as context footage (“b-roll”) when we returned later with the video camera crew. These locations included the town of Aldrich, some of the landscapes in the vicinity such as fields of growing buckwheat and the farmsteads.

From the transcripts of the audio taped interviews, we composed a *treatment*, which is a short (2–3 page) description of the flow of the video from beginning to end. It included excerpts from the interviews and added other narration for clarity when needed.

We then composed a first draft of a script, including desired b-roll from the location that could help connect the viewer with the farmers’ lives and expand their understanding and visualization of the situation. The producer then “blocked” the script and created a master schedule including filming locations and the time at each location.

With this draft in hand the team of camera operator and sound technician, producer/director, and the project managers went to Aldrich a total of three times and videotaped the interviews with six farmers, as well as the b-roll footage. Although we did not expect the farmers to use exactly the same words they had used in the earlier audio-taped interviews, the farmers were asked to express some of the same ideas they had expressed then. They also had time since the audiotaped interviews to think more deeply about their responses to our questions. The views represented in the videotaped interviews generally exceeded the audiotaped ones in quality. We also did the videotaping in early summer, late summer, and fall to capture the appearance of buckwheat fields as different stages of development.

After collecting the video footage, writing the narrator’s text that would connect the interviews together completed a final script as well as presented other key information. Placement of graphics such as superimposed text over the video (e.g., interviewee’s names and bullet points) was also noted in the final script.

### Editing

Videotape editing is often referred to as *post-production*. It involves producing the elements not recorded on location or in a studio and combining them with the video footage itself. Such elements include graphics, video effects, the narration track, and music. Post-production involves at least two rounds of editing—the first is selecting the best “takes” of the video interviews and b-roll and then electronically splicing them together. This is similar to writing a rough draft of a manuscript since it lays out the basic content.

Next comes refining the edits and then one adds all the other elements. During this step it is important for the “content” professionals and those who will be using the video to be involved and to help with the selection of the narration, music, and other creative elements that will make the video suitable for their intended purposes.

### Costs

At the time of its production, *Anybody’s Dream* cost \$12,000 to produce. The videotaping costs were approximately \$5900 and post-production (including narration, graphics, music, etc.) cost \$4600. The remaining expenses were for transcribing the audiotapes and script writing.

When *Anybody’s Dream* was produced in 1998, videotaping and editing was costly and involved professional cameras, editors, and graphic systems. Since that time, digital video cameras have become more common and are relatively easy to use. Desktop computers have become faster and have large

file storage capacities that can run required editing software. Currently, videotaping and post-production costs would be about one-third less than in 1998 assuming that digital cameras and desktop computers were used. These technological advances are changing the preferred format through which video is viewed and the videotape itself is gradually being supplanted by CD-ROM and DVD technologies. However, the process and considerations outlined above remain the same.

### Areas of Concern Unique to Video

#### *Identity of Case Principals*

Because we asked people to tell their personal stories, we needed to build trust with them, as well as provide credit and recognition for their contributions. As explained previously, the two-step process of conducting audio interviews followed by videotaping helped reduce anxieties about having only one chance to speak. It also built rapport between the interviewer and the farmers. All interviewees signed University of Minnesota Extension Service release forms and were identified by their actual name in the video. We also acknowledged their contributions in the credits provided at the end of the video.

In conventional paper-based cases, it is relatively common to change the names of principal characters in a case to protect their confidentiality. Video cases such as *Anybody's Dream*, which portray the principals themselves in the video are not suitable for disguising the identities of the principal characters. It is possible to use "actors" rather than the principals themselves, but this can diminish the impact and credibility of the case with viewers. This quality of visually rich video cases will likely limit their use to case subjects where confidentiality of the principals is not an overriding issue.

#### *Length and Content vs. Audience Attention and Retention*

The utility of video is being able to tell a compelling, visual story so that by the end, the audience is engaged, informed, and motivated to discuss the dilemma that was portrayed. As a "rule of thumb," we feel that the attention span of an average viewer is about 15 minutes. The pacing of words and pictures is crucial to keep the viewer interested. *Anybody's Dream* is 14 minutes in length.

Another challenge in producing *Anybody's Dream* was developing the story while avoiding the confusion that might

arise from hearing six different people's points of view. It would have been easier to script the entire case around a narrator, but we felt that for the sake of interest and authenticity it was important to "hear" many of the arguments directly from the farmers themselves. We also had to strive to convey the leadership and organizational dilemmas ahead of the buckwheat production or utilization dilemmas that are alluded to in the video. Developing a clear vision of the case's purposes and objectives, an understanding of the dilemma(s) to be portrayed, and a firm hand in editing the interviews helped to overcome some of these challenges. It also helped that we had exceptionally cooperative farmers to interview and interesting location footage from which to draw. It also helped that this was a *real* story with important implications for the principals in the case, which greatly enhances the likelihood that viewers will understand and relate to their situation.

### ACKNOWLEDGMENTS

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# Coffee vs. Cacao: A Case Study from the Vietnamese Central Highlands<sup>1</sup>

Dang Thanh Ha and Gerald Shively\*

## ABSTRACT

Mr. Nam, the vice chair of a village in Dak Lak province of Vietnam, was keen to protect farmers in his village from the sharp decline in prices of coffee (*Coffea canephora* Pierre ex Froehner). He did this by encouraging farmers in his village to plant cacao (*Theobroma cacao* L. subsp. *cacao*). Cacao was suitable to the soil and climate of the area, and because a foreign company had promised to buy cacao from the farmers, it seemed to offer greater financial security. However, uncertainty about crop losses due to pests, the cost of chemicals such as pesticides, and potential fluctuations in the prices of cacao made it imperative to carefully evaluate the benefits of cacao production. In making his recommendation to the village, Mr. Nam utilized additional information about the potential demand and the marketing networks for cacao. The decision to switch from coffee to cacao provides a village-level example of learning about agricultural supply and demand issues, perennial crop production, and economic and environmental consequences of growing particular crops. This case was written for undergraduate students in agriculture and forestry programs at Nong Lam University. Students were expected to understand the nature of land use changes and major issues facing the coffee farmers in the central highlands of Vietnam. They were also encouraged to identify and critically evaluate economic and environmental benefits and costs, and the policy and institutional supports needed for ensuring a sustainable cocoa production in the Central Highlands. The case was subsequently translated into English and used in classrooms at Purdue University.

The province of Dak Lak is located in the Central Highlands of Vietnam. The province has a total population of nearly 1.8 million people, accounting for 58% of the population of the four provinces of the Vietnamese Central Highlands. With most of its basal soil having advantageous qualities such as a fine texture, a high water absorption level, and high fertility, Dak Lak is well-suited for the production of various perennial industrial crops including coffee, rubber, pepper, cashew, and cacao, as well as annual crops such as hybrid maize and cotton. During the past decade, both planned and spontaneous immigration have created demographic pressures in Dak Lak. The influx of people has also played a major role in transforming the physical and socioeconomic landscape of the province.

The liberalization and global integration of Vietnamese trade has resulted in a dramatic change in land use in upland areas. High market prices for coffee in the early 1990s motivated many farmers to plant coffee from valleys of the Central Highlands up to areas that were fully forested not so long ago. In the decade from 1990 to 2000, coffee area in the province expanded greatly, by about 14% per year. By 2000, the coffee plantation area in Dak Lak had

reached 260,000 hectares and coffee accounted for 57% of agricultural land and 86% of industrial crop area in the province. Dak Lak is one of the most specialized coffee regions of the country, accounting for 50% of total area and 53% of national output (Ha and Shively, 2004).

The coffee production system in most areas of the province is monocultural, relying on high levels of fertilizer and pesticide, large consumption of water, and full market orientation. Households that produce coffee on a small scale (about 1 hectare per household) comprise the majority of coffee-growing households in the province. During high-price periods, with coffee as the main source of income, all coffee producers were encouraged to invest strongly in new tree plantations and maintenance of current plantations. Motivated by high coffee prices, many farmers planted coffee even when they had no experience cultivating coffee and no knowledge regarding local conditions for growing coffee. Many planted coffee on very steep slopes with unsuitable soil and water conditions.

The expansion of coffee production has broken down the ecological balance of the region. Forest cover decreased from about 90% in the 1960s to 57% in 1995 and to less than 50% in the late 1990s (ICARD and Oxfam, 2002). In the past 20 years, Dak Lak has lost 20 thousand hectares of forest a year to both public and private coffee plantations and farms. The serious devastation of the forests brought about by the increase in coffee plantations has led to an ecological imbalance, particularly an inability to regulate water resources. Agricultural expansion, especially of coffee, reduced marginal forest area. Farmers note that floods seem to be increasing in frequency and magnitude. The natural surface flow is also observed to be decreasing over the years and soil erosion is becoming increasingly common.

Coffee is a water-intensive perennial crop. About 40% of the current coffee plantation area is irrigated by groundwater, using up about 66 million m<sup>3</sup> during the dry season, or 438,400 m<sup>3</sup> per day. Provincial authorities find it difficult to manage water resources, and the high rate of exploitation has already exhausted a number of sources. Farmers report that the groundwater table is extremely low during the dry season, raising the cost of pumping.

In the 1990s Vietnamese farmers planted more than 1 million hectares of Robusta coffee, enabling Vietnam to surpass Colombia as the world's second-largest coffee producer (ICO, 2002). Fueled by the government's policy of privatization and economic liberalization (known as Doi Moi), state-sponsored migration into the

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<sup>1</sup> This teaching case study grew out of a collaborative research project that the authors initiated following their first meeting at a conference in 1999. Through conversation they recognized a shared interest in improving undergraduate classroom experiences at their institutions, in particular making class materials more realistic for students. The idea for working together to develop case studies led to several exchange visits and the creation of four case studies at Nong Lam University. This is the first of the cases to be published.

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**Abbreviations:** BMPs, best management practices; CAFOs, confined animal feeding operations; HAP, high available phosphorus; M3-P, Mehlich-3 extractable P; NRCS, Natural Resource Conservation Service; PAN, plant-available nitrogen; PLAT, Phosphorus Loss Assessment Tool; RYE, realistic yield expectations; SERA-17, Southern Extension–Research Activity Information Exchange Group 17.



Central Highlands, and price spikes generated by frosts in Brazil, by the mid-1990s more than 1 million Vietnamese were participating directly or indirectly in the country's coffee economy (Nhan, 2002). However, the increase in coffee exports coincided with a precipitous decline in international coffee prices brought about by Vietnam's entry into the world coffee market, combined with rising stocks, inelastic demand, and a shift toward low-cost Robusta for processing (Ponte, 2002).

The fall in the export price of coffee led to a sharp reduction in the farm gate price. In Dak Lak, the price of dry coffee beans fell more than 60% between January and December 2000 and fell further throughout 2001, to levels insufficient to cover production costs (USDA-FAS, 2002, 2003). The low prices caused losses for coffee producers and traders, discouraging people from further investing in coffee, and leading farmers to destroy several thousand hectares of coffee plantation area to grow other crops. Meanwhile, farmers face indebtedness as it is difficult to repay loans borrowed in better times to expand coffee areas.

Policymakers, governments, and international organizations have been exploring ways to mitigate the coffee crisis in Vietnam and other coffee-dependent areas. Potential mitigating steps range from establishing fair trade coffee markets to undertaking mass destruction of coffee beans. Another possible solution is to restructure cropping patterns in favor of more profitable cash crops like cashew or cacao. This case study highlights issues surrounding the potential shift from coffee to cacao in a Vietnamese village.

### THE CASE

Like many other coffee growing villages in Dak Lak province, the decline in coffee price since the year 2000 rendered coffee cultivation in Ea Tul village an unprofitable enterprise. Large and wealthy households have retained their coffee crop, but stopped investing further in coffee production. Some farms retained their best coffee trees while they cut down the less productive ones and planted other crops. The fall in coffee prices reduced the income of poor farmers in the village. Many of them had to sell assets such as animals to continue investing in and maintaining their coffee plantations. As the price of coffee continued to fall during 2001–2002, many coffee-producing households began to prioritize other crops and income sources, such as hybrid maize, cotton, rice, and livestock. Some farmers gave up coffee growing altogether. Among those who suffered economically, the poor bore the heaviest losses. With low coffee prices, farmers regularly asked, "What should we produce?"

One person most frequently asked this question was Mr. Nam, the vice chair responsible for agricultural production in Ea Tul village, located in Dak Lak province. As an example, one recent morning, just as he was stepping out the door to visit his neighbor Mr. Bay, Mr. Nam bumped into Mr. Tu, a fellow farmer from his home village in Quang Ngai province. After exchanging some pleasantries, the two men continued to Mr. Bay's house where the conversation quickly turned to farming and the state of coffee prices. Mr. Bay related his situation.

"This year, I had a good coffee harvest and solid yields, but the price was dismal. My revenue was insufficient to cover my production costs. If coffee prices don't recover, I'm going to have to cut a part of my coffee and shift to another crop."

Sipping from the cup of coffee in his hand, he continued.

"Unfortunately, our land is not well suited for rice; and other annual crops provide very low income. I want to shift from coffee to another crop to earn enough income for my family, but what crop should I grow now?"

The three men sat in silence, pondering the situation and searching for an answer. After a few minutes, Mr. Tu raised his voice.

"The other day I met one of my relatives from Dak Mil district who started growing cacao last year. According to him, cacao can generate a much higher return than coffee. I even heard that in other provinces the officials are currently encouraging farmers to grow

cacao. Tell me, Mr. Nam, do you think the farmers in this village should be planting cacao, too?"

As the vice chair responsible for agricultural production in his village, Mr. Nam was concerned about helping farmers in the village cope with the decline in coffee price. Cacao seemed to hold out some hope, provided land in the village would be suitable for cacao cultivation. Mr. Nam decided he needed to learn more before making a recommendation.

### Cacao: An Opportunity for Farmers in Dak Lak

In the subsequent week, Mr. Nam met with the chair of the village and discussed with him the idea of introducing cacao to farmers in the village. The village chair agreed with the idea and encouraged Mr. Nam to go to the agricultural extension center of the province to learn more about cacao cultivation. He also asked Mr. Nam to make a recommendation on how best to promote cacao in the village.

At the agricultural extension center, Mr. Nam obtained a lot of good information on cacao. He was fortunate to meet Dr. Hong, a cacao expert from the local agricultural university, who spent time explaining numerous details regarding cacao and cacao cultivation techniques. Dr. Hong explained that the Vietnam Cocoa Development Program was initiated in 1997, at which time a private cocoa company and the American Cocoa Research Institute (ACRI) were main drivers. The aim of the program had been to lay a strong foundation for Vietnam to realize its vision of having 100,000 hectares of cocoa planted in the country by the year 2010.

Mr. Nam learned a great deal about cacao during his visit. Cacao is an important tropical rain forest species. It is grown for its oil-rich seed, to produce cocoa and cocoa butter. Cacao is also called cocoa or chocolate tree. The name chocolate is believed to have originated in Mexico. Currently the largest cacao producer is Cote d'Ivoire (Ivory Coast) in West Africa. Hybrid species have been developed to grow quickly in South East Asia, especially near equatorial areas. Evergreen cacao trees grow best between 20° north and south of the equator, usually below 300 meters. The tree requires uniformly high temperatures with recommended mean of 26.6°C. Trees are wind-intolerant and are therefore often planted on hillsides for wind protection and good drainage. Being drought-intolerant, cacao thrives in climates with high humidity and rainfall. Plants are shade-tolerant and thrive in rich, organic, well-drained, moist, deep soils.

The major management requirements of cacao agro forests are shade control, weeding, pest and disease control, harvesting of pods, and processing of beans. Cocoa trees are planted in arrangement of 3 by 3 meter and 4 by 2 spacing on flat and slanted lands, respectively, resulting in 1100 trees per hectare. Before cocoa is planted, there should already be cover crops or trees that cover young cocoa trees from direct sunlight. As the cocoa trees mature these cover crops can be reduced: trees less than 2 months old require 70 to 75% shade; and those aged 3 to 5 months require 30 to 70% shade. Fields should remain partly shaded for 3 years. Cacao is often intercropped with other trees of economic value, such as banana, rubber, oil palm, or coconut.

Weeding is by hand or herbicides. Irrigation may be practiced, but drain ditches should always be provided to prevent excess water. Fertilizer is applied two to three times per year by penetrating it 10 to 20 cm under the soil surface at the tree's crown. In general, the fertilizer used should contain large amounts of nitrogen, phosphate, and potassium, not to mention small amount of micronutrients. In the market, these fertilizers are known as urea/za (N source), triple super phosphate (TSP), and KCl.

In Dak Lak, cacao starts to bear fruit in the second year after planting. Fruit requires 5 to 6 months from fertilization to harvest. The harvest season lasts about 5 months. Pods are cut from trees and allowed to mellow on the ground. Then pods are cracked and the beans are removed; the the husks are burned. Beans are fermented in leaf-lined kegs 2 to 8 days before drying in the sun, at which time they change from purple to brown. The purposes of cocoa fermenta-

tion are to prevent germination and generate cocoa-typical aroma. Cocoa seeds are the source of commercial cocoa, chocolate, and cocoa butter. Fermented seeds are roasted, cracked, and ground to give a powdery mass from which fat can be expressed. This is the cocoa from which a popular beverage is prepared. In the preparation of chocolate, this mass is mixed with sugar, flavoring, and extra cocoa fat. Milk chocolate incorporates milk as well. Cocoa butter is used in confections and in manufacture of tobacco, soap, and cosmetics.

In the 1960s, cacao was introduced to Vietnam and planted in several areas. The soil and climatic conditions of the country are suitable for the crop but due to the lack of market outlets, early plantings of cacao were cut down to make way for coffee, black pepper, and cashews. Recently, with falling coffee prices, the agriculture sector has paid more attention to cacao, particularly because a foreign company recently started buying cacao from farmers.

However, Dr. Hong noted, like other perennial crops, cacao cultivation is not without some risks. There are numerous insects in the field and in storage that damage the quality and quantity of cocoa beans and that hinder cocoa production in general. Each year, an estimated one-third of the world's cacao crop is lost from diseases and pests. Conventional chemical insecticides and fungicides do not always work well in the tropics, where insect resistance develops quickly and heavy rains simply flush fungicides away. The cost of such agrochemicals makes them unaffordable for most small cacao growers, and a lack of modern agricultural extension services compounds the problem. There is also risk in the cacao market. Cacao prices are highly volatile and economic hardships occur when prices are low. World prices weakened in 1987 and remained depressed through the mid-1990s. Since 1997, however, world cacao prices have improved somewhat.

Cacao production can also be beneficial for the environment. In an agroforestry system, as the cacao tree and the other components grow to maturity, the agroforest becomes a more diverse and structurally complex, closed-canopy multi-strata system that resembles natural forest. Agroforest is capable of providing lasting economic, social, and environmental benefits. In terms of carbon sequestration and below- and aboveground bio-diversity, the cacao agroforest is superior to alternative food crops. With the exploitation of forest trees (as in many places in Dak Lak) it has become necessary to plant alternative fast growing tree species to provide shade. However zero-shading and chemical spraying are two main causes for environmental concern in the industry. There is also one concern

that the high profitability from cacao production may encourage farmers to expand cacao area into the forest.

At the end of the afternoon, Dr. Hong emphasized to Mr. Nam that, at current prices, and with the favorable climatic and soil conditions that existed in Dak Lak, cacao offered a good opportunity for farmers in Mr. Nam's village. He provided Mr. Nam with data on production costs and yields for coffee and cacao (Exhibits 1 and 2) to use as inputs into his decision.

### Back to the Village

At the end of the afternoon, Mr. Nam returned to his village. He was happy to have learned more about cacao and felt comfortable with the idea of promoting cacao production in his village. The soil and climatic condition in the village were suitable for cacao, and the village was located not far from the city, so that transport costs would be low. Although it was true that most farmers did not have any technical knowledge regarding cacao cultivation, Mr. Nam felt certain that the village could seek support from the provincial extension center to train farmers.

Nevertheless, Mr. Nam still had a few reservations regarding his decision. Before making a recommendation to the chair of his village, Mr. Nam decided to invite colleagues and representative farmers for a meeting to report what he had learned about cacao and to get their comments on how best to promote cacao expansion in the village. Some important issues and comments were raised at this meeting. Most farmers at the meeting felt convinced of the benefits from the possible changeover to cacao. Not only would cacao provide a good opportunity for all farmers in the village to increase their incomes, it would also provide some degree of crop diversification in the village. Furthermore, it could help the village to mitigate water shortage problems, especially because cacao would need much less water than coffee.

Another concern of farmers was the difficulty of accessing credit. Due to the collapse in coffee prices, many farmers felt they simply did not have enough cash for new investments. Many were already in debt. These farmers would be unable to shift from coffee to cacao because they had used their coffee trees as collateral for loans, and the bank would not allow them to cut the trees. Most farmers at the meeting also expressed concern about revenue uncertainty: if cacao prices were to fall in the future, or if coffee prices were to increase, they felt they would be caught on the wrong side of the market.

**Exhibit 1. Information on cacao production (per-hectare basis).**

Items	Unit†	Unit price 1000 VDN	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6–25
Output (dried beans)	kg		0	400	1000	1500	2000	2500
Price of beans	VND 000/kg	20						
Costs								
Establishment cost	000 VND	1	17,300	0	0	0	0	0
Fertilizer (N–P–K)	kg	4.40	0	400	600	800	1500	1900
Manure	m <sup>3</sup>	150.00	0	0	0	6	8	8
Pesticides	kg	15.00	0	10	10	10	10	10
Sacks	no. (60 kg)	1.50	0	9	21	27	32	35
Water pump	hour	20.00	0	20	20	30	30	30
Family labor	days	20.00	0	60	60	60	60	60
Hired labor	days	20.00	0	10	20	35	45	55
Processing labor	days	20.00	0	30	60	90	144	136
Land tax	000 VND	1.00	0	0	0	0	0	740
Other								
Water quantity	m <sup>3</sup>	–	0	500	500	700	700	700

† VDN, Vietnamese Dong.

**Exhibit 2. Information on coffee production (per-hectare basis).**

Items	Unit†	Unit price 1000 VND	Year 1	Year 2	Year 3	Year 4	Year 5	Years 6–25
Output (beans)	kg		0	0	500	1000	2000	2500
Price of beans	VND 000/kg	10						
Costs								
Establishment cost	000 VND	1	15,748	0	0	0	0	0
Urea	kg	3.2	0	250	300	360	420	420
Phosphate	kg	2.0	0	250	300	360	420	420
Potassium	kg	3.5	0	200	240	290	375	375
Manure	m <sup>3</sup>	150.0	0	0	9	9	9	9
Pesticides	liter	40.0	0	1	5	5	5	5
Sacks	no. (60 kg)	1.5	0	0	25	52	78	100
Water pump	hour	14.0	0	67	139	184	184	184
Processing	rate/tonne	150.0	0	0	0	1	1	2
Family labor	days	20.0	0	160	174	220	280	275
Hired labor	days	20.0	0	78	143	100	103	120
Land tax	000 VND	1.00	0	0	0	0	0	740
Other								
Water quantity	m <sup>3</sup>	–	0	1200	2500	3300	3300	3300

† VND, Vietnamese Dong.

**Mr. Nam's Dilemma**

After considering the sentiments expressed at the meeting and the data at hand, Mr. Nam decided to recommend that the village farmers switch from coffee to cacao. However, that evening, just as he was sitting down to write his recommendations to the chair, he saw a shocking news story about farmers in a neighboring province who had resorted to feeding cacao to pigs, because prices were too low to justify taking the crops to market. Hearing this news, Mr. Nam wavered. If the village promoted cacao cultivation too slowly or waited until other villages had planted cacao, farmers in his village would lose the opportunity to earn high incomes from cacao. Nevertheless, if the village promoted cacao too aggressively, the farmers in the village might end up like those in the news.

**TEACHING NOTE****Learning Objectives**

This case offers a look at land use and agricultural land management in a low-income tropical environment. It is to be used as a basis for students to identify and discuss the complex issues relating to the introduction of a new crop to an existing agricultural production system and natural environment. The case also helps students in applying their knowledge in crop budgeting, sensitivity, and risk analysis in analyzing a practical situation using spreadsheet analysis.

Upon completion of this case study, students will:

1. Understand the nature of land use changes and major issues facing the coffee farmers in the Central Highlands of Vietnam.
2. Understand how to perform a crop budgeting for competing crops and assess the risks of competing crops under different scenarios.
3. Identify and critically evaluate economic and environmental benefits and costs, environmental risks, and market risks that likely result from future cacao expansion in the Central Highlands of Vietnam.
4. Identify policy and institutional supports needed for

ensuring sustainable agricultural production in the low-income tropics.

**Intended Student Audience**

This case was written for undergraduate agriculture and forestry students at Nong Lam University, in Vietnam. It was used in a course for the first time in 2004 for undergraduates majoring in extension and rural development. Students worked in groups of five to complete case study assignments. In late 2004 the case was translated into English and used for classroom discussion and as a homework assignment in an environmental and natural resource economics course for undergraduate students at Purdue University. A primary benefit of using the case in an American classroom is that it provides an opportunity to discuss a wide range of issues related to economic development in the low-income tropics, including poverty, environmental degradation, and sustainable development. Students found the case to be highly realistic and they spontaneously identified areas of ambiguity in the case in which more information was required or simplifying assumptions were critical.

**DISCUSSION QUESTIONS**

1. What is the major problem facing decision makers in the case? If there is more than one problem, list them in order of importance.
2. What have been the historical changes in land use in the Central Highlands and what are the major factors affecting these land use changes?
3. Do you think that the current agricultural production and resource management system is sustainable in the long run (at local, national, or global levels)? If not, what are the key socioeconomic and environmental problems associated with the continued production of coffee in the Central Highlands of Vietnam, particularly in Dak Lak?
4. How might the problems of Dak Lak be linked to the current plight of coffee farmers in other countries? How might the patterns described here be similar to or different from the historical experiences of farmers in other countries (e.g., cacao farmers in Malaysia in the 1970s and 1980s)?

5. The information in Exhibits 1 and 2 fully describe the economic costs and returns associated with producing 1 hectare of cacao and coffee. Use these data to construct a spreadsheet to compute the annual net income per hectare of coffee and cacao in Years 1, 2, 3, 4, 5, and 6 (each year separate). In addition, compute these returns per m<sup>3</sup> of water used for irrigating cacao and coffee. Based on your results, what conclusions do you draw from the analysis and why? Which crop seems to make the best use of water?
6. Assuming a discount rate of 5% and a 25-year horizon, use your data from (5) to compute the net present value (NPV) of income for each crop. Now assume the price of cacao decreases by 10, 20, 30, 40, and 50%. What happens to the NPVs? Do you think this is a good method to assess price risk? Based on results from this calculation, discuss how farmers may react to reductions in price. Who is likely to suffer most from the risk of falling prices?
7. Repeat your analysis from (6), but now assume that, due to pests and disease, cacao yields decrease by 10, 20, 30, 40, and 50%. As in the previous question, use benefit–cost analysis to show how the changes in yield affect farmers’ income. Briefly discuss.
8. Identify some of the benefits and risks associated with the expansion of cacao production in Dak Lak province. Use S-W-O-T analysis to identify major strengths, weaknesses, opportunities, and threats associated with cacao expansion in this area.
9. You have been asked to identify major stakeholders involved in the process of cacao expansion in Dak Lak province and the issues they may face. Might small and large farmers look at cacao differently? Farmers and policymakers? Why?
10. If you were Mr. Nam, the vice chair responsible for agricultural production in Ea Tul village, what would you recommend to help the village to achieve sustainable development? What other factors would you consider?

## ACKNOWLEDGMENT

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# Balancing the Phosphorus Budget of a Swine Farm: A Case Study

Nathan O. Nelson\* and Robert L. Mikkelsen

## ABSTRACT

Trends in animal production have moved the industry toward large confined animal feeding operations (CAFOs). These CAFOs concentrate large amounts of manure-based nutrients in relatively small areas, which increases the risk of nutrient loss to the surrounding environment. In response to water quality concerns, P-based manure application regulations are becoming more common. Mr. Pritchard is the owner and operator of two 4500-head swine (*Sus scrofa*) farms located in an area of intensive animal production in North Carolina. He has noticed an increasing trend in the soil P concentrations in his manure application fields and realizes that he does not have enough land to apply his anaerobically treated liquid swine manure based on crop P uptake. Mr. Pritchard is now faced with the dilemma of what to do to slow down the P accumulation in his soil. This case constructs a P budget for Mr. Pritchard's farm to examine ways of balancing on-farm nutrients. Students are encouraged to explore solutions related to animal nutrition, crop production, water quality, soil chemistry, and manure management. Furthermore, students should evaluate the appropriate role of government and industry in assisting Mr. Pritchard to protect the environment while remaining a profitable swine producer.

During the past 20 years the trends in the swine production have been moving toward increasing size and number of large confined animal feeding operations (CAFOs). Although CAFOs may have potential economic advantages, there are rising concerns about their long-term environmental impacts; specifically regarding the management of large amounts of manure-based nutrients that accumulate on the farms. To reduce possible environmental impacts, land application of animal manure is regulated based on the nutrient content of the manure. The Natural Resource Conservation Service (NRCS) has updated its Nutrient Management Conservation Practice Standard (Code 590) to include nutrient management guidelines for P (NRCS, 1999). The updated standard recommendations are that annual P application should not exceed the amount of P removed by the growing crop when there is risk for P loss to surface water. Many states, including North Carolina, have adopted the NRCS Nutrient Management Conservation Practice Standard as the basis for issuing permits to CAFOs. During the next 5 to 10 years, producers will need to comply with these new regulations, a change requiring them to re-evaluate their nutrient management practices.

This case study highlights the decisions faced by a typical swine producer who is concerned about the accumulation of P on his farm in relation to new regulations for manure management. The data

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presented in this case are from personal interviews, soil and lagoon liquid analysis, and farm records of lagoon liquid application, crop production, and swine production.

## THE CASE

Mr. Pritchard owns and operates two adjacent swine farms in Sampson County, North Carolina, each with 4500 swine. The *old farm* was established in the early 1970s and the *new farm* was established in 1996. The two farms are operated in much the same way, with the main difference being the age of the farm. Swine manure is treated in anaerobic lagoons and excess lagoon liquid is irrigated onto adjacent crop land to meet the N requirement of the growing crops. However, recent changes in the regulations have prompted Mr. Pritchard to evaluate the risk of P loss from fields receiving swine lagoon liquid. If there is a high risk of P loss, he will need to apply the lagoon liquid based on the P removal of the growing crop. A high P loss rating could easily affect the profitability of his farms as well as the overall value of the farm when he decides to sell it. Therefore, Mr. Pritchard has decided to immediately re-evaluate his current nutrient management plan to determine if he can reduce the rate of P accumulation in soils of fields receiving lagoon liquid.

## General Farm Operation

Like most of the swine producers in the area, Mr. Pritchard contracts with a large swine integrator that supplies him with piglets (20 kg), animal feed, and veterinary services. Mr. Pritchard is responsible for the daily management of the farm, such as caring for the pigs, maintaining the physical facilities, and managing the manure. After 140 days, the integrator returns to Mr. Pritchard's farm and picks up the grown pigs (approximately 106 kg). Mr. Pritchard is paid by the integrator according to the hog weight gain during the time that he cared for the animals. This type of production system is commonly referred to as a *grower-finisher operation*. In the surrounding region, more than 20 million swine are produced each year.

Both farms have several swine houses, which each hold 700 to 1000 swine. Swine manure is removed once or twice a week from cement pits under the swine houses using recycled flush water (Exhibit 1). Manure from the houses is flushed to an open-pit anaerobic lagoon, where most of the organic components are removed through anaerobic digestion (conversion to CO<sub>2</sub> and CH<sub>4</sub>) and settling. Stabilized organic components and other solids settle in the lagoon to form a sludge layer, which is removed from the lagoon every 10 to 15 years and applied to nearby cropland (Mikkelsen, 2000a). An average annual excess of 12,900 m<sup>3</sup> of lagoon liquid, or effluent (<10 g L<sup>-1</sup> solids), containing 3970 kg plant-available N (PAN) and 1170 kg P, is irrigated from each lagoon onto adjacent fields to meet the N requirement of the crop, growing primarily on a Norfolk loamy sand (fine-loamy, kaolinitic, thermic Typic Kandudults; Exhibit 2).

The nutrient flux for the waste application fields depends on the cropping system on the two farms (Exhibit 3). Mr. Pritchard grows

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**Abbreviations:** BMPs, best management practices; CAFOs, confined animal feeding operations; HAP, high available phosphorus; M3-P, Mehlich-3 extractable P; NRCS, Natural Resource Conservation Service; PAN, plant-available nitrogen; PLAT, Phosphorus Loss Assessment Tool; RYE, realistic yield expectations; SERA-17, Southern Extension–Research Activity Information Exchange Group 17.

**Exhibit 1. Average chemical composition of lagoon liquid from Mr. Pritchard's swine manure treatment lagoons compared with statewide average chemical composition of lagoon liquid and lagoon sludge.**

Source	N†	P	K	Ca	Mg	S	Mn	Zn	Cu
	mg L <sup>-1</sup>								
Mr. Pritchard's lagoon liquid	625	92	888	110	25	31	0.4	1.2	0.4
Avg. lagoon liquid‡	563	98	484	122	40	34	0.9	3.1	1.2
Avg. sludge‡	2926	14437	942	2838	818	593	36	94	36

† Total N; the plant-available N (PAN) is determined by multiplying total N content by an availability coefficient of 0.5 when swine lagoon liquid is applied through sprinkler irrigation, or 0.6 for lagoon sludge injected or incorporated into the soil.

‡ Barker et al., 1994.

**Exhibit 2. Soil profile description of Norfolk loamy sand (Typic Kandiuults), the dominant soil series in Mr. Pritchard's fields.**

Horizon	Depth cm	Description
Ap	0–23	grayish brown loamy sand; weak fine and medium granular structure; very friable; strongly acid
E	23–36	light yellowish brown loamy sand; weak medium granular structure; very friable; strongly acid
Bt	36–178	yellowish brown sandy clay loam; weak medium subangular blocky structure; friable; strongly acid
BC	178–208	mottled brownish yellow, strong brown, and yellowish red sandy clay loam; weak medium subangular blocky structure; friable; strongly acid
C	208–254	mottled red, strong brown, brownish yellow, and gray sandy clay loam; massive; friable; strongly acid

**Exhibit 3. Average nutrient concentrations and realistic yield expectations (RYE) for selected field crops and forages grown on a Norfolk Sandy loam soil in North Carolina (adapted from Zublena, 1991).**

Crop	Realistic yield expectation†	N requirement‡	Nutrient conc. in harvested biomass§		
			N	P	K
	kg ha <sup>-1</sup>		g kg <sup>-1</sup>		
Corn grain ( <i>Zea mays</i> L.)	7,220	150	16.1	2.8	4.0
Oat grain ( <i>Avena sativa</i> L.)	3,660	130	19.5	3.4	4.9
Wheat grain ( <i>Triticum aestivum</i> L.)	4,040	140	20.8	4.5	5.2
Soybean [ <i>Glycine max</i> (L.) Merr.]	2,820	180	62.7	6.0	20.5
Tobacco ( <i>Nicotiana tabacum</i> L.)	3,700	110	28.3	2.2	42.9
Coastal bermuda hay¶ ( <i>Cynodon dactylon</i> L.)	17,930	400	25.0	2.5	17.9
Coastal bermuda pasture¶ ( <i>Cynodon dactylon</i> L.)	13,450	300			
Tall fescue ( <i>Festuca arundinacea</i> Schreb.)	7,850	180	19.3	4.1	21.9
Perennial ryegrass ( <i>Lolium perenne</i> L.)	11,210	250	21.5	3.7	19.9

† RYE are for crops at the following moisture contents: corn, 15.5%; oat, 14%; wheat, 13.5%; soybean, 13%; tobacco and forages, 0%.

‡ Recommended N application based on RYE.

§ Nutrient concentrations are for crops with above-mentioned moisture contents.

¶ Overseeded with a winter annual grass.

coastal bermudagrass (*Cynodon dactylon* L.) on the majority of his cropland (Exhibit 4), with some fields grazed and others cut for hay. In addition to the bermudagrass hay and pasture, Mr. Pritchard grows a forage rotation that includes oat (*Avena sativa* L.), rye (*Secale cereale* L.) and sudangrass [*Sorghum bicolor* (L.) Moench]. On the old farm, a few fields are planted in a 3-year rotation of corn (*Zea mays* L.), tobacco (*Nicotiana tabacum* L.), and soybean [*Glycine max* (L.) Merr.]. Each cropping system requires different amounts of N and therefore receives different amounts of P. Irrigated lagoon liquid is the only P import to the annual crops, while P imports to the bermudagrass pasture include lagoon liquid and stocked cattle. The only P export from the pasture is in the cattle. Bermudagrass hay, annual forage, and bermudagrass pasture cropping systems remove 42, 25, and 10% of the applied P, respectively (Exhibit 5).

Anaerobic swine lagoon liquid has a PAN/P ratio (3:1) that exceeds the typical crop biomass N/P ratio (8:1). As illustrated in Exhibit 5, whenever anaerobic swine lagoon liquid is applied to meet crop N requirements, P is simultaneously over-applied by two to three times. The continued application of P in excess of crop needs has increased the soil test P levels well beyond the requirement for crop growth (Exhibit 4).

### Nutrient Management

The manure-derived nutrients from swine production help increase the profitability of Mr. Pritchard's crop and cattle production.

The ready supply of nutrients for his pasture and hay fields helps to maintain maximum productivity, thereby eliminating the need to buy hay throughout the winter months and the need to buy fertilizer. Although excess P will not harm the crops, it could pose risks to aquatic environments if it moves to surface water by runoff, leaching, or erosion. Several research reports have documented that increased dissolved P losses in runoff water are directly related to high soil P concentrations in the fields even when erosion is not a primary loss pathway (Cox and Hendricks, 2000; Sharpley et al., 1994).

Soil P concentration is not the only factor affecting P loss from the effluent application fields. Erosion rate, runoff volume, soil type, manure application rate and method, and riparian buffer width are all factors that affect P transport from the field to surface water (Sharpley et al., 2003). The North Carolina Phosphorus Loss Assessment Tool (PLAT) incorporates all these factors into a simplified model that rates the risk of P loss from agricultural fields from 1 to 100, with 100 representing the greatest risk (Osmond et al., 2003). If the P-loss index exceeds 50, then future P additions cannot exceed P removal by the crop (known as P-based application). The PLAT rating for a field is the sum of P loss risk ratings for the following four loss pathways: erosion P, or P lost through erosion; runoff P, or P desorbed from soil to runoff; leachable P, or P lost below 75 cm through leaching; and source P, or P lost directly from a P source (fertilizer or manure) to the runoff water. Each rating combines the quantity of P available for transport with a transport factor, such as

**Exhibit 4. Rotations, soil test P, and P loss ratings for lagoon liquid application fields on Mr. Pritchard's two swine farms (new and old).**

Field ID	Area	Rotation	Erosion rate†	Surface M3-P‡	Runoff volume§	DRP¶ in runoff	PLAT rating of P loss risk#				
							index				Total
			Mg ha <sup>-1</sup> yr <sup>-1</sup>	mg kg <sup>-1</sup>	cm ha <sup>-1</sup> yr <sup>-1</sup>	mg L <sup>-1</sup>					
<u>New farm</u>											
C01	6.3	bermudagrass hay	0.1	160	0.4	0.8	0	1	0	1	2
C02	1.1	bermudagrass hay	0.0	123	0.4	0.6	0	1	0	1	2
C03	1.8	winter annual/summer annual grazing	1.9	68	2.1	0.3	0	2	0	3	5
C04	2.2	permanent pasture	0.0	176	2.1	0.9	0	4	0	3	7
C05	1.9	permanent pasture	0.0	112	2.1	0.6	0	3	0	3	6
<u>Old farm</u>											
T05	5.5	permanent pasture	0.0	315	0.8	3.1	0	5	3	1	9
T06	3.6	winter annual/summer annual grazing	1.9	259	0.8	2.6	1	4	3	1	9
T07	6.2	tobacco, corn, soybeans (conv. tillage)	3.3	267	7.9	1.3	4	24	3	15	46
T08	7.7	tobacco, corn, soybeans (conv. tillage)	3.3	202	7.9	1.0	1	18	3	14	36
T09	4.4	permanent pasture	0.1	156	0.8	1.6	0	3	0	1	4
T10	3.6	winter annual/summer annual grazing	2.5	248	0.8	2.5	1	4	3	1	9

† Determined using the Revised Universal Soil Loss Equation (RUSLE).

‡ Sampled 0 to 20 cm. Crop response to P fertilizer is not expected for soil tests >60 mg Mehlich-3 extractable P (M3-P) kg<sup>-1</sup> soil. Unfertilized soil on the farm contains <5 mg M3-P kg<sup>-1</sup>.

§ Determined using the NRCS curve number method.

¶ DRP, dissolved reactive phosphorus, determined as a function of soil type and surface M3-P concentration.

# Ratings are as follows: 0 to 25, low; 25 to 50, medium; 50 to 100, high; >100, very high.

**Exhibit 5. Average annual P flux for Mr. Pritchard's lagoon liquid application fields on the new farm.**

Phosphorus flux and storage	Bermudagrass hay	Oat	Bermudagrass pasture
Area, ha	7.4	2.2	3.5
Lagoon liquid application rate, m <sup>3</sup> ha <sup>-1</sup>	1150	220	1050
Cattle stocking rate, head ha <sup>-1</sup>	0	0	30
P imports from lagoon liquid, kg ha <sup>-1</sup>	+106	+20	+97
P imports from cattle, kg ha <sup>-1</sup>	+0	+0	+48
P exports, kg ha <sup>-1</sup>	-45	-5	-58
Surplus P, kg ha <sup>-1</sup>	61	15	87

runoff or erosion. Listing the four parts of a PLAT rating allows the producer to target conservation strategies toward pathways with the highest risk for P loss. For example, a high source P index could be lowered by changing P application method, P application rate, or reducing transport factors (runoff or erosion). The PLAT ratings for two of Mr. Pritchard's effluent application fields on the old farm are nearing the P-based application threshold of 50 (Exhibit 4).

Switching to a P-based effluent application plan could easily decrease the profitability of Mr. Pritchard's swine farms since it would require additional land and irrigation equipment to apply the lagoon liquid to new fields. Furthermore, he would need to purchase supplemental N fertilizer for crops that had previously been receiving the full N requirement from lagoon liquid. He may also have to switch to less profitable cropping patterns.

### Phosphorus Budget

A P budget was constructed to quantify P imports and exports from the swine houses, lagoon, and effluent application fields for the new farm (Exhibit 6). The P flux for the swine barns consists of imports from piglets and feed while exports consist of live hogs, dead pigs (mortality), and manure. Because the swine houses are completely cleaned before receiving new piglets, all excess P moves to the lagoon. The budget shows that 40% of the P entering the barns leaves in the exported hogs and the remaining 60% goes to the lagoon (Exhibit 7).

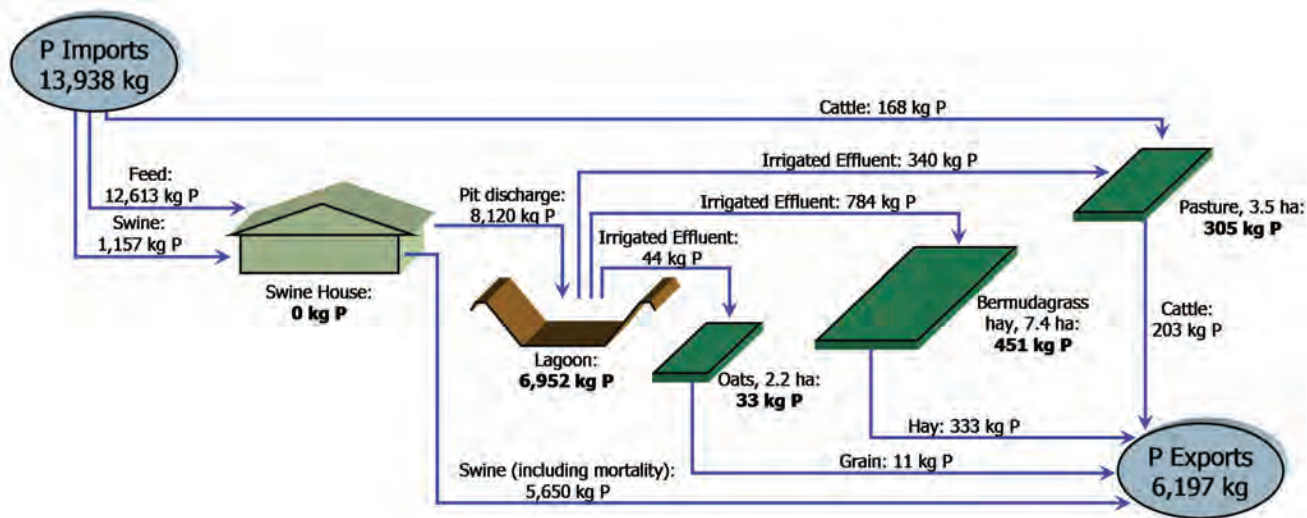
Phosphorus in the lagoon occurs in two fractions, the lagoon liquid (mostly dissolved inorganic P) and the lagoon sludge (mostly

organic and particulate-bound P). On average, only 14% of the P entering the lagoon is removed with the effluent, leaving 86% of the P to accumulate in the sludge (Exhibit 8). Although this sludge is not of immediate concern, it must be cleaned out and land-applied every 10 to 15 years. On average, 0.003 m<sup>3</sup> of sludge accumulates in the lagoon each year per kilogram live animal weight on the farm (Bicudo et al., 1999). Estimating average animal weight of 63 kg, Mr. Pritchard's farms would each accumulate approximately 850 m<sup>3</sup> of sludge per year.

In summary, swine feed is the main P input to the farm, and mature swine are the main P export. However, swine only export 40% of the P imported in the feed and crops export less than 3% of total P inputs. A closer look at the feed reveals that nearly two-thirds of the P in corn-soybean-based feed is in an organic P complex called phytate that passes largely undigested through the swine (Ertl et al., 1998; Jongbloed and Kemme, 1990). Because phytate-P is unavailable for swine, the feed is supplemented with approximately 2 g inorganic P kg<sup>-1</sup> feed. This P supplementation to the swine feed accounts for nearly 4760 kg of P imported onto Mr. Pritchard's farm each year.

### DECISION

Both the soil concentrations and the P budget indicate that P is rapidly accumulating on Mr. Pritchard's farms. Although only a few fields are currently approaching high risk for P loss, Mr. Pritchard is very concerned about the long-term sustainability of his present nutrient management practices. He worries that he might be degrad-



**Exhibit 6. Average annual mass balance phosphorus budget for Mr. Pritchard's new swine farm (bold numbers represent net annual P accumulation for each P sink).**

ing the future value of his farms by what he is currently doing. What actions would you recommend he take to decrease the risk of P loss and/or slow P accumulation in his effluent application fields? Can you balance the P budget of this swine farm?

### TEACHING NOTE

#### Case Objectives

This case should be used to teach students about soil fertility, crop management, manure management, animal science, nonpoint-source pollution, nutrient cycling, and sustainable agricultural production on a farm scale. This case emphasizes multidisciplinary problem solving skills and the interconnections between local- and regional-scale agricultural production systems. Students should learn to identify the long-term impacts resulting from the changes in agricultural production systems and markets. Students can also extend their analysis to more complex issues such as regulatory control of local agricultural practices.

#### Use of the Case

#### Stimulant Questions

1. Is the P accumulation on Mr. Pritchard's land a significant agronomic or environmental concern?
2. What changes, if any, should Mr. Pritchard make in his nutrient management and cropping system to bring on-farm nutrient inputs and outputs closer together?
3. Is continual nutrient over-application and accumulation a sustainable agricultural practice? Does this depend on the nutrient characteristics and soil management practices?

**Exhibit 7. Average annual P flux in Mr. Pritchard's swine houses.**

Source	P content	P flux, kg
<u>Imports</u>		
10,824 piglets	0.10692 kg P head <sup>-1</sup>	+1,157
2,378,895 kg feed	0.005302 kg P kg <sup>-1</sup>	+12,613
<u>Exports</u>		
10,407 live pigs	0.52894 kg P head <sup>-1</sup>	-5,505
417 dead pigs	0.34698 kg P head <sup>-1</sup>	-145
Surplus (to lagoon)		+8,120

4. What are the long-term environmental, economic, and social impacts of farm- and regional-scale P accumulation?
5. Should Mr. Pritchard be allowed to manage nutrients without regulatory interference?
6. What realistic practices can Mr. Pritchard implement (both short- and long-term) to reduce P input to his farms?
7. Currently the only P exports are in mature swine, grazing cattle, and harvested crops. Are there other ways Mr. Pritchard can increase P export from his farm?
8. What role should integrators and government regulatory agencies take in minimizing P accumulation on CAFOs? Who should pay for the expenses associated with possible changes in nutrient management?

#### Teaching Aids

An internet website containing additional information about this case (including maps, photos, and a video interview with Mr. Pritchard on his farm) has been set up at <http://courses.soil.ncsu.edu/ssc342/CaseStudy/index.htm> (verified 29 Aug. 2005). These materials may also be obtained by directly contacting the authors. The video is particularly useful for familiarizing students with the farm operation and a production viewpoint on nutrient management.

Because direct suggestions on methods of addressing issues discussed have been reserved for the Author's Analysis and Interpretation section, some students may benefit from additional information pertaining to best management practices (BMPs) to control P loss. A series of P loss BMP fact sheets have been developed by the Southern Extension-Research Activity Information Exchange Group 17 (SERA-17) and are available on the internet at [www.sera17.ext](http://www.sera17.ext).



**Exhibit 8. Average annual P flux in Mr. Pritchard's anaerobic swine manure treatment lagoon.**

Source	P content	P flux, kg
Surplus P leaving swine houses	Imports	
	NA†	+8,120
12,700 m <sup>3</sup> irrigated lagoon liquid	Exports	
	92 mg L <sup>-1</sup>	-1,168
Surplus (accumulation in sludge)		+6,952

† Not available.

vt.edu (verified 29 Aug. 2005). Fact sheets particularly pertinent to this case study include Smith and Joern (2005), discussing methods to reduce P solubility in lagoon liquid; and Smith (2005), discussing reduction of feed P concentrations.

### Author's Analysis and Interpretation

Mr. Pritchard's new farm accumulates an average of 55% of the imported P, or a total of 7741 kg P yr<sup>-1</sup>. The majority (86%) of the P accumulates in the sludge with the remainder largely accumulating in the soil of the irrigated fields. Looking at the P flux for each operation of the farm reveals some important points for balancing the nutrient budget. First, swine feed is the largest source of P entering the farm and only 40% of the feed P is exported in the mature swine. Second, soil P concentrations in the effluent application fields of Mr. Pritchard's old farm are double the already high soil test P in the newer farm, thus suggesting the long-term accumulation of P, which will result from continued lagoon liquid applications. The lagoons will soon require that sludge be removed, at which point he must address the disposition of a large amount of stored P. He will have to dispose of perhaps as much as 70 Mg of P (typically irrigated onto adjacent cropland or hauled in trucks to nearby fields and applied to meet the N needs of the growing crop).

Large nutrient accumulations are not uncommon in other CAFOs such as poultry, beef feed lots, and many dairies. This case study focuses on the farm-scale P imbalance; however, CAFO nutrient imbalances also exist on the regional scale. The CAFO operations frequently become locally concentrated for economic efficiency and the feed is often brought in from outside the region. For example, two neighboring North Carolina counties, Sampson and Duplin, contain 7.2 million broilers (*Gallus domesticus*), 3.9 million swine, and 5.8 million turkeys (*Melleagris gallopavo*). These same counties only have 107,160 ha of cropland on which to apply the manure-based nutrients (North Carolina State University, 2000). The majority of the feed-based nutrients are imported from other states where the crops are grown with mineral fertilizers, creating a continual influx of nutrients to this region. Students should be able to identify that nutrient imbalances are not sustainable in the long-term. Although Mr. Pritchard's options may appear to be limited, students should creatively explore industry-wide changes that may be useful.

Options for balancing the P budget on the farm consist of either decreasing the P imports (mainly in the feed) or increasing the quantity of P exported from the farm. Since the integrator supplies the feed formulated for maximum swine growth (supplemented with inorganic P), this is not a factor that Mr. Pritchard currently controls. Increasing the digestibility of phytate-P present in feed grain would reduce the need for inorganic P supplementation. The digestibility of phytate-P in grain-based feed can be increased by adding phytase, a microbially derived enzyme that hydrolyzes the phytate-bound P. Studies have shown that the addition of phytase to a corn-soybean meal diet can increase the digestible P by as much as 1 g kg<sup>-1</sup> (Beers and Jongbloed, 1992). Another method of increasing the digestibility of P in swine feed is by the use of high available P (HAP) corn, also known as low-phytate corn. The HAP corn is a genetically mutated corn variety that has 65% less phytic acid than traditional corn with a corresponding molar increase in available P (Ertl et al., 1998). Low-phytate soybean plants are also being developed (Olt-

mans et al., 2004). Using such technology, it may be possible to greatly reduce or even eliminate the need for feed supplementation with inorganic P.

Phosphorus loading to cropland could be reduced by precipitating and recovering P from the lagoon liquid. A common method of P removal used by municipal waste treatment plants is the precipitation of Ca- or Al-phosphates. This method could work for swine lagoon liquid also, although the precipitation process relies on chemical amendments and produces a sludge that requires disposal. Another less common method of P removal from wastewater is precipitation of P-containing minerals such as magnesium ammonium phosphate (MgNH<sub>4</sub>PO<sub>4</sub>·6H<sub>2</sub>O; struvite). Struvite precipitation is advantageous compared with other forms of P removal from lagoon effluent because the precipitation requires fewer chemicals and the product can potentially be sold as a slow-release fertilizer (Wrigley et al., 1992; Bridger et al., 1962). Research has shown that struvite precipitation has the potential to reduce P concentration in anaerobic swine lagoon liquid to 2 mg L<sup>-1</sup> (Nelson et al., 2003). Struvite precipitation has had only limited field-scale evaluation in the swine industry. Struvite could possibly be sold as a value-added waste product, thereby removing the P from the farm and possibly generating income to help offset the additional lagoon liquid treatment costs.

A less expensive but short-term solution to reduce the risk of P loss from fields is to stabilize the P in the soil. Land application of various materials high in Ca, Fe, or Al (such as drinking water treatment residuals, alum, or other industrial waste products) will decrease P solubility and thus reduce P concentrations in runoff (Gallimore et al., 1999; Haustein et al., 2000; Elliott et al., 2002). Because drinking water treatment residuals, which contain Al, Fe, and/or Ca, are currently disposed of in landfills, they may be available at minimal cost to farmers. This will not change the overall P budget, but it has potential to temporarily reduce the risk of P loss to surface waters. The long-term stability of the Al-, Fe-, or Ca-phosphate minerals in these acidic soils remains an important consideration when using this technique to remediate high P conditions. Calcium phosphates would not be stable at low pH (Lindsay, 1979). Initial research suggests that Al-phosphate complexes formed in alum-treated chicken litter would be stable for long periods (Peak et al., 2002). However, there is a lack of long-term data to support this. Students may discuss the benefits of short-term solutions compared with achieving a long-term balanced P budget.

The students will benefit from a discussion of this situation from a regulatory standpoint. The imposition of mandatory P-based manure application would be a major financial burden for Mr. Pritchard and other CAFO operators in the area, and could possibly put them out of business. The Norfolk loamy sand is a common soil used for agricultural production in the southeastern U.S. Coastal Plain with a high (>7.5 cm h<sup>-1</sup>) infiltration capacity. This soil has minimal erosion and runoff when planted into permanent grass. The sandy clay loam subsoil will likely provide sufficient adsorption capacity to minimize P leaching. The PLAT model currently used to rate the risk of P environmental impacts is science based, but largely unproven and these model predictions vary considerably from state to state. Should the farmer be forced to change management practices before all the scientific studies have been completed?

This case study can be customized by discussing animal production practices in the student's local area. Students could develop a nutrient budget for local dairies, feedlots, or poultry farms (e.g., Tarkalson and Mikkelsen, 2003). Focus could be placed on other nutrients, such as Cu and Zn that also may accumulate in effluent application fields (Mikkelsen, 2000b). This case should be used with these and other questions to impress upon students the essential role of nutrient management planning in sustainable animal production.

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### About the author...

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Nathan O. Nelson is currently a soil scientist at the USDA-ARS in Kimberly, ID; and as of 1 Nov. 2005 will be assistant professor, at the Kansas State University, Manhattan, KS. Dr. Nelson believes case studies bring real situations into the classroom, allowing students to think through complex problems and come up with a variety of solutions. Solutions to case studies are often multidisciplinary, thereby allowing students to draw on their own backgrounds and ideas. He adds, "I prefer offering minimal guidance in solving problems presented in the case, which gives students greater ownership in the solutions they develop. I have observed that students respond positively to case studies and ask questions that extend beyond the presented material, thus showing their expanded interest in the subject matter."