Leopold Center

FOR SUSTAINABLE AGRICULTURE

1990 ANNUAL REPORT

1990 Advisory Board

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From the Director

It was a very good year. In 1990, the Leopold Center for Sustainable Agriculture completed its third peer-reviewed competitive grants program, started two new research teams, hired Richard Pirog to coordinate educational programs, and held its first annual conference.

The Center invested a considerable amount of its funding into competitive research and educational grants. Nearly $1 million was spent on 40 innovative projects. The interdisciplinary research teams of scientists, farmers, and conservationists also made great headway in 1990. Four teams were aggressive in their research and educational activities during the year, and some have received significant additional funds to augment their Center-sponsored research.

The Leopold Center depends on cooperation and shared responsibilities with state universities and colleges, especially Iowa State University. The interaction between the Leopold Center and ISU's College of Agriculture has permitted both units to rapidly advance research into the critical issues facing Iowa agriculture. The Center also is encouraged about its current and future educational programs with the Cooperative Extension Service.

The close working relationships among the Leopold Center and the Department of Agriculture and Land Stewardship and the Department of Natural Resources allows cooperative programs to be built without overlapping similar work, which oftentimes accompanies environmental research and education agendas.

In early 1990, we moved the Center's expanding operations to the National Soil Tilth Laboratory. The laboratory is governed by the U.S. Department of Agriculture, Agricultural Research Service, and is an excellent place for the Leopold Center. Dr. Jerry Hatfield directs the laboratory's progressive interdisciplinary program in environmental research releated to soils and groundwater, and the Center works with several of the researchers.

Sustainable agriculture became a barnyard word in Iowa and across the nation in 1990. Its many synonyms not only appeared in the farm press, but also surfaced in national newspapers and magazines. The committee report, *Alternative Agriculture*, of the National Academy of Science's Board on Agriculture (chaired by Dr. John Pesek, former head of ISU's agronomy department) was widely reviewed and helped focus the debate on the future of agriculture in America.

Last year I wrote: "Obviously sustainable agriculture is a journey, not a destination. But it's a journey well worth taking."

The journey still continues, but the way has become clearer.

Dennis R. Keeney
Director

Aldo Leopold (1887-1948), conservationist, ecologist, and educator, for whom the Center is named.

From the Chair of the Advisory Board

As the Leopold Center completed its third year, its value and significance for the state of Iowa became clearer every day. Passage of the 1990 federal farm bill with its strong environmental protection provisions and rapidly advancing public environmental concerns combined to bring sustainable agriculture to the forefront of national attention.

The work and reputation of the Center have unquestionably placed Iowa in the vanguard of research and development on this important subject, helping create untold opportunities for expanding federal research efforts in Iowa. The credit for helping invigorate and refocus the state's agricultural research efforts on sustainability must go to Dr. Dennis Keeney and the staff of the Leopold Center, as well as to the dozens of researchers at ISU and throughout Iowa working under Center funding. These individuals are seizing the opportunity to develop new scientific knowledge and understanding that will allow us to continue farming our productive lands in harmony with nature for generations to come.

We are now beginning to reap the early harvest of the fruits of the Center's research, such as the cost savings farmers can gain by using the late-spring soil nitrogen test. As each year adds to the body of Leopold Center-funded research, the true promise of the Center becomes clearer. This report shows the content of that research and reveals the promise of new knowledge and insight yet to come.

Neil D. Hamilton
Director, Agricultural Law Center, and Richard M. and Anita Calkins Distinguished Professor of Law, Drake University, Des Moines, Iowa

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Leopold Center

for Sustainable Agriculture

For the land and its people

The love of the land is what drives the sustainable agriculture movement. Caring for the land helps keep farmers' resources rich and available far into the future. And land conservation helps water run clear and gives food and shelter for wildlife.

Moving to more efficient and natural ways of land stewardship is what sustainable production is all about. Farmers can reduce their need for purchased chemicals without cutting profits.

That's why the state legislature created the Leopold Center in 1987—to help farmers make money while they conserve their natural resources.

The Center's research findings and ideas have spread throughout Iowa. This report is about the Center's third year and how it is helping to solve difficult problems that face Iowa agriculture.

Working within an annual budget of about $1.5 million, the Leopold Center funds various projects that deal with sustainable farming, such as water quality, crop and livestock management, biological pest control, forestry, wildlife biology, energy production and use, animal health, soil fertility, and social and economical implications.

The Center has two research programs—competitive grants and interdisciplinary research teams—and is building a strong cooperative educational program.

The Leopold Center develops profitable farming systems that conserve natural resources through programs of basic and applied research, education, and demonstration.

About the Leopold Center

The Leopold Center for Sustainable Agriculture seeks to identify and reduce adverse environmental and socioeconomic impacts of farming practices, develop profitable farming systems that conserve natural resources, and create educational programs with the Cooperative Extension Service. It was established by the landmark Iowa Groundwater Protection Act of 1987 (Iowa Code 1987, Section 266.39).

Competitive Grants

Through competitive grants, the Center supports research and demonstration projects throughout the state. In its first three years, it funded $2.3 million in 55 grants at 11 institutions and nonprofit organizations in Iowa. Oftentimes, Leopold Center grants are seed money to launch sizable research projects that attract additional funds from colleges, universities, and state agencies in Iowa; from federal agencies, such as the U.S. Department of Agriculture and the U.S. Environmental Protection Agency; and from private foundations, such as the Northwest Area Foundation.

After evaluation by more than 100 peer reviewers, awards were announced in April 1990 for 16 renewals and 24 new projects. They totalled $989,781 and ranged from $3,650 to $62,790.

Crop rotations can increase yields and reduce pest problems. Corn, soybeans, and oats were planted in narrow, adjoining strips as part of the Center's work on new cropping systems.

Educational programs reach a wide variety of audiences throughout Iowa.

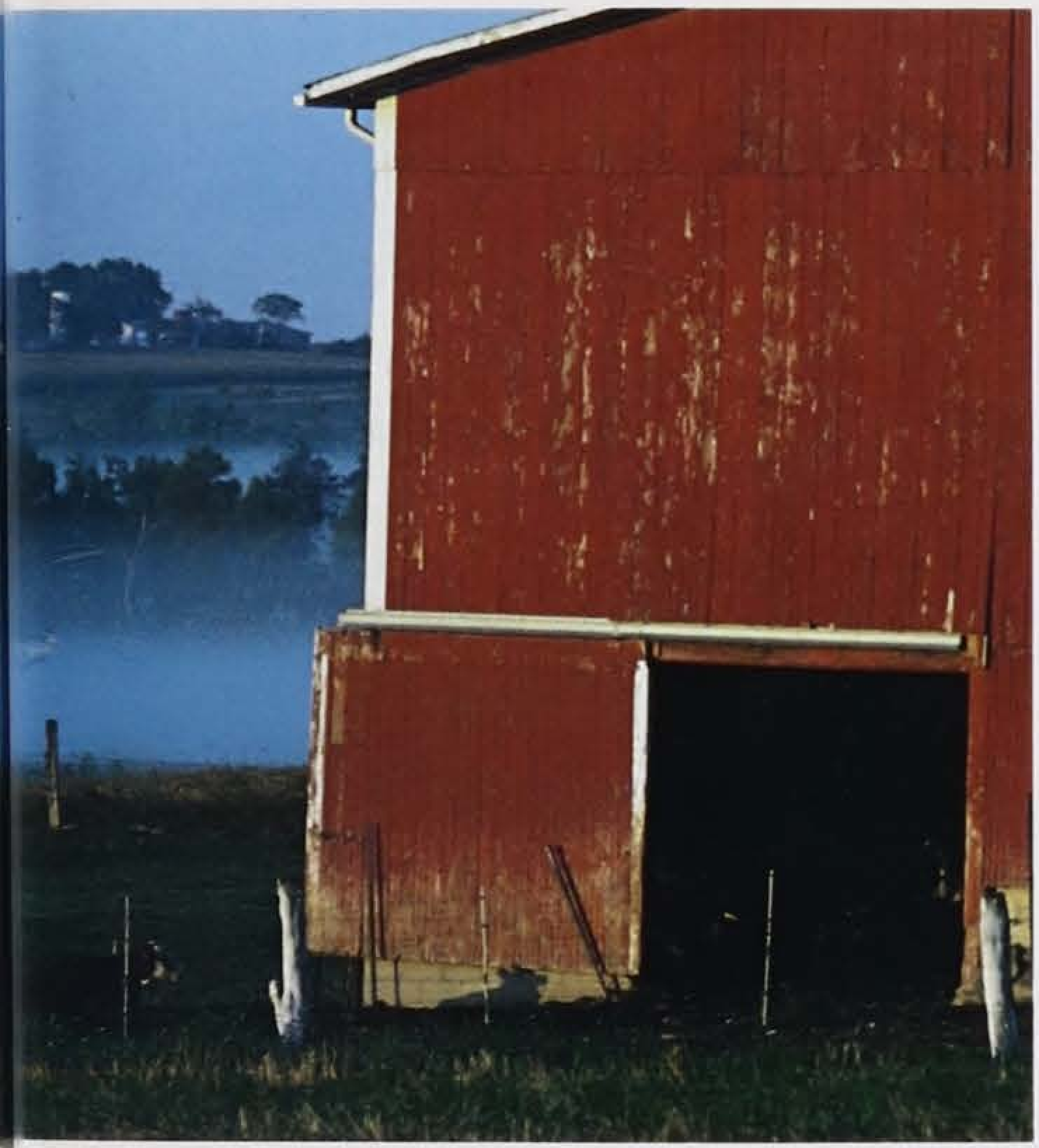
Interdisciplinary Research Teams

The Center's interdisciplinary research teams, which began in fiscal year 1990, attempt to bring the variables in farming together. In 1990, four research teams studied cropping systems, socioeconomic aspects of sustainable farming, grazing and forages, and biological controls of alfalfa pests.

These working teams draw together researchers from Iowa's colleges and universities, farmers, and conservationists. Each team is conducting long-term analyses of problems facing people living on farms and in rural communities. From there, the teams will begin to help solve these problems and those to come.

Education and Demonstration

The Center conducts educational programs based on its research findings. With help from the Iowa Cooperative Extension Service and other



agencies and organizations in Iowa, educational programs reach farmers, extension personnel, conservationists, nonprofit groups, agricultural chemical dealers and applicators, community colleges and students, and agricultural lenders.

Administration

The staff of the Leopold Center now includes the director, assistant director, associate director, educational coordinator, information specialist, research associate, secretary, and account clerk. The core staff is located in the U.S. Department of Agriculture's National Soil Tilth Laboratory on the campus of Iowa State University.

A 13-member advisory board, established by the groundwater law, has members from Iowa's three state universities, private colleges and universities in Iowa, the Iowa Department of Natural Resources, the Iowa Department of Agriculture and Land Stewardship, and the farming community.

Up Next

In addition to a new year of competitive grants, three more interdisciplinary research teams will start in 1991. They will study animal-waste management, weed management, and agroecosystems.

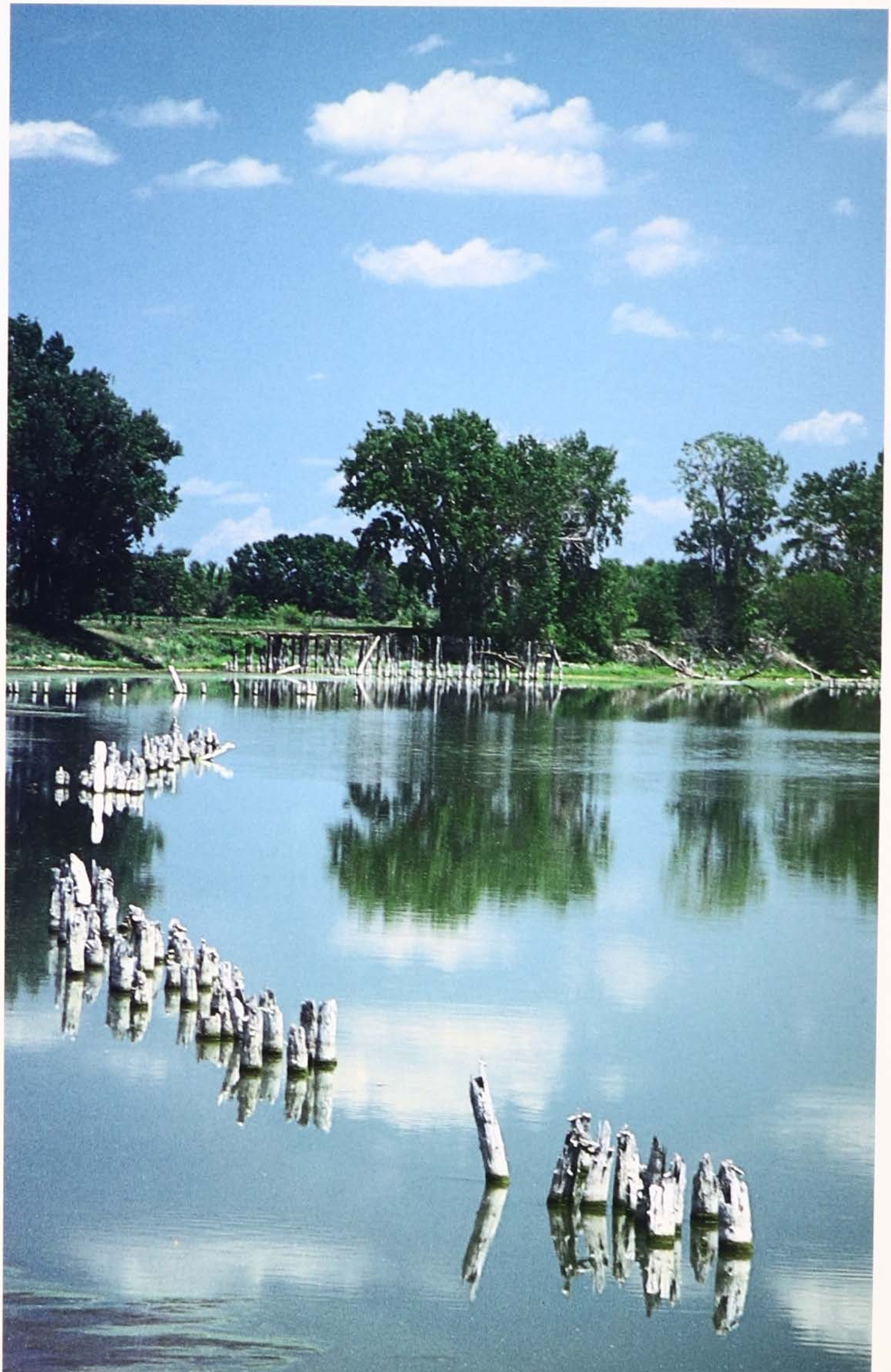
The Center will be working to attract new sources of funding to expand its research in resource-conserving agriculture.

The final results are in from the Center's first round of research projects. They will be released in technical and non-technical reports.

Education and information campaigns, particularly with Extension, will be expanded. In addition, the Center will increase collaborative work with state and federal agencies, as well as with nonprofit groups.

Research on farms across Iowa studies specific relationships between agriculture and the ecosystem.

Many of the Center's projects assess agriculture's impact on water quality.



Public Education

The why of sustainable agriculture is easily understood. The how is much harder.

That's why the Leopold Center is dedicated to taking its research findings to Iowans who need them most—people living on farms and in rural communities.

The Center is developing educational programs and packages to help Iowa farmers, youth, and local agricultural businesses adopt and adapt sustainable farming concepts and practices.

It will take time and a lot of applicable information and technology before sustainable agriculture will become commonplace on Iowa farms. It also will take a deliberate process of education and on-farm trials before most farmers will trust new technologies and alternative practices. The Center knows the risks that farmers face, and it is targeting its research and educational programs to help reduce those risks.

Most of the Center's research has an educational arm. More than 30 presentations were part of field days in 1990. Leopold Center projects also attracted 10 tours during the year. Nearly 50 talks on the Center's research were part of workshops and conferences for farmers, agricultural input suppliers, farm consultants, and educators working directly with farmers.

Along with various brochures and publications, several Leopold Center projects sent out weekly or monthly

The Center targets its research and educational programs to help farmers reduce their risks.

The goal of the Center's educational programs is to get working information on sustainable agriculture to Iowans.

newsletters on sustainable farming. Researchers shared their findings in other newsletters, magazine and newspaper articles, press conferences, and radio and television spots.

Research results were used to train area and county Extension staff to help them take sustainable techniques to Iowa farmers. In addition, members of the Center's staff and interdisciplinary research teams spoke to gatherings of farmers, farm interest groups, and government agency representatives throughout the year.

Field days and tours

The old adage, "You have to see it to believe it," holds true with some sustainable farming practices. In 1990, many of the Center's competitive grant projects were part of field days and tours held on farmers' fields, university experiment stations, college agricultural centers, and even a wildlife refuge.

In September, more than 200 farmers, Extension specialists, and scientists went to a field day to see the effects of various tillage and crop rotations on groundwater quality. The study is at ISU's Northeast Research Center near Nashua.

Buffer strips were planted along crop

fields to protect surface water and remove groundwater contaminants on the site of the 1990 Farm Progress Show in Amana, which drew thousands of Midwestern farmers and their families.

Five field days on nitrogen management and water quality from two Leopold Center studies were held in northwest Iowa by Extension specialists and researchers at Dordt College.

The Center's projects on weed population in ridge-tilled soybeans, northern corn rootworm management, environmental effects of contrasting farming systems, and strip intercropping were part of on-farm field days sponsored by the Practical Farmers of Iowa.

Demonstration projects show that farming with nature can be practical and profitable.

Showing how to farm with nature

The Center's demonstration project at the DeSoto National Wildlife Refuge in southwestern Iowa hosted several tours in 1990, including groups of farmers, students from nearby community and private colleges, and participants in a U.S. Department of Agriculture national conference on sustainable agriculture.

This hands-on project shows how scouting crops, testing soil, and managing crops can be profitable. Two brochures were distributed, and during the growing season, a weekly newsletter was sent to 50 farmers whose fields surround the refuge.

Telephone hotline for farmers

The late-spring soil nitrate test, developed at ISU, is helping Iowa farmers cut back on nitrogen fertilizer without affecting crop yields. To answer farmers' questions about the test, the Leopold Center helped fund a telephone hotline and a question-and-answer publication. In 1990, the Center's research team on socioeconomic aspects began collecting farmers' reactions to the test and how they feel it will affect farm profits and environmental quality.

Farmers often led field demonstrations of Center-sponsored work in 1990.

One Model Farms Demonstration Project on pasture and forage improvement has cooperators on 16 farms.

Farm demonstrations

The Leopold Center helped fund the Model Farms Demonstration Project in south-central and southeastern Iowa. Model Farms is a farm management program led by Extension specialists and supported by the Iowa Department of Agriculture and Land Stewardship and the Iowa Department of Natural Resources.

The south-central project, on pasture and forage improvement, has coopera-

The Iowa Groundwater Protection Act of 1987 defines sustainable agriculture as: "...the appropriate use of crop and livestock systems and agricultural inputs supporting those activities which maintain economic and social viability while preserving the high productivity and quality of Iowa's land."

tors on 16 farms. It had two field days and sent out 11 news releases in 1990. The work in southeastern Iowa has tillage demonstrations on seven cooperators' farms. Eight farm field days were held during the year, drawing nearly 130 local farmers. The project sent out more than 15 press releases and held several local radio call-in programs to spread the word. Both projects have monthly newsletters.

A video was produced to show commercial tomato growers how to reduce fungicide sprays.

Video on reducing fungicides

A video was produced from the Center's work on reducing fungicide sprays in tomatoes. The video, "TOM-CAST in Iowa," explains how to monitor the weather to lower the risk of disease. The video was shown at a workshop for Iowa commercial tomato growers. Copies are available from Iowa area Extension offices and ISU's Media Resources Center in Ames.

"Leopold Letter"

The "Leopold Letter," the Center's quarterly newsletter, grew in both size and quantity in 1990. The "Letter" releases findings of the Center's competitive grants and interdisciplinary research teams and reports on demonstration projects, conferences, and other educational programs directed by the Center.

Thought-provoking essays and technical research reports are mixed in with features by scientists and farmers who are working toward a more sustainable agriculture. The "Letter" also covers issues and events on and off the farm.

Conference Series

The Center's conference series provides an annual forum for sharing ideas and information about profitable farming systems that conserve natural resources and protect the long-term security of the world's food supply. The Center holds a conference each year in February.

In 1990, the Center kicked off its conference series with a two-day meeting on new cropping and livestock management systems. It drew together farmers, researchers, conservationists, and Extension staff to discuss developments in sustainable agriculture.

LEOPOLD CENTER
CONFERENCE SERIES

The first day, farmers and conservationists heard research reports on sustainable cropping and livestock systems. The second day of the conference, farmers explained how they use sustainable practices to lower production costs, maintain crop yields, conserve soil, and minimize agricultural pollution.

The general theme of the meeting was that mainstream farmers are beginning to look at sustainable agriculture, although there are many details to work out. The conference also showed that researchers are making significant steps toward developing sustainable practices that farmers can use.

Nearly 50 research posters and displays were part of the Center's first conference in early February.

Satellite Course

In 1989, the Leopold Center funded a satellite and video course on sustainable agriculture that reached farmers and Extension specialists in Iowa.
Material from that course was revised in 1990 for a class on an agricultural satellite network. The network is a consortium of 34 land-grant universities across the United States.

The course identified major problems in modern-day agriculture and explored possible solutions to the problems. It was produced at Iowa State University. Topics included tillage systems, resource conservation, fertilizers and groundwater, food security, farm policy, farming systems, agricultural economics, agroecology, public health, pesticides, and biotechnology.

Future Programs

In 1991, education and demonstration projects will become a stronger part of the competitive grants. The Center will be directly involved in more local programs and will start a sustainable agriculture fact sheet series with Extension. The Center will add audience evaluations of its educational programs and will step up work with Iowa groups and agencies that teach sustainable farming.

In short, the goal of the Center's educational programs is to get working information on sustainable agriculture to Iowans.

Education and demonstration will become a stronger part of future competitive grants.

Interdisciplinary Research Teams

The animal management team develops year-round grazing systems for beef cattle.

The human systems team studies how sustainable agriculture affects people living on farms and in rural communities.

Farming, by its nature, is an integrated and complex process. The Leopold Center's diverse research teams are of the same nature.

The teams study many aspects of specific farming systems and address how each relates to problems or solutions in agriculture today.

Each research team has scientists with varying expertise, farmers, and conservationists working together to develop new farming systems and address important issues in rural Iowa.

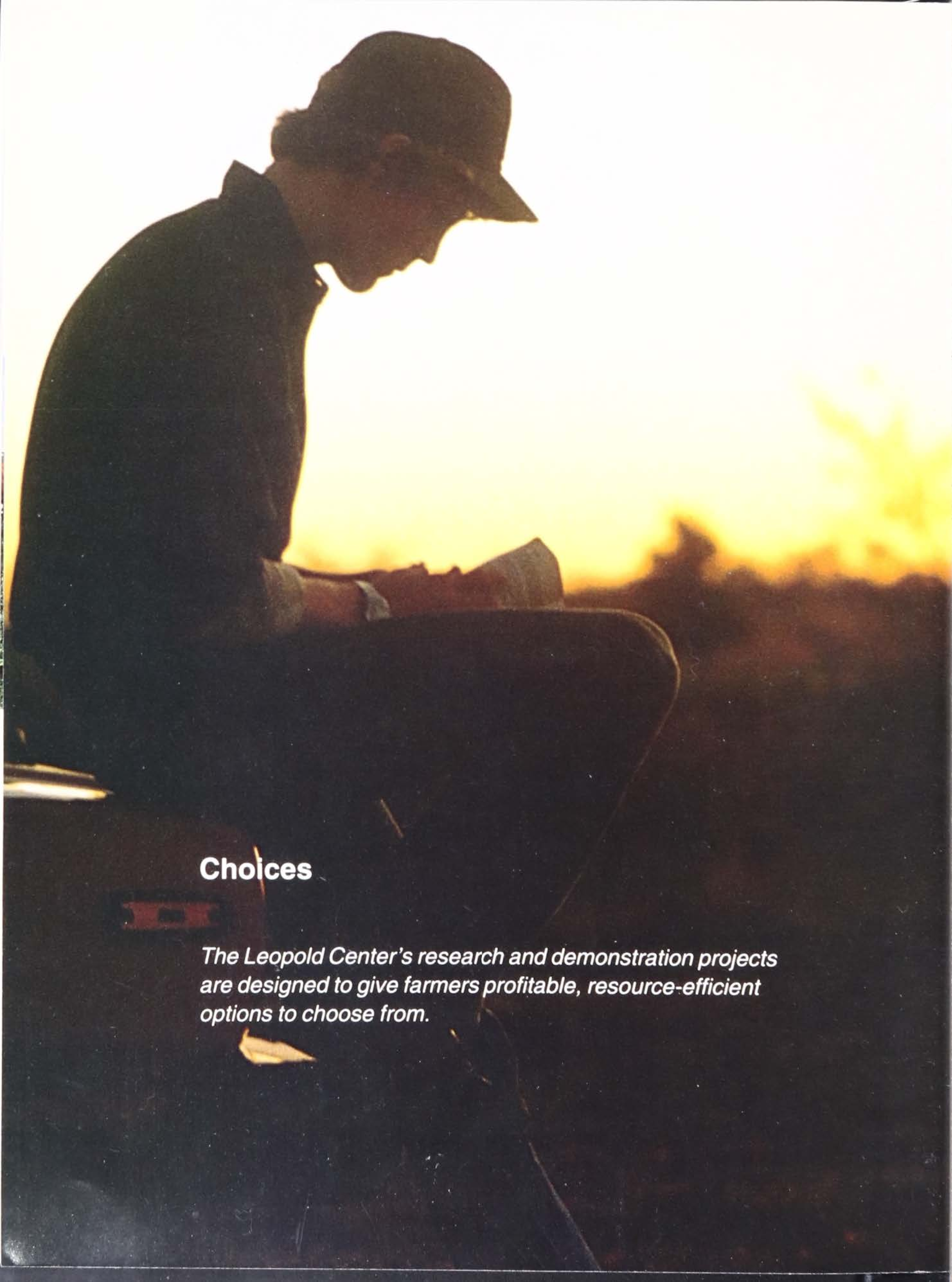
In 1990, four research teams studied cropping systems, socioeconomic aspects of sustainable farming, grazing and forages, and biological controls of alfalfa pests.

Each team receives base funding from the Center and seeks additional support to conduct long-term analyses. Each team has a leader with a part-time appointment in the Center.

Informational and educational programs based on team findings, such as field days, seminars, newsletter articles, fact sheets, guides, and other materials, are an important part of each team's work.

The teams' findings in 1990 can be found on pages 17-21.

Interdisciplinary research teams of scientists, farmers, and conservationists study whole farming systems at one time.



Choices

The Leopold Center's research and demonstration projects are designed to give farmers profitable, resource-efficient options to choose from.

Interdisciplinary Research Teams

Solving the dilemmas facing Iowa agriculture today will require interdisciplinary approaches to research and education in sustainable farming. So the Leopold Center established interdisciplinary research teams to develop new farming systems and to address important issues on Iowa farms. Each team has scientists from various backgrounds and affiliations, as well as farmers and conservationists. The following four teams conducted research in 1990.

Table 1. Number of alfalfa weevil larvae that successfully completed development, were parasitized, infected by a fungal pathogen, or died from unknown causes in Marion and Lucas counties, 1990.

Date	Total count	Adult emerged	Parasitism	Fungal pathogen	Unknown mortality
		percent			
5/2/90					
Marion	111	49	17	12	23
Lucas	153	68	10	8	13
5/10/90					
Marion	134	60	25	10	5
Lucas	139	77	9	10	4
5/17/90					
Marion	151	49	24	12	15
Lucas	150	65	13	9	13
5/24/90					
Marion	72	13	7	39	42
Lucas	160	50	3	31	16
5/31/90					
Marion	21	0	14	52	33
$\bar{x}$ stems/ft.^{2}					
Marion	80.4				
Lucas	66.7				

Alternative pest controls

The Integrated Pest Management (IPM) Team is led by John Obrycki, an entomologist at ISU.

The team has two basic long-term objectives:

- Integrate biological, cultural, and chemical controls, as well as interactions of diverse pest complexes (insects, pathogens, and weeds) into IPM decision models.
- Deliver environmentally and economically sound IPM systems for sustainable agriculture in Iowa.

The team's research is currently on pests in alfalfa. Despite the fact that insects and pathogens can cause considerable reductions in the yield and quality of alfalfa, there have been few long-term studies of these pests in Iowa. To improve management programs, the team will closely study the correlation between pest incidence and yield loss.

In 1990, the team began research on the alfalfa weevil in three areas: Climatic effects on population levels, the use of biological control agents, and appropriate management strategies for Iowa.

Population levels. Population levels were studied at four locations in Iowa along an axis from Waverly in the north to Chariton in the south. A cold, wet spring at the northern sites and unexpectedly high levels of fall egg laying observed at the southern Iowa sites reemphasized the fact that research on insects, like farming in general, often can be a study in extremes.

Biological controls. Biological control agents that attack the alfalfa weevil include a larval parasitoid, *Bathyplectes curculionis*, and a fungal pathogen, *Zoophthora phytonomi*. The team investigated both control agents in 1990 and will continue work in 1991 (Table 1).

Management practices. IPM spray strategies and cultural controls were examined. At the sites studied, a calendar-spray strategy and the degree-day model were both effective in reducing larval populations of the alfalfa weevil to noneconomic levels. The cultural control strategies of early cutting and early bloom cutting were, in these cases, not effective in preventing economic loss.

Crop diversity with space and time

The Cropping Systems Team is led by Richard Cruse, research agronomist at ISU, and Douglas Karlen, a soil scientist at the National Soil Tilth Laboratory, USDA Agricultural Research Service.

The team is primarily involved in strip intercropping, in which narrow strips of adjoining crops are grown in the same field. Corn, oats, alfalfa, soybeans, wheat, and barley were grown in 1990.

Preliminary results show increased yields from border and rotation effects, reduced reliance on expensive inputs, and improved soil conservation (Figure 1).

In 1990, the team studied energy efficiency, economic return, disease and insect management, and farmer acceptance of this novel cropping system.

Energy efficiency. Weed control by banding herbicides proved more efficient than either broadcast application or use of no herbicides. In fact, weed control methods had more effect on energy efficiency in the fields studied than did either tillage or the use of legumes to fix nitrogen. Team members will continue to examine the savings on nitrogen fertilizer from legumes, particularly because the extreme dry and wet conditions of 1989 and 1990 did not produce normal stands.

Profits. Economic analyses of the first study year showed higher returns from strip intercropping than from large fields of a single crop. Three crop rotations (continuous corn, corn-soybeans, and corn-oats-soybeans) and two tillage systems (conventional and ridge tillage) were compared.

Disease. Low rainfall in 1989 resulted in low potential for disease infestation in 1990. Foliar diseases were studied in all crops in the strips—corn, soybeans, oats, wheat, barley, and alfalfa. Oats and alfalfa were affected most by disease. Long-term studies will examine if the rotation effect of the strips offers special opportunities or problems in breaking the cycles of plant pathogens.

Insects. The incidence of corn rootworm, European corn borer, and several beneficial insects was studied at two locations. The team found that the use of strip intercropping actually may reduce European corn borer stalk tunnelling damage. Plus, the soybean strips did not seem to attract significant numbers of European corn borer adults that could lay eggs on adjoining corn strips.

Farmers' thoughts. Sociologists analyzed farmers' views of the unconventional rotations of strip intercropping. Participating farmers suggested several ways to make the system more functional. Among the controlling factors they cited were the type of machinery required, government farm policies, and commodity markets. Farm operators were valuable in identifying areas for further research.

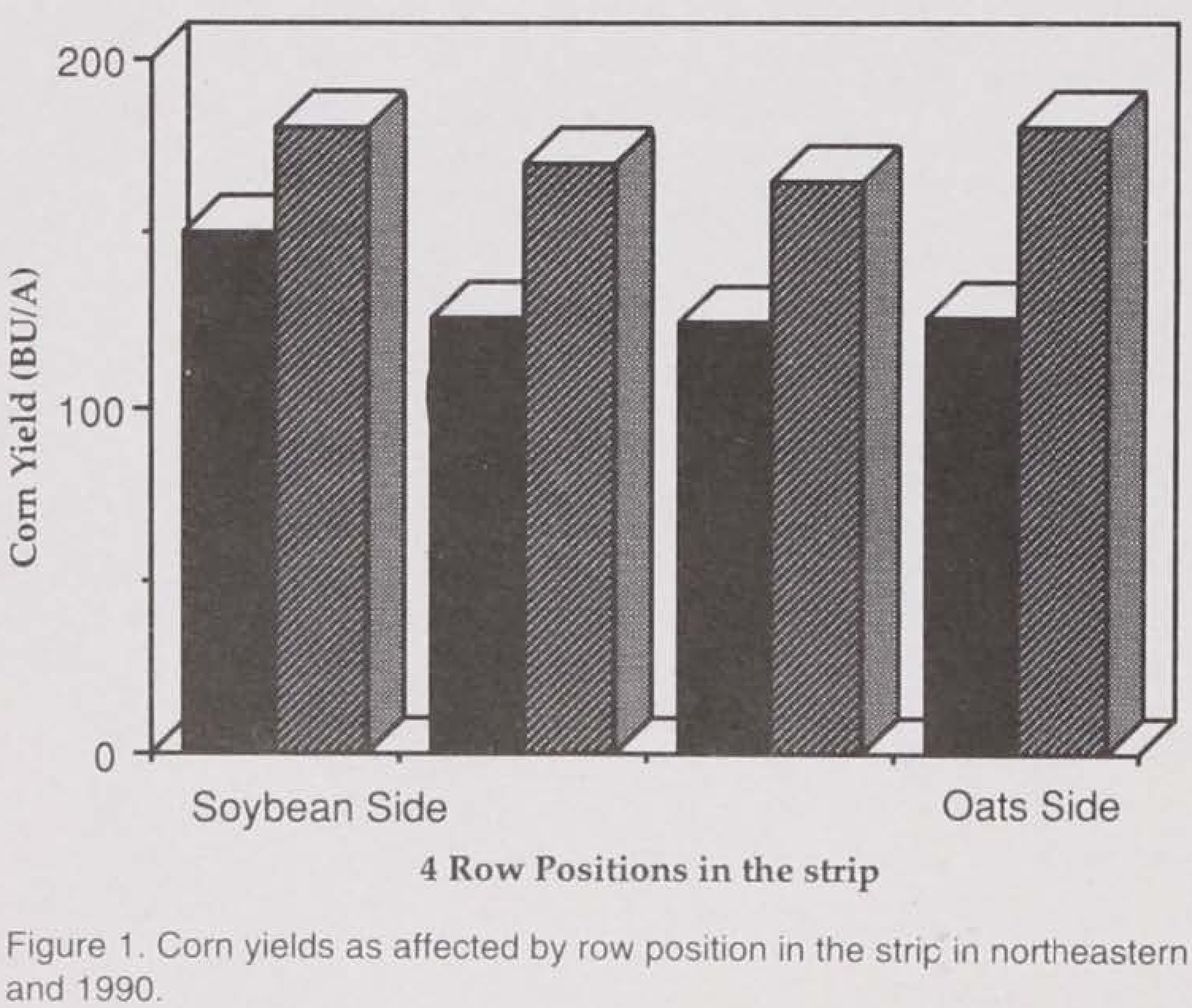


Figure 1. Corn yields as affected by row position in the strip in northeastern Iowa, 1989 and 1990.

Forages and grazing

The Animal Management Team is led by ISU animal scientist James Russell.

A five-year experiment is evaluating the effects of grazing alfalfa-grass and grass pastures on animal production and sward characteristics. Four alfalfa-grass and four bromegrass pastures were grazed for 149 days either by continuous grazing at 0.6 cow-calf units/acre or by high-intensity rotational grazing at 1 cow-calf unit/

acre. Rotational pastures were divided into 8 paddocks and the lengths of rotations were adjusted with the forage growth rate. In the spring, smooth bromegrass pastures were fertilized with 100 lbs nitrogen, 30 lbs phosphorus, and 30 lbs potassium; and alfalfa-grass pastures were fertilized with 30 lbs phosphorus and 40 lbs potassium.

In the first year, pasture species and grazing systems did not affect the weight changes of individual cows and calves. Calf weight gains/acre were 16 percent greater on the alfalfa-grass pastures than on the smooth bromegrass pastures (Table 2). High-intensity rotational grazing resulted in 61 percent and 40 percent more calf weight gains per acre than continuous grazing on alfalfa-grass and smooth bromegrass pastures, respectively. Alfalfa-grass pastures grazed by high-intensity rotational grazing had 69 percent more calf weight gains per acre than pastures grazed by conventional rotational grazing.

Pastures grazed by high-intensity rotational grazing had lower available forage than continuously grazed pastures. The high-intensity rotationally grazed pastures, however, had less dead forage than continuously grazed pastures. In addition, alfalfa-grass pastures grazed by high-intensity rotational grazing contained less grass and more legume than those grazed by continuous grazing.

The digestibilities of the grass and legume in the forage from the high-intensity rotational pastures were 5 percent and 6.5 percent greater than those in the forage from continuously grazed pastures. The digestibility of the forage selected by cows in the high-intensity rotational system was 5 percent greater than the continuously grazed pastures. Feed intake and reproductive efficiency are also being evaluated.

To evaluate the effects of grazing systems on the use of corn-crop residues, duplicate corn-crop residue fields were either continuously grazed at planned stocking rates of 0.5, 1, or 2 acres/cow/month or strip-grazed at 0.5 acres/cow/month. Two additional groups of cows were fed hay ad libitum in a drylot. Although it was planned that the grazing would be conducted for 56 days, grazing was terminated after 51 days because of excessive snow. Furthermore, there was considerable snow cover on the stalks during the last three weeks of grazing. Changes in bodyweight (lbs) of cows continuously grazing stalks at 0.5, 1, and 2 acres/cow/month and 0.5 acre/cow/month were -39, -43, 14, and -32, respectively. However, bodyweight changes of hay-fed cows were -55 lbs over the same period. This implies that cows grazing corn stalks may have greater bodyweight gains than cows fed hay without the additional costs of hay harvest. Furthermore, 22 percent of the dry matter was lost from the hay stored in large bales.

Increased use of legume forages will decrease soil erosion and nitrogen fertilizer use on farms. Legume forages, however, may not persist well when grazed. Controlled rotational grazing may increase animal production per unit of land and legume persistence in pastures. Because about 40 percent of the cost of cow-calf production is required for stored feeds, profitability may be improved by optimizing grazing of crop residues during the winter.

Table 2. Animal production from different grazing systems.

	Pasture species and grazing system				
	Alfalfa-grass			Smooth bromegrass	
Item	Continuous	Conventional rotational	High-intensity rotational	Continuous	High-intensity rotational
Cow wt., lb.					
initial	1383	1353	1396	1395	1362
final	1439	1426	1413	1441	1336
Cow wt. change, lb.	56	74	17	46	-26
Cow condition score change	0	0.33	0.07	0.0	0.0
Adjusted 205-day calf wt., lb.	654	624	631	625	573
Calf gain on pasture					
lb/day	2.76	2.74	2.68	2.60	2.21
lb/day	243	231	391	228	319

SOCIOECONOMIC ANALYSES

The Human Systems Team is led by Gordon Bultena, a rural sociologist at ISU.

The team compared the personal characteristics and orientations, as well as farming practices, of conventional and sustainable farm operators in Iowa. The two types of farmers were selected through an elaborate, multistage procedure. By assigning the respondents numerical scores based on their relative use of farming practices that are central to the concept of sustainability, farmers were placed either in the sustainable category (n=89) or in the conventional category (n=128).

As to be expected, given the classification criteria, the conventional and sustainable farms differed in many of their production practices. Data were obtained in the study on both general farming practices and practices used on selected "typical" cornfields, which were neither the respondents' highest nor lowest yielding.

Table 3. Comparison of selected farming practices on conventional and sustainable Iowa farms.

Farming practices (1989)*	Conventional farms (N=128)	Sustainable farms (N=89)
	Average score	
Entire farm		
Number of crops grown	2.9	3.8
Percentage of all cropland in corn or soybeans	81	66
Percentage of 1989 corn acreage previously in corn or soybeans	97	77
Percentage planting listed crops		
soybeans	91	85
small grains	35	85
forage/pasture	52	75
another crop	12	30
Percentage with livestock	73	91
Selected corn field		
Yield goal (bu/acre)	145	130
Yield (bu/acre)	123	119
Number of different crops grown in 5-year period (1985-1989	1.7	2.4
Lbs/acre of purchased N fertilizer˙	127	39
Total lbs of N/acre**	160	93
Percentage of all N purchased commercially	83	44

* A corn field was selected on each farm for detailed analysis. The respondents were asked to select a "typical" corn field, and not their highest or lowest yields corn field. Practices and yields on these corn fields were undoubtedly affected by statewide drought conditions in 1989.

˙ Includes nitrogen from bulk blend and starter fertilizer, anhydrous ammonia, nitrogen solution, and dry urea.

** From purchased fertilizers, previous crop rotations, and manure applications.

As shown in Table 3, sustainable farmers are planting a larger number of crops than conventional farmers, more often have livestock, plant proportionately less corn and soybeans, more often raise small grain and other crops, and more often have acreage in forage/pasture. Important differences also are found between the two subcategories in their cropping and nutrient practices on the selected cornfields. Sustainable farmers typically use more elaborate crop rotations and apply less purchased nitrogen fertilizer (both in pounds per acre and in percent of all nitrogen) than conventional farmers. Although yield goals for the selected corn fields were higher for conventional farmers, only a small difference was found between the subcategories in actual yields (Table 3).

Between the two groups, several differences were found in personal characteristics and in the scale of their farming operations. For example, sustainable farmers generally had more formal education, were farming fewer acres (both owned and rented), and had slightly smaller debt-to-asset ratios than conventional farmers. They also had, on average, somewhat lower gross farm incomes.

The respondents were asked a series of questions about what would likely happen on their farms if they used sustainable farming practices (a list of such practices was given). Sustainable farmers obviously answered this question with some first-hand knowledge of these "hypothetical," on-farm impacts. As shown in Table 4, conventional farmers usually anticipated a decline in crop yields if they adopted sustainable practices, whereas sustainable farmers typically saw no effect on yields.

All respondents generally agreed that their production costs would decline with the use of sustainable practices, but they were sharply divided in their assessments of likely net returns and financial risks. Sustainable farmers typically predicted improved profits and reduced risks, whereas conventional farmers anticipated diminished profits and increased risks. Conventional farmers usually perceived increased weed and insect problems, but fewer sustainable farmers foresaw these problems. Both groups largely agreed that management complexity and labor needs would increase with adoption of sustainable practices, but these views were held most frequently by conventional farmers.

It is noteworthy that sustainable farmers overwhelmingly anticipated increased job satisfaction from the use of sustainable practices, whereas conventional farmers either perceived no change in their job satisfaction or expected that it would decline (Table 4).

A set of six questions was asked about the likely off-farm (societal) impacts of sustainable agriculture if it were to become more common. Conventional and sustainable farmers differed sharply in their projected impacts, with conventional farmers typically expecting negative outcomes and sustainable farmers expecting positive outcomes. For example, most conventional farmers predicted increased food prices, reduced ability to feed hungry people abroad, diminished international competitiveness of U.S. agriculture, and farmers having less time to participate in family and community activities. These views were basically rejected by sustainable farmers. Sustainable farmers usually saw a concerted shift to sustainable agriculture as aiding rural communities and providing safer food—views that were supported little by conventional farmers.

The divergent views of the respondents about likely on- and off-farm impacts of sustainable agriculture are striking and suggest that there are different referents, or lack of a common "universe of discourse," in farmers' appraisals of these alternative systems. Each subcategory of farmers has developed opinions about sustainable agriculture, which often are contrary to the views of persons in the other subcategory. Perceptions of the general farm population about on- and off-farm impacts of sustainable agriculture generally fell between the polar positions of these two subcategories.

Farm size. The size of conventional farms in this study is similar to the class of commercial farms that generally is growing today in numbers and economic power. Conversely, the size characteristics of the sustainable farms most closely resemble the types of operations that make up the "disappearing middle" in American agriculture. But the question of whether or not sustainable farms are surviving better than conventional farms of similar size remains unanswered.

The team receives supplementary funding for its research from other organizations, including the Northwest Area Foundation, Iowa Agriculture and Home Economics Experiment Station, and Iowa Cooperative Extension Service.

Members of the team are also examining factors important to Iowa farmers' adoption of ISU's late-spring soil nitrate test; personal values that affect farmers' decisions to adopt sustainable agricultural practices; and the knowledge and beliefs

Table 4. Perceived impacts if sustainable agricultural practices become popular with farmers.*

Item	Conventional farmers	Sustainable farmers
Food Prices will increase	65% agree·	61% disagree·
U.S. will be less able to feed hungry people abroad	73% agree	87% disagree
Farmers will be less competitive in world markets	67% agree	91% disagree
Farmers will have less time to participate in community and family activities	72% agree	86% disagree
Rural communities will become stronger and more prosperous	64% disagree	82% agree
Safer food will be produced	Mixed Response**	94% agree

* Responses were "strongly disagree," "agree," "unsure," "disagree," and "strongly disagree."

· Numbers are percentages of farmers selecting the designated repsonses.

** Mixed response is where fewer than three-fifths (60%) of the respondents either agreed or disagreed with the item.

about sustainable farming of key purveyors of agricultural information.

Other teams

Two teams were planned in 1990 to research animal-waste managment and agroecosystems. The teams will begin work in 1991. The animal-waste management team will be led by Stewart Melvin, an agricultural engineer at ISU. Bruce Menzel, an ISU animal ecologist, and Richard Schultz, a forester from ISU, will lead the team on agroecosystems.

Competitive Grants

Water Quality

Evaluation of tillage and crop rotation effects on groundwater quality

R.S. Kanwar, D.E. Stoltenberg, D.L. Karlen, T.S. Colvin, G.F. Czapar, and W.W. Simpkins, ISU

Contamination of groundwater by pesticides and nitrate is a serious problem in Iowa. While groundwater contamination in Iowa has been well documented, the mechanics of contamination is not well understood.

Conservation tillage practices are important to sustainable farming systems because they help control soil erosion and reduce energy consumption. Conservation tillage often reduces pesticide contamination of surface water by reducing soil erosion and water runoff. However, conservation tillage may increase the risk of groundwater contamination because infiltration is increased.

This study compares use of the moldboard plow with three conservation tillage systems (chisel plow, ridge-till, and no-till) with two crop rotations (continuous corn and corn-soybean) on groundwater contamination. The study is at a well-instrumented site at ISU's Northeast Research Farm near Nashua. The site allows for monitoring of groundwater and tile effluent from 36 one-acre, long-term tillage plots. Each plot has been instrumented with sumps and subsurface drainage metering and monitoring devices. Tile effluent is monitored at a depth of 4 feet and shallow groundwater at depths of 6, 8, and 12 feet for the presence of nitrate-nitrogen and the herbicides atrazine, cyanazine, alachlor, and metribuzin.

Average monthly nitrate-nitrogen concentration in drainage water was greatest under the moldboard plowing plots. However, no-tillage plots had the greatest total nitrate-nitrogen and herbicide losses to groundwater. These losses are thought to be caused by direct transfer from the soil surface to tile depth by macropore flow. Continuous corn resulted in significantly higher nitrate-nitrogen losses than with the corn-soybean rotation. The highest total nitrate-nitrogen losses of 95.7 lb/acre were observed on the no-tillage, continuous-corn plots. This is equal to about 50 percent of the applied fertilizer nitrogen. More data on nitrate-nitrogen and pesticide leaching must be collected in coming years to determine cause-effect relationships.

Pesticides and their major degradation products as potential contaminants of groundwater

L. Somasundaram, J. Coats, and R.S. Kanwar, ISU

In spite of much attention on pesticide pollution of water supplies and the presence of pesticide metabolites, such as aldicarb sulfoxide and aldicarb sulfone in groundwater, no studies have been conducted in Iowa on the potential of the breakdown products of pesticides to contaminate groundwater. Research to date has largely focused on the movement and degradation of individual parent insecticides and herbicides under field conditions.

The chemical and microbial degradation of pesticides in soil and the formation of breakdown products have been well documented. Research conducted in our laboratory and elsewhere has identified properties of some pesticide metabolites that may enhance movement toward groundwater. The presence of pesticide degradation products in saturated and unsaturated zones is an important research area to be addressed.

This project will: 1) assess the mobility of pesticides and their degradation products under field conditions, 2) study the movement of pesticides and their degradation products in undisturbed soil columns in the laboratory, and 3) investigate the persistence and degradation patterns of pesticides and their degradation products in the saturated and unsaturated zones.

Analysis of soil and water samples taken during the 1990 growing season is in progress. Soil samples also were collected from different depths in a field not treated with pesticides for 7 years. These samples are part of ongoing laboratory studies with undisturbed soil columns treated with radioactively labeled pesticides to understand the mechanisms of persistence, degradation, and movement of pesticides and their degradation products.

Findings from this study will provide insight into the potential of degradation products as contaminants of groundwater and influence future research and monitoring of water quality to focus on pesticide degradation products in addition to parent pesticides.

Efficient herbicide application to reduce environmental losses

J.L. Baker and S.K. Mickelson, ISU

Accurate positioning of herbicides in the soil should increase the effectiveness of weed control while decreasing herbicide losses to surface water runoff, leaching, volatilization, and photodecomposition. Currently herbicide banding, as opposed to broadcast spraying, is promoted to reduce the amount of herbicides used. But spray-banding at planting on a windy day may cause considerable loss to the atmosphere. In addition, herbicides cannot be effectively incorporated with conservation tillage practices that leave crop residue on the soil surface.

A point-injection system was designed to inject and incorporate liquid herbicide into the soil profile. This point-injection cylinder has several spokes that penetrate the soil or crop residue and accurately place the herbicide in the soil. It can incorporate herbicides in a single pass through the field while leaving the soil surface virtually undisturbed. The point injector functions effectively on both bare soil surfaces and soil covered with corn residue.

The relative persistence of banded herbicides (alachlor, atrazine, and propachlor) using the injection cylinder and a band sprayer was compared in a field study. A bare soil surface and soil covered with an average of 79 percent corn residue were used in the comparison. Point injection reduced losses due to volatilization, photodegradation, and runoff, thus increasing persistence for alachlor and propachlor in the soil profile. The relative persistence of atrazine was found to be about the same for both methods 21 days after application. Losses to the environment were higher for the herbicides sprayed on the corn residue as compared to herbicides injected into the soil.

The point-injector was compared to broadcast spraying with disk incorporation for effective weed control. Oats were used as the test species. No significant difference was found between the two application methods in controlling oats with the herbicides atrazine, alachlor, butylate, or EPTC. Weed control was significantly greater with trifluralin when it was disk incorporated versus applied by the point-injector.

Transformation and fate of nitrate, atrazine, and alachlor in freshwater wetlands

W.G. Crumpton and A. van der Valk, ISU

It is clear that wetlands in agricultural regions may receive significant agricultural chemical loads. However, wetlands provide considerable opportunity for chemical transformation and loss and may have significant effects on the quality of water moving from wetlands to surface and groundwater supplies. Especially in light of current efforts to restore wetlands in the prairie pothole region, there is a critical need for understanding the effects of agricultural chemical contaminants on northern prairie wetlands and the transformation of contaminants in these wetlands.

This project uses experimental wetland mesocosms and microcosms to study the transformation, fate, and effects of nitrate, atrazine, and alachlor in freshwater wetlands. Initial results confirm the considerable capacity of freshwater wetlands to transform nitrate and suggest that denitrification is the dominant loss process. Results are consistent with models for agricultural streams, which suggest that in the presence of high nitrate loads, denitrification rates are controlled by the nitrate concentration in the overlying water and the effective length of the diffusion path between the overlying water and the primary site of denitrification in underlying anaerobic sediments.

Contrary to the assumptions of these models, however, data suggest that nitrate concentrations in the overlying water also significantly affect the activities and/or population densities of denitrifying bacteria in the underlying wetland sediment. The results suggest that the assimilative capacity of wetlands for nitrate might be greatly enhanced if nitrate loads are sufficient to maintain high population densities of denitrifying organisms.

Sustainable tree-shrub-grass buffer strips along waterways

R.C. Schultz, J.P. Colletti, C.W. Mize, W.W. Simpkins, M.L. Thompson, P.H. Wray, R.B. Hall, and L.C. Rule, ISU

Fence row-to-fence row agriculture has cleared most of the native ecosystems that once covered the Midwest. Loss of these ecosystems has brought about an increased potential for eroded soil particles and chemicals to reach surface and groundwater systems. Reintroduction of properly placed tree, prairie, or wetland ecosystems can help reduce the impact of soil and chemical movement. For these systems to be embraced by the farmers, however, they must also provide economic returns on the land removed from crop production.

With cooperation from a farmer, this project is evaluating the technical, environmental, and economic aspects of tree-shrub-grass buffer strip plots along a 0.6 mile stretch of Bear Creek, in northern Story County, Iowa. Short-rotation, woody crops are grown with switchgrass to protect the riparian zone of Bear Creek. Plots 280 feet long consist of 7 rows of woody plants and a strip of switchgrass 24 feet wide running parallel to the creek. The 5 rows closest to the creek are planted to pure poplar hybrids, green ash, or a mixture of silver maple with a center row of black walnut trees. The next 2 rows are planted, 1 each, to red-osier dogwood and ninebark shrubs.

The last 24 feet are planted to switchgrass. Spacing between rows is 6 feet and within rows is 4 feet for trees and 3 feet for shrubs. The poplar hybrid, green ash, and silver maple are grown on a 4- to 6-year rotation for biomass fuel, and the walnut is grown on a 60-year rotation for high-quality timber. The switchgrass also can be harvested for biomass energy.

The hypothesis is that the buffer-strip system will trap soil eroding from the row-cropped uplands and process contaminated subsurface water carrying agricultural chemicals and moving into the alluvial zone. The buffer strip can provide economic returns to the farmer as harvested biomass that can be used for on-farm energy. It will also provide increased wildlife habitat, especially because of the diversity of plants. It also will provide long-term carbon storage to reduce global warming.

The Leopold Center's agroecology research team is monitoring the site to test our hypothesis. The team includes specialists in forage crops, soils, groundwater, forest hydrology, ecology, economics, biometrics, and landscape ecology. Chemical and nutrient changes of surface and groundwater, soil, and plants are being measured to determine the fate of chemicals moving through the buffer strip. Sediment movement from the crop fields is being measured, as are weather parameters and growth and yield of the various trees, shrubs, and grass. Streambank stability and wildlife populations also are being monitored.

Seed coating with environmentally acceptable polymers as an alternative to fungicide treatment of corn and soybeans

D.C. McGee and J.S. Burris, ISU; J. Lach, P.S. Grover, and R. Bilous, University of Iowa

All commercial seed corn used in Iowa is treated with the fungicide Captan to protect emerging seedlings from soil-borne fungi. In the United States, more than 1.2 million pounds of the fungicide are applied each year on treated corn seed.

This study of degradable polymeric seed coatings may provide an environmentally safe alternative to harmful fungicides. Polymeric films can also help keep seeds from taking up moisture when stored at high humidity.

This cooperative investigation involves ISU's Seed Science Center and the Pharmaceutical Service Department at the University of Iowa. Its primary objective is to identify environmentally acceptable polymeric coatings that could regulate/delay water uptake and thus improve seed germination and emergence without the need of traditional fungicides. The regulation/delay of water uptake may allow the seedling to simply outgrow soil-borne disease organisms or to avoid their competition by delaying germination until seedbed conditions are more conducive to seedling germination and growth.

In 1989, trials were conducted using soybean seeds as a model system. Soybeans were chosen because of their sensitivity to soil borne organisms and their normally rapid rate of water uptake. A range of currently utilized pharmaceutical coatings was evaluated. Coating seed with either Aquacoat DDS, Cellulose-acetate-butyrate, or Ethylcellulose provided the most consistent delay in germination; coating the soybeans with Sepiret accelerated the rate of water uptake and initial germination.

The field trial indicated that coated soybean seed was delayed 1 to 2 weeks in emergence as compared with the uncoated seed. These results prompted evaluation of additional coating materials, some of which could be applied in organic solvents. Although these coatings seemed to provide some delay in germination, the organic solvents used in their application caused abnormal seedling development.

In 1990, trials were conducted using dent corn, sweet corn, and soybeans. The seedcoat characteristics of corn genotypes are very different, and many of the coating materials that were successfully applied to soybeans could not be readily applied to corn. Additional efforts have been made to develop coating equipment, both fluidized bed and pan systems at the Seed Science Center. A custom laboratory fluidized-bed and a pan coating machine were designed and constructed, and the coating system for both corn and soybean was developed using these machines. This allowed a major increase in the number of materials that can be screened.

Twenty coating materials with different coating rates were evaluated during 1990 on both soybeans and corn. Laboratory and field screening of all these polymers identified at least four materials (Chitosan, WE film, Sacrust, and PVP) that when used as seed coatings resulted in field emergence similar to Captan treatment. The coated seed performed better under adverse field conditions than in the standard warm germination test. The warm germination may be reduced because of a delay in imbibition due to the coating that results in a reduced number of normal seedling when counted at 7 days. A modified cold test (14 days at 10° C followed by 7 days at 25° C) in a sand/soil mixture provided results similar to the field emergence.

We will continue to screen additional materials for activity as an alternative to fungicide treatment of corn and soybeans. The coating technology will also be modified to effectively apply candidate materials to seed. Extensive laboratory studies will be made of the physiological and pathological impacts of delayed water uptake and the acceleration of water uptake on seedling performance.

Poplar tree buffer strips grown in riparian zones for nonpoint-source pollution control and biomass production

L. A. Licht and J.L. Schnoor, University of Iowa

This project demonstrates that tree buffers can be productive while protecting the environment. Poplar trees were planted in a buffer between a creek and a corn crop to use the natural ability of plants to remove nitrate from groundwater and convert this nitrogen into a useable, renewable crop. Nitrate mainly comes from agricultural nonpoint sources that leach from agricultural fields. Application of fertilizers at rates exceeding crop uptake is normal in conventional farming practices. Therefore, the problem of nonpoint nitrate leaving farmed fields is expected to continue into the foreseeable future.

Our research shows that poplar trees can be cultured at population densities similar to corn with roots grown intentionally deep enough to intersect the near-surface water table. Data indicate that a substantial mass of nitrate is removed from rooted soils. The nitrogen uptake by the plant is present as protein in the leaves and woody stems.

Near-surface groundwater was sampled during the 1990 growing season using 5-foot deep wells placed upgrade, midplot, and downgrade from the tree buffer. Buffers grown from both 10-inch and 60-inch cuttings reduced nitrate in the groundwater by more than 95 percent, reducing the concentration to less than 20 percent of U.S. Environmental Protection Agency's drinking water standards (Figure 1).

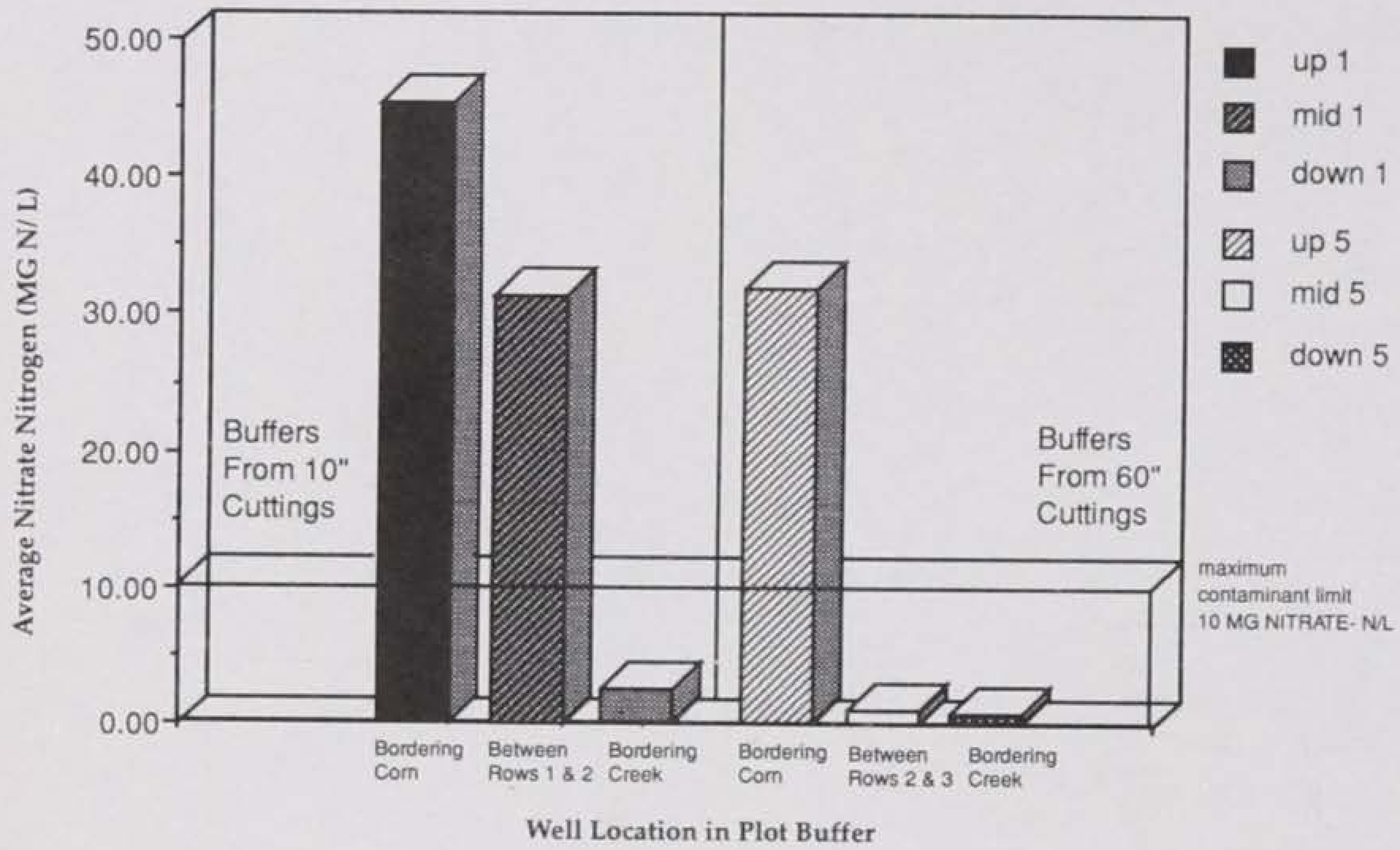


Figure 1. Nitrate-nitrogen reduction in near-surface groundwater by poplar buffers.

Survival of poplars in the 4 plots planted in 1990 ranged from 50 to 92 percent. Several hybrid varieties consistently exceed 90 percent survival rates in riparian conditions bordering crops. Weed control and culturing techniques are being perfected to ensure a thriving buffer ecology. The trees' physiological attributes of fast wood growth, cut-stem rooting, resprouting from a stump, and a high protein content in the leaves contribute to a harvested value that is economical while achieving water quality goals.

In addition to fertilizer removal from groundwater, the wooded riparian strip can serve as wildlife habitat, wind shelterbelts, and sources of renewable fuels that cycle carbon. This is a potential Best Management Practice for reducing nonpoint-source pollutants created by modern farming practices or urban storm water runoff.

Effectiveness of vegetative filter strips

J. Schultz, Allamakee Soil and Water Conservation District; and R.M. Cruse, ISU

Vegetative filter strips can help reduce soil erosion and water contamination by partially filtering sediment and sediment-borne nutrients and pesticides from overland surface water flow. Most research on vegetative filter strips has addressed treatment of water from feedlots, strip mines, and municipal waste facilities. Little research has been conducted on the practicality of the strips for controlling cropland runoff.

Runoff from cropland can affect water quality and deface environmentally sensitive areas, such as streams and sinkholes. This study investigates the effectiveness of the strips for filtering cropland runoff. (Legislative mandates are being considered for strip treatment of these areas.)

Two research plots have been established on land with C (5 to 9 percent slope) and D (9 to 14 percent slope), Fayette silt loam in Allamakee County. Each plot has a continuous fallow strip 60 feet wide positioned up-slope of a grass filter strip of the same width. Runoff samples were collected at 0, 10, 20, 30, 40, and 60 feet into the filter strip.

Preliminary results of the D-slope plot show that 85 percent of the sediment is removed from the runoff in the first 10 feet of filter, and 95 percent is removed within 30 feet of filtration (Figure 2). These results were compiled during a 3-inch rain on saturated soils with about 2 inches of runoff on the test plots. It seems that vegetative filter strips have great potential for sediment control where runoff flow is not concentrated.

Storm Lake watershed demonstration project: Planning phase

R. Lampe and J. Hutchins, Buena Vista College; K. Arends, Buena Vista Soil and Water Conservation District

A variety of environmental problems associated with agricultural land use require solutions developed through a landscape perspective. The Storm Lake watershed has been selected for long-term research on landscape management of an agroecosystem. Currently, researchers are in the planning phase and are developing environmental and socioeconomic data bases for the project. Survey elements include watershed cover features, water quality, socioeconomic, and wildlife surveys.

Land use in the watershed has been identified and quantified by using Geographical Information Systems (GIS) technologies. Quantified agricultural features are cropland (50 percent, predominantly corn and soybeans), pasture (4 percent), field borders (1.8 percent), farmsteads (1.4 percent), cattle feedlots (<0.1 percent), and shelterbelts (<0.1 percent). Natural features include lakes (16 percent), drainageways (9.1 percent), and wetlands (1.1 percent). The remainder is roads, urban, and industrial areas. This information will be used to identify critical areas for environmental management.

Powell Creek, the primary tributary of Storm Lake, carried high concentrations of nitrate and sediment after summer and fall water runoff. But water quality improved dramatically as flow continued through a natural marsh and the lake. Preliminary results demonstrate the utility of natural landscape elements for ameliorating agricultural non-point source pollution.

Surveys of small mammals and birds began in the summer and those for aquatic biota will start in spring 1991. Other continuing water surveys include hydrology, phosphate, pesticides, and substrate sediment composition. Planning is underway for socioeconomic and recreational surveys that also will start in the spring.

Multispecies toxicity tests using indigenous organisms: Predicting the effects of pesticides in streams

K.W. Pontasch, University of Northern Iowa

Research on new methods for assessing chemical hazards in the aquatic environment has moved to the development of multispecies toxicity tests. Multispecies toxicity tests are better predictors of environmental hazards because they consider interspecific interactions, test a broad range of species, and are conducted under environmentally realistic conditions.

Although most agricultural and industrial contaminants end up in streams and rivers, little research has been conducted to determine their effect on nontarget stream-dwelling organisms. This project investigates the effects of a pyrethroid insecticide on insect communities commonly found in Iowa streams. Pyrethroid insecticides are particularly toxic to aquatic organisms. The investigators tested Pydrin 2.4 (active ingredient fevalerate). The investigation was conducted in

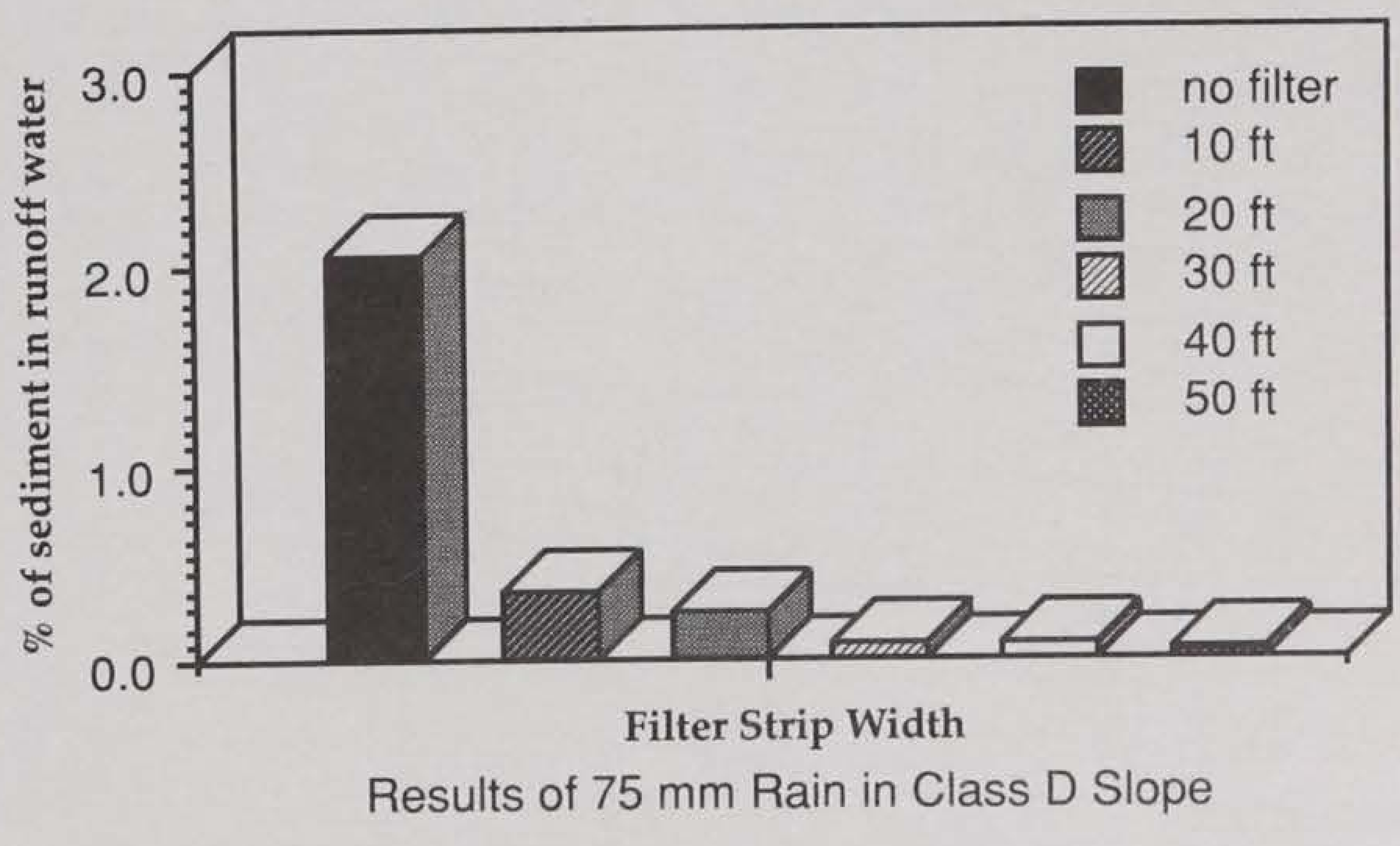


Figure 2. Effect of filter strips on runoff water quality.

the Ecosystems Simulation Laboratory at the University of Northern Iowa, Cedar Falls. This facility is the only laboratory in the state, and one of a few in the country, capable of testing contaminant effects on stream communities.

Test organisms were transferred to 15 artificial streams in rock-filled containers previously colonized for 6 weeks in a riffle of the Volga River in northeastern Iowa. The 15 stream microcosms were exposed in triplicate at 0.0, 0.01, 0.1, 1.0, and 10.0 ppb (ug/L) fenvalerate. Insect drift was quantified in each microcosm 1 hour after initial dosing. Emergent adults were collected from the microcosms every 48 to 72 hours. After 30 days in late summer, all organisms remaining in the microcosms were counted. The relative sensitivities of the various species tested were determined by comparing species-abundances of adults and immatures combined over all concentrations.

Sublethal effects, such as increased drift, immobility, and quivering of appendages were observed at 0.01 ppb (ug/L). In addition, one species taxon exhibited a significant reduction in density at 0.01 ppb (ug/L). Most species taxa exhibited significant mortality in the 0.1 ppb (ug/L) treatment. The concentrations tested were several orders of magnitude less than the label application concentration of about 200 ppb (mg/L). Thus under certain conditions, there is potential for deleterious effects on stream communities. Preliminary results show that at 0.01 ppb fenvalerate (ug/L), mayflies (*Ephemeroptera*) and stoneflies (*Plecoptera*) would be eliminated, and that riffle beetles (*Coleoptera: Elmidae*), caddisflies (*Trichoptera*) and some midges (*Diptera: Chironomidae*) would be significantly reduced.

Further research will involve other commonly used pesticides to determine their potential effects on organisms in Iowa streams.

Agroecosystems

Species and varieties of conifers for Christmas tree production in Iowa

P.H. Wray, R.B. Hall, C.W. Mize, J. Iles, R.C. Schultz, H.S. McNabb, and E. Hart, ISU

The Christmas tree industry in Iowa continues to expand rapidly. Yet, current production is limited in number of species/varieties used for Christmas trees in the state. As competition increases from outside producers, Iowa growers need to expand the choices available to consumers to maintain a competitive advantage. Suitability of many available species/varieties of conifers for Christmas tree production in Iowa is nonexistent.

During the summer of 1990, 285 growers were asked to respond to a survey to outline what they planted over the past 7 years. In addition, growers were asked if they would participate in a species/variety test for the next 7 years. The survey was used to select 14 species/varieties for field testing and to determine which species/varieties are currently used for Christmas trees. Growers currently are planting 77.6 percent Scotch pine, 13.5 percent white pine, 2.9 percent red pine, 1.7 percent blue spruce, and 4.5 percent of 10 other species. Growers planted 23 different varieties of Scotch pine; however, four varieties accounted for more than 50 percent of the total Scotch pine planted.

Twenty-nine growers expressed interest in cooperating in field trials. Fourteen have been selected and will plant two replications of the field trial each of the next 3 years beginning in spring 1991.

Oak regeneration response to thinning from below

D.W. Countryman, R.B. Hall, C.W. Mize, R.C. Schultz, and P.H. Wray, ISU

Farmers own two-thirds of the woodland resource in Iowa, yet they are not reaping the potential economic benefits from the woodlands. Woodlands can add diversity to farm enterprises through periodic income from sawlog and veneer harvests. In addition, management and thinning of these stands can improve the regeneration, growth, and quality of the sawlog and veneer crop while producing a continuous supply of fuelwood or chips as a source of on-farm energy to reduce reliance on off-farm energy sources.

Most wooded tracts are 50 acres or larger. Oaks are high-quality species that are moderately intolerant to shade. Leaving low-quality trees in upland hardwood stands after harvesting makes it nearly impossible to establish adequate oak regeneration. Management and thinning of stand can improve oak regeneration, growth, and quality of the remaining sawlog and veneer crop.

This study is evaluating regeneration of oak by removing all non-oak species from upland hardwood stands and planting oak seed, unprotected seedlings, growth-tube protected seedlings, or allowing natural regeneration to produce the next generation of trees. Once the new seedlings are established, the overstory oaks also will be removed. The study will be replicated at the McNay Research Farm on the Stephens State Forest near Chariton to provide a more broad base for the research and to provide a second demonstration area.

Testing new methods of improving the productivity of woodlands while demonstrating production of an energy crop helps farmers diversify their operations and improve their financial status.

Bird use of roadsides in an agricultural ecosystem

L.B. Best and M. Camp, ISU

Areas of native prairie vegetation used by grassland birds are being eliminated by intensified farming practices in the Midwest. Thus, remaining areas of this type (fencerows, grassed waterways, railroad right-of-ways, and roadsides) are becoming more important to avian wildlife. Row-crop fields adjacent to these areas may be "ecological traps" for grassland birds, but because of factors such as human-induced disturbances, the birds reproduce at levels below those needed to offset annual mortality. Strip-cover habitats may attract birds that would reproduce at higher levels than those in fields, thus stabilizing regional bird populations. Achieving such a balance between agriculture and wildlife is a vital element of responsible land management.

Our study characterized vegetation types common in secondary roadsides adjacent to row-crop fields and evaluated avian use and nesting success in these areas. The objectives of the study were to 1) ascertain which bird species used roadsides and to what extent, 2) document nest-site selection and nesting success, 3) assess the influence of different vegetative characteristics in roadside and adjacent crop fields on bird use and nesting success, and 4) evaluate present vegetation management strategies relative to each of these objectives and suggest changes that will enhance avian use of roadsides.

Eighteen roadsides were censused and searched for nests between May and August 1990. Ten roadsides were composed of predominantly native prairie grasses, and eight were smooth bromegrass (*Bromus inermis*). Five native prairie and four smooth brome roadsides were burned in the spring. Fields adjacent to the study sites also were censused. Density, height, and percent canopy cover of vegetation were measured in roadsides throughout the summer.

Thirty-one species of birds were observed in roadsides, compared with 24 in fields. The relative abundance of birds in roadsides was 44 times greater than that in adjacent fields. There were no significant differences in bird species richness or overall bird abundance among treatment types, although a few species did show preferences for either burned or unburned roadsides. Less distinct preferences were exhibited by some species for roadsides with either native prairie or smooth bromegrass.

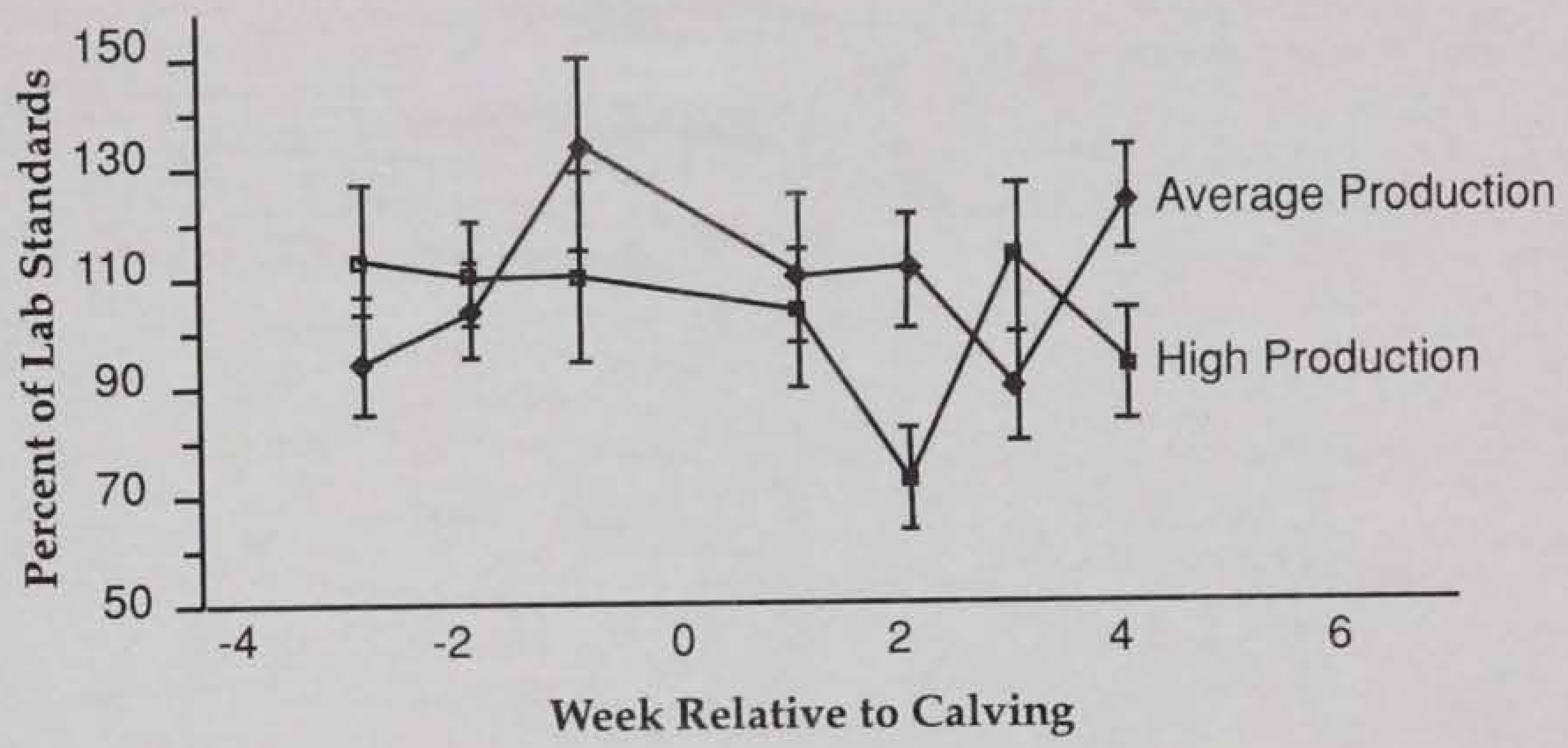


Figure 3. Lymphocyte Blastogenesis (PWM).

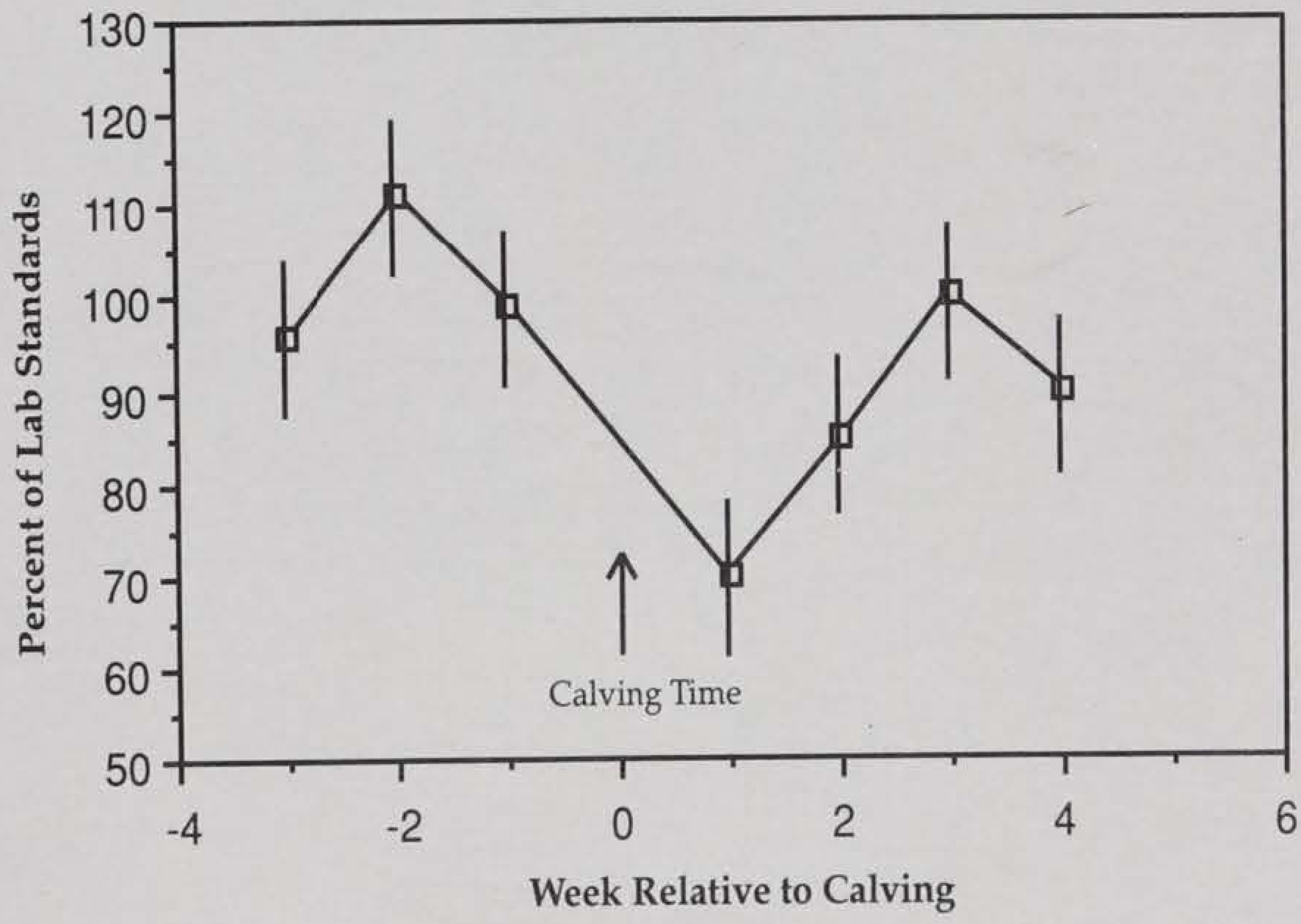


Figure 4. Lymphocytes Blastogenesis (PHAP).

Livestock Management

Improving disease resistance in dairy cattle through selection: Correlation of health disorders with immune status

A. E. Freeman, ISU; and M.E. Kehrli, Jr., USDA Agricultural Research Service

Ruminants, such as dairy cattle, are among the most profitable animals that can be maintained in a sustainable agricultural system. They consume large amounts of forage and produce large amounts of milk. However, high-producing dairy cows are particularly susceptible to increased health problems for which there are few or no vaccines.

Because many organisms are involved in diseases, such as mastitis and uterine infections, we are determining if cattle can be selected for increased general disease resistance, as opposed to specific disease resistance.

Many tests are used to assess the innate immune mechanisms of cattle. These tests measure migratory, phagocytic, and extracellular killing abilities of neutrophils; growth and division of T- and B-lymphocytes, which function in immune regulation and antibody production; serum immunoglobulin, complement, and conglutinin levels to evaluate activity of the soluble defense proteins; and BoLA types, which are genes known to be involved in disease resistance.

In the first phase, 95 cows were sampled in midlactation, and we found differences between selected lines and among sires for these tests. Also, the tests were associated with mastitis incidence and reproductive problems, and there was a genetic basis for these associations.

We are now in the process of sampling 150 cows four times before and four times after calving when more health problems occur. Our preliminary data (70 cows) for this second phase show that cows are immunosuppressed around calving time, and the high genetic group is immunosuppressed more than the average genetic group (Figures 3 and 4).

Preliminary results look favorable in this second phase of the work. Our ultimate goal is to prescreen dairy sires used in artificial insemination (AI) for health of their daughters. If our work is successful, it has great potential to reduce health problems in high-producing cows because about 70 percent of dairy cattle are bred by AI. Thus, costs of production would be reduced and the potential for contaminating milk and the environment with antibiotics and drugs would be reduced.

Optimal efficiency in the use of Iowa's energy, soil, and feed resources for beef production

J.R. Russell, D.D. Loy, D.R. Strobehn, S.K. Barnhart, J.A. Hallam, and M.S. Honeyman, ISU

In recent years, the number of forage acres has increased considerably in the Corn Belt because of government programs. Keeping these acres in soil-conserving forages, however, will require profitable, alternative production systems. Rotational grazing at increased stocking rates is one method to increase animal production and return per acre. Planting legume forage species also may reduce the need for nitrogen fertilizer in subsequent corn crops.

Summer grazing. Six, 5-acre alfalfa-grass pastures were grazed in one of two rotational systems, where cattle were moved regularly between sections of pasture, or in continuous grazing. The rotational grazing systems varied by stocking rate: a high-intensity system supported 5 cow-calf pairs/pasture and a low-intensity system used 3 cow-calf pairs/pasture.

During the grazing season, pounds of calf produced per acre were 34 percent and 41 percent greater on the high-intensity rotational system than on the continuous system or the low-intensity rotational system, respectively. The high-intensity system also produced 24 percent more total pounds of beef/acre than the continuous grazing system.

Rotational grazing significantly increased sward height and decreased the proportion of dead plant material in the available forages. Alfalfa-grass pastures under both rotational grazing methods had a significantly smaller proportion of grass and tended to have a larger proportion of legume in the live plant material than did alfalfa-grass pastures grazed continuously.

Grazing crop residue. Both continuous grazing and strip grazing of corn-crop residue were compared under various stocking rates. Fields were continuously grazed at stocking rates of 0.5, 1.0, and 2.0 acres/cow/month for 56 days. The cows also strip-grazed at a stocking rate of 0.5 acre/cow/month.

Cows strip-grazing at a rate of 0.5 acre/cow/month had weight gains near those of cows that continuously grazed at 2 acres/cow/month because strip grazing offers greater feed selection and greater dry-matter intake. Cows continuously grazing at 0.5 acres/cow/month maintained their bodyweights. Cows continuously grazing at lower stocking rates had greater weight gains.

During the study period, 39.6 percent, 26.9 percent, and 27.8 percent of crop residue dry matter disappeared from fields grazed at 0.5, 1.0, and 2.0 acres/cow/month, respectively. Total amount of dry matter loss did not differ between grazing systems at the same stocking rate. About 25 percent of crop residue dry-matter loss resulted from weathering.

Farmers may save money by grazing stockpiled forages and crop residues because about 30 percent of the cost of cow-calf production is associated with using stored feeds.

Social and Economic Implications

A comparison of three cropping systems at the Allee Research Farm

D.A. Grundman and M.S. Honeyman, ISU

Three cropping systems have been compared since 1987 in a replicated systems project near Newell, Iowa.

System I uses insecticides, herbicides, and commercial fertilizer at preventive or maintenance levels. A chisel-plow tillage system is used. No crop scouting, soil testing, or manure is used. Continuous corn and a 2-year corn/soybean rotation are being evaluated.

Under system II, management plays an important role. Soil tests are used to establish fertilizer and manure rates. Ridge tillage with banding of herbicides and crop scouting are part of the system. Continuous corn and a 2-year corn/soybean rotation are being studied.

System III uses a diverse rotation of oats, meadow, corn, soybeans, and corn silage with minimal use of insecticides, herbicides, or phosphorus and potassium fertilizers. Tillage rotations and livestock manure are used to replace these inputs. A limited amount of commercial nitrogen fertilizer is used whenever legumes and manure do not supply adequate nitrogen for corn production. Crop scouting and soil testing also are used.

The 3-year averages for returns to management per acre are: minus $57.65 for System I Continuous Corn, $32.76 for System I Corn/Soybean Rotation, $3.58 for System II Continuous Corn, $53.66 for System II Rotation, and minus $37.01 for System III. Comparisons involving System III over this time period are not appropriate because yields have not stabilized, but comparisons of Systems I and II show improved returns from the adoption of best management practices and crop rotations. Preliminary results from crop year 1990 show that these trends continue for Systems I and II, but returns from System III were very competitive.

Determining the influence of information on farming practices: A study of Big Spring Basin farmers

C.K. Contant and G.R. Hallberg, University of Iowa

This study identifies informational and educational factors that influence farmers' decisions when adopting sustainable agricultural practices. The Big Spring Basin (BSB) has been used for extensive groundwater investigations. During the past 4 years, extensive educational and informational programs have been implemented as part of the Big Spring Basin Demonstration Project. Evidence from past surveys of BSB farmers suggests that farming practices have changed.

To assess the influence of information and education on the adoption of sustainable farming practices, surveys will be conducted to determine: 1) which information is most influential in motivating farmers to change their practices, 2) which sources provide the most valuable information, and 3) which means of disseminating information is most useful. Comparisons on information usage will be made between BSB farmers, who have been exposed to a variety of intensive information efforts, and other similar Iowa farmers, who have not been exposed to such information programs. These comparisons will assist in understanding farmers' decisions regarding chemical use and the role of information in those decisions.

Increased use of agricultural chemicals has been recognized as a significant environmental, economic, and social concern. In response, public programs have been designed to educate farmers about sustainable agricultural practices. In these educational approaches, communication between governmental entities and the farmer is critical. Improving communication of sustainable farming information through trusted, valued, accessible, and useful sources is an important component in promoting changes in farming practices.

The findings will be important in guiding sustainable agriculture education and demonstration programs to provide accurate, useful, and influential information to farmers.

Alternative Pest Controls

Utilizing an entomopathogenic fungus, *Beauveria bassiana*, for season-long suppression of larval populations of the European corn borer

J.J. Obrycki, ISU; L.C. Lewis, USDA Agricultural Research Service and ISU

The European corn borer (*Ostrinia nubilalis*) causes an estimated $110 million in corn losses each year in Iowa. Presently, host-plant resistance and rescue treatments with chemical insecticides are used to suppress populations. But there are problems with these methods. It is difficult to recognize the borer problem, and there often is a lag time between recognition of the infestation and application of the insecticide. Sometimes, a second application is needed. With the increasing costs of chemicals and their application, the potential to contribute to nonpoint pollution of groundwater, and the potential damage to the ecosystem, it is imperative to develop environmentally compatible biological controls with long-term residual activity.

This study has been determining the efficacy of a naturally occurring fungus (*Beauveria bassiana*) in suppressing corn borer larvae. A commercially available biological insecticide (*Bacillus thuringiensis*) and a chemical insecticide, carbofuran, were included in the experiments. *Beauveria bassiana* alone significantly reduced the number of live corn borer larvae in the whorl of the plants and the amount of tunneling by the corn borer (Figure 6).

There was no antagonism between the commercial insecticides and *Beauveria bassiana*. Development of techniques that use such a natural fungus to manage the European corn borer could result in a single safe and effective application for season-long suppression.

Evaluation of an Integrated Pest Management program for northern corn rootworm extended diapause

J. J. Tollefson, ISU

The common Iowa crop rotation that alternates corn and soybeans each year may no longer control the northern corn rootworm (*Diabrotica barberi*). Research has demonstrated that some eggs of the insect do not hatch the first spring, but instead overwinter a second year. This is known as "extended diapause." In 1986, researchers attributed larval damage in rotated field corn to northern corn rootworms with the extended diapause trait. During 1987, damage by corn rootworm larvae in corn grown in an annual rotation with another crop, usually soybeans, made its third consecutive, dramatic increase.

The chance that farmers would control the insect by applying a prophylactic soil-insecticide to rotated corn caused the Leopold Center to support a 3-year survey of extended diapause in northwestern Iowa. The survey objectives were to determine the extent and seriousness of the problem and to develop an economic threshold for predicting management needs.

Corn in a biannual rotation in 35 northwestern Iowa counties was considered to be at the greatest risk of damage by extended diapause corn rootworms. In 1988, a stratified-random survey of the area was conducted. With help from the Iowa Department of Statistics, a random list of farmers was selected from each county.

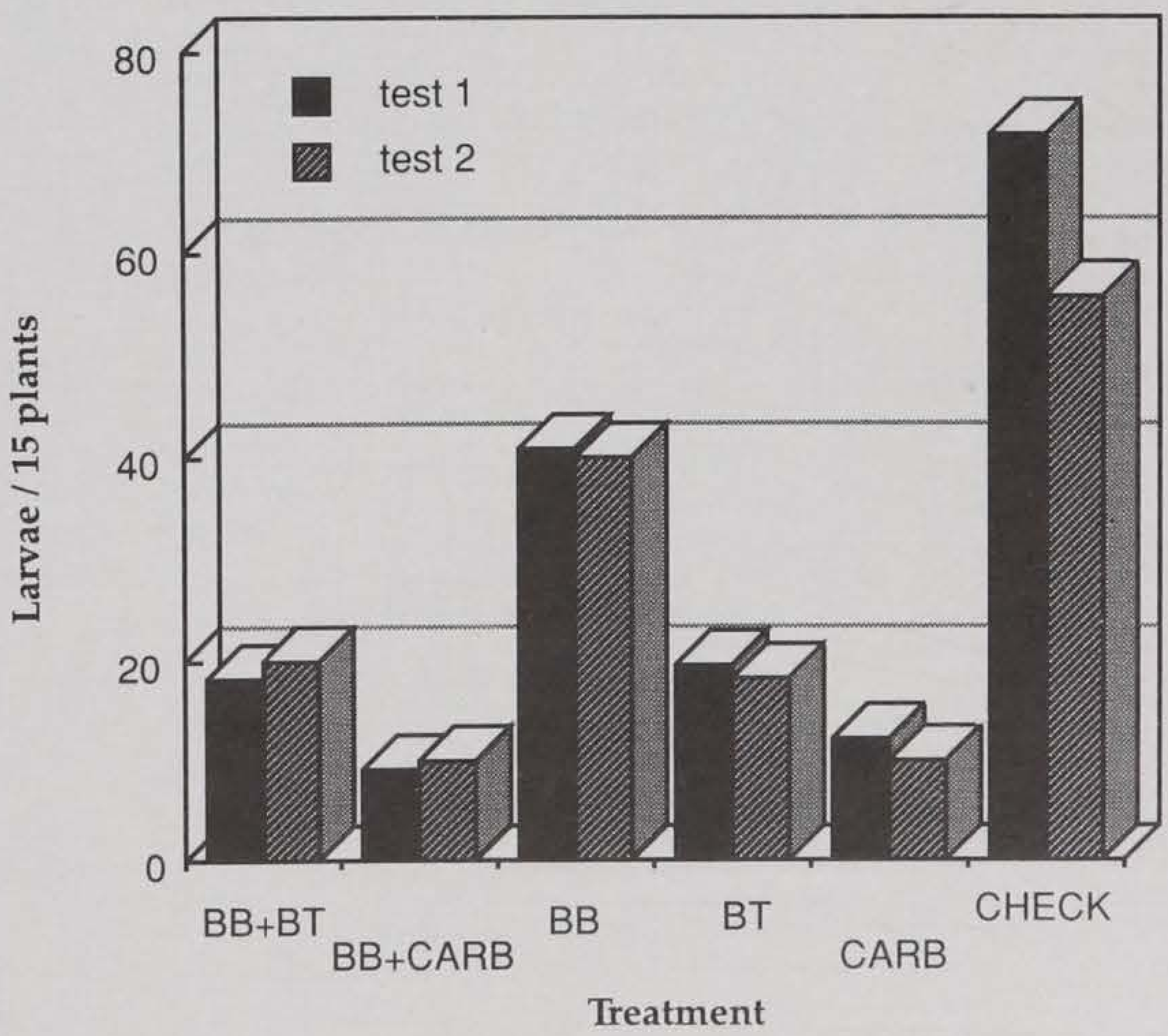


Figure 6. Effect of combining *Beauveria bassiana* (BB) with commercial insecticides and carbofuran on European corn borer larvae and tunnelling.

Three teams of two scientists each sampled for the presence of *D. barberi*. All but 2 of the 326 fields were sampled within 14 days in July. A field was considered to harbor a population of extended-diapausing *D. barberi* if there were northern beetles present and if corn roots showed evidence of larval feeding. Beetles were counted on 20 plants, and the densities were assigned to one of the following categories: 1) less than 1 beetle/plant, 2) 1 to 2 beetles/plant, 3) 2 to 4 beetles/plant, or 4) more than 4 beetles/plant. Because the larval stage could not disperse and the survey was conducted rapidly while adult emergence was approaching its peak, the presence of larval feeding was taken as evidence that the beetles counted had developed in that field.

To develop a damage-prediction threshold, 1990 larval damage had to be assessed in the same fields where beetle densities had been classified in 1988. Beetle densities were available from 192 fields sampled in the northern six counties in 1988. Larval damage was assessed in 185 fields in the same six counties in 1990. Most (152) of the fields had both beetle density estimates from 1988 and larval damage assessments in 1990. Larval feeding was classified by digging 20 plants and rating them on the Iowa 1-6 damage-rating scale with 1 representing no damage or slight scaring and 6 equalling severe damage with three nodes of roots completely destroyed.

A trend in the data can be demonstrated by assuming an economic root damage rating as 3 on the 1-6 scale and plotting root damage against beetle density (Figure 5). Although economic root damage did not occur when beetles were not found, damage could occur if fewer than 1 beetle/plant was found when the field was planted previously to corn. When beetle densities averaged greater than 4 beetles/plant, subsequent ratings of larval damage ranged from 1.0 (no symptoms on the 10 roots evaluated) to 4.1 (one node of roots completely destroyed). The damage was not surprising with such high beetle densities, but it was a surprise to farmers growing corn in rotation who had not experienced or expected rootworm infestations. As the density of beetles in a field increased, economic root damage in the subsequent planting of corn occurred more frequently.

This relationship is better demonstrated by subdividing the data and looking at the frequency distribution of the data by beetle density. When there were fewer than 1 beetle/plant, 3 of 49 fields sustained economic larval damage to the subsequent corn planting. Of the 30 fields with beetle densities between 1 and 2 beetles/plant, only one had root-damage ratings greater than 3 two years later. When beetle densities increased to 2 to 4 beetles/plant, the proportion of fields sustaining economic larval damage rose to 15 percent. With densities of more than 4 beetles/plant, larval control would have been justified in half the fields. In summary, economic corn rootworm larval damage in continuous corn was likely to occur when there was 1 beetle/plant the previous year. In an annual rotation where corn is planted regularly during alternate years, substantial risk of larval damage does not occur until more than 4 beetles/plant were present in the previous corn crop.

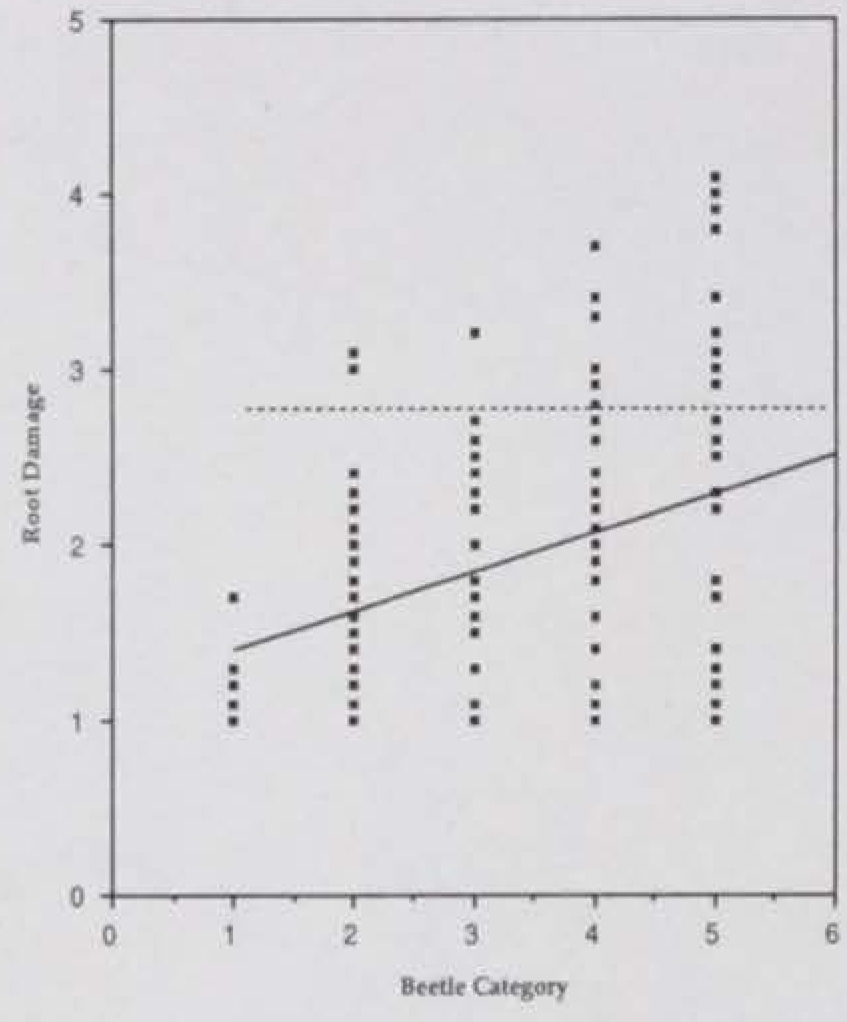


Figure 5. Relation of root damage to beetle densities.

Control of soil-borne plant pathogens with strategic use of animal manures

C.A. Martinson, ISU

Root-infecting fungi cause significant amounts of damage to soybeans and corn every year although their effects are often not recognized. Several pathogens may attack a single plant. Yield losses to specific root pathogens are measured inexactly in most cases because it is impossible to have disease-free controls and have only one pathogen acting in a natural environment.

One approach to controlling root pathogens is to stimulate or to facilitate natural biological controls by cultural manipulations of the soil environment that activate and support the growth of microorganisms antagonistic to the pathogens.

Organic amendments to the soil are used most often. Use of animal manure as an organic amendment for controlling plant pathogens is a logical approach, but there is little documentation that they have been investigated for this purpose. In theory, manure could directly affect survival of pathogen propagules, the level of fungistasis in the soil (the complex in soil that inhibits spore germination), the growth and activity of the pathogen before plant infection, and indirectly affect disease development in the plant. Direct toxicity of manure must also be considered. Manure applications are also known to increase root pathogen diseases. Timing, location, manner of application, and amount of manure can influence whether or not disease control may be expected. For example, fungistasis may decrease to a very low level soon after adding manure but reach a maximum 2 to 3 weeks later and then decline somewhat. Therefore, strategic use of manures could result in disease control, even if used on crops such as soybeans that are not normally manured.

The purpose of this research is to determine if liquid hog and chicken manures can be used to 1) reduce the survival of plant pathogens in soil, 2) increase soil fungistasis and inhibit pathogen spore germination near the root surface, and 3) inhibit and antagonize pathogen growth and development after spore germination as well as before and during the process of plant penetration.

Root diseases being investigated are caused by soil-borne fungi. These include *Fusarium graminearum* and *Helminthosporium pedicellatum*, which are common root rot pathogens of corn. The former is also a common stalk rot and ear rot pathogen. *Phytophthora megasperma* f.sp. *glycinea* incites Phytophthora root rot of soybean, a serious problem in wet and heavy soils. *Rhizoctonia solani* attacks primarily the lower stem and the tap root of the soybean plant and can cause seedling damping off. *Phialophora gregata* incites a wilt disease of soybeans commonly called brown stem rot that is a severe problem throughout Iowa.

This project began in July 1990. Initial experiments have focused on *Rhizoctonia solani*, the cause of damping off, root rot, and hypocotyl cankers in soybeans. Suppressiveness to *R. solani* was detectable 10 to 20 days after blending chicken and hog liquid manures into soils, with hog manure being the better of the two. The pathogen became inactive in manured soils within 30 days and would not invade baits placed in the soil or attack radish seedlings. The suppressiveness of *R. solani* remained in the soil for at least 3 months. Sclerotia of *R. solani* reinfested into the suppressive soils would not incite disease, although the germinability of the sclerotia in the soils was not affected. Suppressiveness associated with manuring evidently was not inhibiting propagule germinations but was affecting growth through soil and/or infection processes by *R. solani*. The suppressiveness was not related to soil populations of *Trichoderma viride*, a common antagonist of *R. solani*.

Techniques for isolating and quantitatively sampling these pathogens from soil, roots, and other tissues were studied for effectiveness. We used selective culture media for isolating the pathogens that were supposedly the best techniques available, based upon the literature. However, it was found that the media for isolation of *H. pedicellatum*, *P. gregata*, and *R. solani* were not adequate for this research.

Extensive research on possible additives to the media showed that the best selective medium to date for *P. gregata* is as follows: One 4-oz jar of strained green beans, 200 mg PCNB, 200 mg oxgall, 0.5 g gallic acid, 200 mg benzimidazole, 200 mg streptomycin sulfate, 20 g agar, and distilled water to make one liter. The best isolation medium for *H. pedicellatum* has been potato dextrose agar (PDA) amended with 200 mg benomyl, 1.0 g oxgall, 200 mg streptomycin sulfate, and 120 mg metalaxyl per liter. PDA amended with 200 mg streptomycin sulfate and 40 mg dichloronitroaniline per liter has been best for *R. solani* isolations. These media should help us to better achieve our research goals.

Reducing pesticide use in orchards through environmental monitoring for pest protection

M.L. Gleason, P.A. Domoto, D.R. Lewis, and M.D. Duffy, ISU

Pesticide spray strategies for control of apple scab, codling moth, and apple maggot were compared in the second year of a field study in a Red Delicious apple orchard. Spray timing was determined by five treatments:

1. Weather data (temperature, relative humidity, and leaf wetness) from an electronic data logger, interpreted by a modified Mills Table for apple scab, a degree-day model for codling moth and apple maggot, and insect trap captures.
2. Weather data from a strip chart recorder, interpreted as in treatment 1.
3. A traditional spray program timed by apple tree phenology and calendar date.
4. A prescheduled, 4-spray program for scab control, with insecticide timing as in treatments 1 and 2.
5. A control with no fungicides. Pheromone traps and bait traps were used to monitor for codling moth and apple maggot, respectively.

Drought prevailed in 1989, while 1990 was unusually wet. The Integrated Pest Management (IPM) treatments averaged six fewer pesticide sprays per year than the traditional treatment. Scab was absent during 1989, but foliar and fruit symptoms appeared late in the 1990 season. Codling moth was captured in both years, but fruit injury occurred only in 1989. Apple maggot was absent in both years. Yields were not significantly different among treatments 1-4, but were lower in the control (treatment 5).

Estimated costs of the IPM treatments were comparable to the cost of the traditional spray program. The IPM treatments had increasing cost advantages over the traditional program as orchard size increased. Return (total revenue minus cost of control of the target pests) for the IPM treatments was comparable to or greater than return for the traditional program.

Adapting predictive models to reduce fungicide spray on tomatoes in Iowa

M.L. Gleason, S.E. Taylor, M.D. Duffy, and H.G. Taber, ISU

TOM-CAST, a weather-based spray advisory system for fungal diseases on tomatoes that was developed in Ontario, Canada, was tested in field trials on processing tomatoes near Ames, Iowa. Fungicide was applied according to one of nine modifications of TOM-CAST, a traditional (weekly) schedule, or was not applied (controls). Plots were inoculated in July with the fungi that cause Septoria blight, early blight, and anthracnose fruit rot. In late August, plots were harvested and graded according to commercial standards.

Marketable yield in the weekly spray treatment was not significantly greater than that in several TOM-CAST treatments. Yield in most TOM-CAST treatments was not significantly different from unsprayed controls. One cause of this indeterminate result was a severe epidemic of bacterial spot. In addition, leaf wetness measurements input to TOM-CAST from sensors installed in lilac bushes underestimated periods of leaf wetness in the tomato canopy by an average of 3.7 hours/day from July 10 to August 21.

Analysis of weather data (duration of periods of leaf wetness and temperature during wetting periods) from monitoring stations located next to the field and 1, 5, and 12 miles away indicated that variation among the monitoring sites was relatively small. This variation seemed to be influenced more by differences in microtopography among sites than by the distance between the sites. The results suggest that weather data taken several miles from a tomato field may be adequate for making useful disease forecasts with TOM-CAST in central Iowa, if microtopographic differences among sites are minimized. If this hypothesis is verified by future field trials, weather could be monitored at centralized stations rather than in each tomato field.

A biorational approach to soybean cyst nematode management in Iowa

G. A. Kraus and G. Tylka, ISU

The soybean cyst nematode (SCN) was first discovered in Iowa in 1978. SCN has since spread to nearly half of the counties in the state and was detected in 77 percent of state-wide soil samples tested for SCN at ISU in 1989. This nematode is rapidly becoming a limiting factor in soybean production in Iowa. Nematicides and resistant soybean varieties have been used to manage SCN. However, the use of nematicides is not acceptable because of environmental concerns. Furthermore, soybean resistance to SCN has broken down. Ecologically sound alternatives are urgently needed for management of SCN and the yield suppression it causes.

Gylcinoeclepin A is a natural hatching stimulus for SCN. It has been extracted from roots in minute quantities and is incredibly effective, initiating hatching at the parts-per-trillion level. Gylcinoeclepin A should have enormous potential for managing SCN if it is used to initiate premature egg hatch in soils when conditions are not suitable for nematode survival and before soybeans are planted.

Gylcinoeclepin A will be prepared from readily available compounds, and a egg hatch test will be developed. Gylcinoeclepin A will be tested in stimulated egg hatch trials in the laboratory and later in greenhouse tests and field trials. Biodegradability of gylcinoeclepin A will also be evaluated. The results to date indicate that the entire molecular structure of gylcinoeclepin A may be required for activity.

Weed population dynamics in ridge-tilled soybeans with and without herbicides

T.W. Jurik, M.D.K. Owen, and A.D. Knapp, ISU

The effect of herbicide on weed populations and soybean yield was tested on three north-central Iowa farms in 1990, an extremely wet year.

Herbicide (Amiben, Dual, or Dual +Lexone) was banded in the row at planting in late May or early June in a ridge-tillage system. Corn had been grown the previous year in all plots. Three experimental treatments were used. Plots with herbicide received no or one rotary hoeing; plots with no herbicide received one or two rotary hoeings. All plots received two or three cultivations, depending on the farm.

Weed seedling emergence was highest in mid-June, with little seed germination occurring after late June. Mean densities of broadleaf weeds in early August ranged from 170 weeds/acre to 648 weeds/acre on plots with herbicide added but no rotary hoeing, from 20 to 676 weeds/acre on plots with herbicide and one rotary hoeing, and from 409 to 943 weeds/acre on plots without herbicide but with one or two rotary hoeings. Over all three farms, plots without herbicide but with rotary hoeing averaged 69 percent more weeds, while plots with herbicide plus one rotary hoeing averaged 42 percent fewer weeds when compared to plots with herbicide and no rotary hoeing. Over the three farms, there was no consistent pattern of differences in soybean yield for plots with or without herbicide.

Characterization of the rose rosette disease causal agent potential for biological control of multiflora rose

A.H. Epstein, J.H. Hill, and W.A. Miller, ISU

Multiflora rose (*Rosa multiflora*), a thorny shrub introduced from Japan about 100 years ago for conservation purposes, has become naturalized in Iowa and now significantly reduces the value of more than two million acres of nontilled land in Iowa. The cost of eliminating this pest in Iowa with conventional technology, primarily herbicides, is conservatively estimated at $40 to $60 million, with the associated potential for environmental damage to nontarget species and water quality.

This project identifies and characterizes the agent causing Rose Rosette Disease, develops methods of monitoring the spread of this causal agent in the environment, and documents the host range of this agent in the environment.

The results of our observations to date indicate that Rose Rosette Disease is highly effective in managing multiflora rose. In 5 years of greenhouse and field experimentation, we found no evidence to suggest that this disease moves to other genera of plants. It does infect hybrid tea roses but there seems to be a "preference" for multiflora rose. Native roses including "prairie rose" do not appear to be vulnerable to attack.

Progress has been made in characterizing the causal agent, and several sensitive probes (cDNA) have been made that will enable detection of the presence of the causal agent in multiflora rose and other plants growing in their vicinity. These are now being rated for efficacy. We expect that the most sensitive of these will be ready for testing in the field in 1991.

Using potential weed pressure to improve efficiency of weed management programs

R.G. Hartzler and T. Smidt, ISU

Current weed management programs for corn and soybean production rely heavily on both tillage and herbicides. Although these programs have minimized losses associated with weeds, there are problems with current weed management systems. Environmental safety of pesticides, reliance on external inputs, and soil erosion from intensive tillage are major concerns stemming from current production systems.

Development of efficient weed management systems is a critical step in the adoption of sustainable agriculture practices. A key aspect involves adapting the program to specific weed problems in individual fields. Management programs based on the use of preemergence herbicides often fail to consider this factor, and weed control is based on worse-case situations. Because of this, many growers may use more inputs (either tillage or herbicides) than necessary to achieve acceptable weed control.

This project is evaluating the ability to predict weed pressures based on seed density in the upper 6 inches of soil and to use these predictions to modify weed management programs. The research is conducted on farmers' fields in Butler County as part of the local Integrated Crop Management program. Each site has detailed field records for the past 3 growing seasons.

Preliminary results showed wide variations in weed-seed numbers between fields. The accuracy of seed counts for predicting weed pressures will be evaluated in 1991. Relationships between weed populations and the effectiveness of control strategies to both weed-seed numbers and past field history also will be studied. Information from this research should allow farmers to more accurately estimate potential weed pressures in their fields and help them to adjust management programs accordingly.

Sustainable weed control system using natural product allelochemicals to replace conventional herbicides in maize (*Zea mays*)

J. Dekker, R. Cruse, and R.G. Burmester, ISU

There are chemicals produced naturally that will kill other plants. Allelopathy is the production of these natural inhibitors (allelochemicals) of plant growth. But using natural products for weed control is not a simple task.

Studies were conducted to determine the feasibility of using an allelochemical derived from corn grain as an alternative to synthetic herbicides to control weeds in crop fields. Various rates of the corn allelochemical from 0 to 90,000 lbs/acre were applied to small plots near Ames, Iowa.

In general, pigweed (*Amaranthus* spp.) was the most resistant to the corn natural product, whereas soybeans and foxtail (*Setaria* spp.) were the most sensitive. Corn was sensitive at low rates of the allelochemical, but relatively more resistant to high rates than the other species. This may indicate the possibility for natural resistance mechanisms in corn that could be exploited for enhanced crop safety. Injury to sensitive species occurred at rates as low as 675 lbs/acre (soybeans, foxtail spp.), while effective weed control required as much as 76,000 to 87,000 lbs/acre (corn). These results were mitigated by two factors: They were tested under noncompetitive field conditions, leading to poorer weed control; and 1990 was a very wet year, leading to greater weed control and crop injury.

These results indicate that this natural product may have potential as a weed control agent, especially for foxtail spp. control in corn. Limitations to its use include crop safety and the cost of using effective amounts of the allelochemical.

DeSoto National Wildlife Refuge demonstration and education project

M. Buske and G. Guge, ISU; T. Root and G. Gage, U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service initiated a low-input farming system at the DeSoto National Wildlife Refuge in 1979. This system includes a forage legume (usually sweet clover), corn, and soybean crop rotation. No nitrogen fertilizer is applied to the corn because it is assumed the forage legume will supply sufficient nitrogen to achieve optimum yield.

Insecticides and many commonly used herbicides, such as triazines, alachlor, and metolachlor, cannot be used on refuge farmland. Instead, mechanical weed control is encouraged.

The low-input farming system was adopted to limit nutrient loading and pesticide contamination of the refuge ecosystem and improve wildlife habitat. However, agricultural activities on nearby private cropland can periodically have a negative impact on the refuge. Tools such as soil testing and Integrated Pest Management (IPM) can improve crop management decisions on private as well as on refuge cropland.

The project primarily demonstrates that crop scouting and soil testing are important tools for profitable and environmentally responsible farming. We wish to refine crop management decisions on both private and refuge cropland and use these tools in a manner consistent with refuge objectives. We are also comparing the productivity and profitability of the low-input systems to a more conventional corn-soybean crop rotation. Other activities include monitoring surface and groundwater for pesticides and nitrate, establishing an alfalfa weevil parasitoid insectary, documenting local production practices, and extending project activities to local crop producers, local agribusinesses, private organizations, public agencies, and the general public. In 1990, about 1,100 crop acres involving 11 farm units were scouted.

Nutrient management. Nutrient management studies included testing refuge and nearby private cropland for available phosphorus and potassium. Soil-test levels of potassium were very high in all fields sampled. Soil-test levels of phosphorus were very low to low in 80 percent of fields sampled. This indicates that fertilizer potassium was not needed for maximum economic yield, but fertilizer phosphorus was needed in most fields sampled.

Low-input fields were sampled in 1988 and 1989 to evaluate the nitrogen contribution of one year of sweet clover to the following corn crop using the late-spring soil nitrate test. Average soil test values in 1989 were 14 ppm (mg/kg) nitrate ranging from 10 ppm to 22 ppm. Only 1 field in 11 did not require additional fertilizer nitrogen. 1990 soil test values averaged 22 ppm nitrate and ranged from 7 ppm to 41 ppm. Five out of 9 fields did not require additional fertilizer nitrogen.

Water quality. Surface and groundwater water were monitored for nitrate (detection limit = 1 ppm [mg/L]) and several herbicides commonly used in Iowa. These included atrazine, bentazon, cyanazine, metolachlor, eptam, alachlor, metribuzin, butylate, and trifluralin. Also, water samples were analyzed for specific insecticides when detections were considered likely.

Nitrate detections were found infrequently in surface and groundwater. Maximum concentration was 3 ppm (mg/kg). However, nitrate has been consistently detected in the soil profile below the normal crop root zone. Concentrations ranged from 15 ppm to 106 ppm (mg/kg).

Alachlor, atrazine, cyanazine, eptam, metolachlor, and metribuzin have been detected in shallow groundwater. Detections were seasonal, corresponding to peak herbicide use periods. All detections were less than 0.7 ppb. Curiously, of the herbicides detected, only eptam is approved for use within the refuge.

Atrazine and cyanazine were consistently detected in DeSoto Lake throughout the year. Maximum concentrations were 1.5 ppb for atrazine and 0.48 ppb for cyanazine. Alachlor, eptam, and metolachlor have been infrequently detected at concentrations near the analytical detection limit of 0.1 ppb. Detections of alachlor, eptam, and metolachlor are seasonal.

Agricultural runoff in drainage ditches that discharge into DeSoto Lake was analyzed for nitrate, commonly used herbicides, and occasionally for specific insecticides. Herbicides detected and maximum concentrations recorded are as follows: alachlor (37 ppb), atrazine (66 ppb), bentazon (17 ppb), cyanazine (0.48 ppb), eptam (13 ppb), metolachlor (58 ppb), and trifluralin (0.67 ppb). The insecticide carbofuran was detected in runoff at 0.11 ppb shortly after it was aerially applied in nearby cornfields for European corn borer control.

Crop yields. Corn yields were highly variable. Yields from the low-input crop rotation averaged 113 bu/acre. Conventional crop rotation corn yields averaged 109 bu/acre. Soybean yields average 36 bu/acre in the low-input crop rotation and 35 bu/acre in the conventional crop rotation.

Controlling alfalfa pests. The larval parasite, Bathyplectes annurus, and adult parasite, Microctonus aethiopoides, were released in refuge alfalfa fields in 1988 and 1989, respectively. Alfalfa fields were surveyed in 1990. Five larval parasite species were collected. These include *Bathyplectes curculionis, Bathyplectes annurus, Microctonus aethiopoides, Microctonuse colesi,* and *Tetrastichus incertus.*

Nitrogen Management

Operating procedures for use of the late-spring soil test by fertilizer dealers as consultants in Iowa

A.M. Blackmer, ISU

The late-spring soil test for nitrate shows great promise as a tool for improving nitrogen management in Iowa. The problem addressed in this project is that many details in operating procedures still need to be established before this test is ready for widespread use in production agriculture. ISU researchers and Iowa fertilizer dealers are working together to identify and solve potential problems in implementing the test before these problems hinder its acceptance.

In 1990, the dealers established replicated strip plots in 41 farmers' fields to compare nitrogen rates indicated by the soil test with those of the farmers' normal practices. The average fertilizer nitrogen rate of the farmers' normal practices was 131 lbs/acre, and the average nitrogen rate for the soil test treatment was 104 lbs/acre. Corn yields averaged 137 bu/acre for both treatments. These data indicate that the soil test performed satisfactorily despite the unusually wet weather of 1990.

Results showed the importance of applying some fertilizer nitrogen before planting to avoid extreme nitrogen deficiencies early in the season. There was a loss in yield potential that was not reversed by sidedressing nitrogen in fields where the late-spring soil test indicated that nitrate-nitrogen concentrations were less than 10 ppm (mg/kg).

When fields having these extreme nutrient deficiencies were not considered, the soil test did extremely well. In these fields, the average fertilizer nitrogen rate for the farmers' normal practice was 126 lbs/acre, and the mean rate for the soil test treatment was 84 lbs/acre. Grain yields averaged 132 bu/acre for the farmers' normal practice and 139 bu/acre for the soil test treatment. The results of these and other studies continue to show that proper use and interpretation of the late-spring soil test has great potential for reducing inputs of fertilizer nitrogen without lowering yields.

Optimizing microbial associations to enhance nitrogen and phosphorus soil nutrient availability

T.E. Loynachan, H.S. McNabb, and S. Khalil, ISU

This project is studying soil microorganisms that help plants use soil nutrients more efficiently: Rhizobia, which are bacteria that live in nodules on legume roots and fix atmospheric nitrogen so it can be used by the host plant, and mycorrhizae, which are fungi found in plant roots that absorb phosphorus in the soil and transmit it to the plant. This research is investigating the interrelationships of these two soil organism associations with the soybean plant. The soybean plant is being used because of its importance in Iowa agriculture. However, the findings may apply to other leguminous crops.

Soils are frequently deficient in nitrogen, phosphorus, and potassium. The contribution of nitrogen from atmospheric nitrogen fixation and phosphorus from mycorrhizal (plant-fungal) associations are well documented. Little is known, however, about the extent of mycorrhizal colonization of field-grown soybeans and other legumes. This research attempts to verify the ecological and physiological factors affecting this close association of plant fungus and bacteria. Nitrogen fixation and phosphorus uptake efficiency may be increased by taking advantage of this biological system. Field surveys to determine the types and extent of colonization of mycorrhizal fungi and bradyrhizobia occurring in Iowa soybean fields have shown widespread presence of both. Mycorrhizal fungi were found in association with soybean plants from most of the soils sampled. Four fungal genera were found in association with the soybean rhizoshpere, of these a *Glomus* spp. was the most prevalent. Research is being continued to determine the benefits of these organisms acting in concert and whether differences exist among genera.

Implementing nitrogen management to protect Iowa's groundwater

K. Kohl and S. Melvin, ISU; J. Hultgren, Farmer

Nitrogen is an important crop nutrient, but excess soil nitrogen from any source can contaminate groundwater. To help farmers reduce potential nitrate contamination of groundwater, demonstration plots were established to promote better nitrogen management using the late-spring soil nitrate test developed by researchers at ISU.

The late-spring nitrate test was used on corn demonstration plots to analyze tile water under each plot. Two treatments were evaluated—the farmer's standard nitrogen management and management based on recommendations of the soil test. Additional demonstrations on plots were set up on other farms to promote use of the test for nitrogen management.

Corn yields were not significantly different during 1989 and 1990. No nitrogen was applied in 1989, and 173 pounds were applied in 1990 on the late-spring test plot. This compares to 263 pounds and 193 pounds applied on the farmer's plots in 1989 and 1990, respectively.

Preliminary findings indicated that nitrate-nitrogen levels in soil water under the farmer's plots were 1.5 to 2.9 times the 10 ppm Environmental Protection Agency standard for drinking water during the 1990 crop year (Figure 7). Soil water under the test plots fertilized according to the soil test recommendations contained less nitrate-nitrogen. However, only 2 of 10 samples were below 10 ppm.

Monitoring and modeling cropping system nitrogen for a sustainable agriculture

D. Vander Zee, R.J. Vos, and C.L. Goedhart, Dordt College

Modern-day agriculture has become heavily dependent upon commercial nitrogen

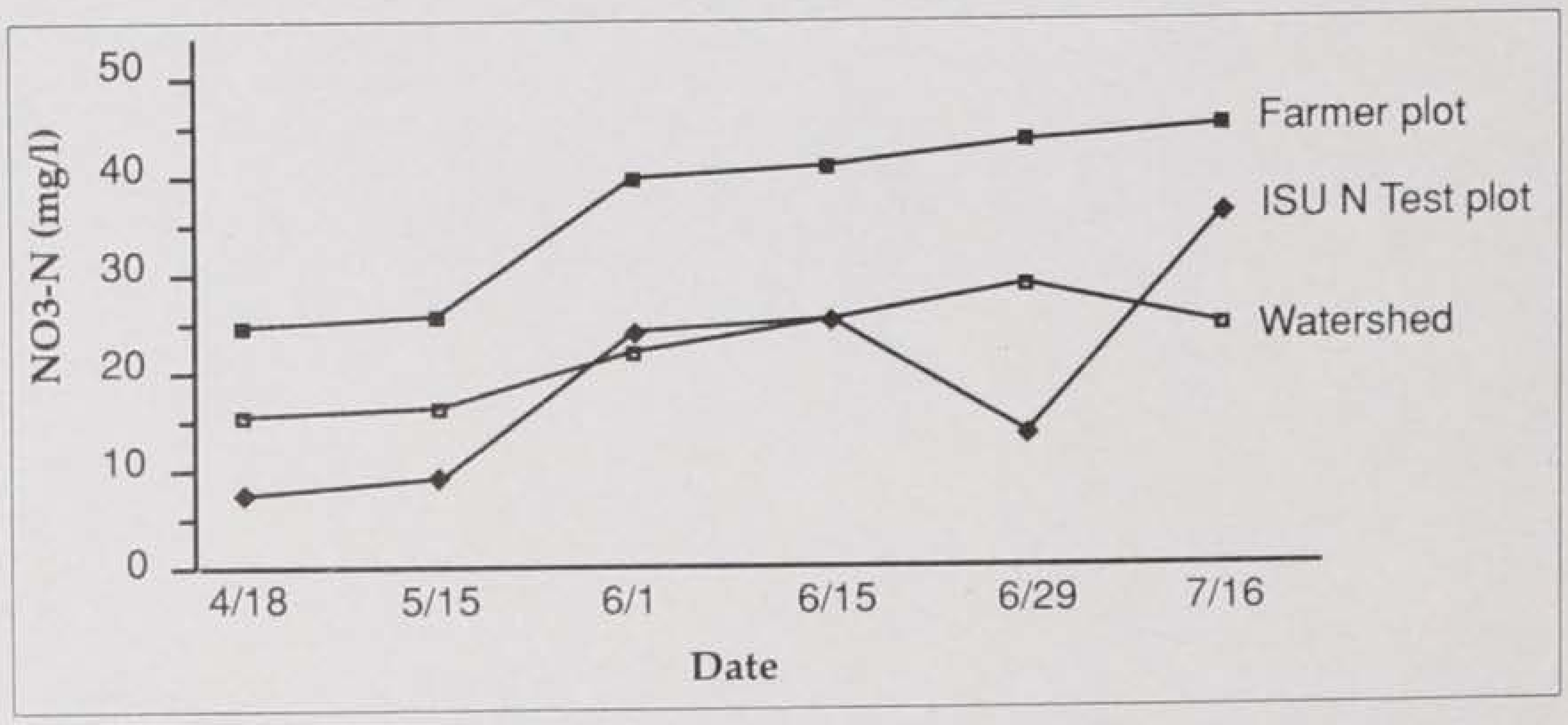


Figure 7. Water quality data for farmers' plots, ISU nitrate plot, and a 60-acre watershed containing the plots and other corn and soybean fields, 1990.

for maintaining soil fertility. Because nitrogen levels in soils have not been regularly tested in the past, overapplication of fertilizer and subsequent nitrate contamination of water resources is a problem in Iowa.

Researchers are monitoring the use and movement of nitrogen in soils, making on-farm decisions for timely and prudent application of commercial and manure sources of nitrogen, and developing a cropping strategy for using and retaining soil nitrogen.

Results from the first two cropping years show that average soil nitrate concentrations in all but an alfalfa plot exceeded the concentration required for optimal corn growth, 22 ppm (mg/kg).

The analysis of groundwater in eight wells at four field sites showed that all wells had some nitrate contamination ranging from 1 to 29 ppm (mg/L) nitrate-nitrogen.

Soil suction lysimeters under corn at 4.9 feet (1.5 m) deep showed very high nitrate levels in the leachate. Soils under alfalfa down to 3.3 feet (0 to 1 m) deep had soil-nitrogen levels significantly below those found in soils under corn or soybeans. Measurements from alfalfa fields in four locations (and different age stand) indicate that alfalfa might be useful to remove excess nitrogen from soils. This suggests the importance of including alfalfa in temporal or spatial rotations with other row crops in the total cropping system.

Soil Conservation

Fall-planted spring oats: A low-risk cover crop to reduce erosion following soybeans

S. J. Corak, ISU; T. C. Kaspar, USDA National Soil Tilth Laboratory; and R. Horton, ISU

Soil erosion during a corn-soybean rotation is often greater than during continuous corn. Loss of residue cover after soybean harvest exposes soil to the impact of raindrops. This, coupled with a deterioration in soil aggregate stability associated with soybean cropping, results in dispersion and transport of soil particles.

Water infiltration decreases as dispersed particles clog water-conducting pores. Consequently, runoff increases. The cumulative effect of these processes is accelerated soil erosion. Use of a cover crop following soybeans might reduce erosion.

A state-wide study was initiated in Iowa during 1990 to evaluate fall-planted spring oats as a management option for reducing erosion following soybeans. Above-ground dry matter produced by oats before winter-kill will supplement and anchor residue remaining after soybean harvest. Furthermore, because oats do not overwinter, the risk of moisture depletion should be minimized and no herbicides will be needed to kill the cover crop.

Several experimental sites were used. Oats were planted with a no-till grain drill on the farms of two Practical Farmers of Iowa members in Grundy and Des Moines counties, Dordt College's Agricultural Stewardship Center Farm in Sioux County, and an ISU farm in Boone County. Three other planting methods were tested at the ISU location. These were: broadcasting oats into the soybean crop at the beginning of leaf drop, broadcasting oats immediately before soybean harvest, and broadcasting oats immediately after soybean harvest. Plant population, dry matter production, and soil surface cover were determined at 4 to 7 weeks after planting.

At Boone, satisfactory results were achieved by either broadcasting oats into soybean at the beginning of leaf drop or drilling oats immediately after soybean harvest. Above-ground dry matter production for these two treatments was 179 and 148 lbs/acre, respectively, when sampled on November 1.

An adequate stand, but poor growth, was obtained when oats were broadcast immediately ahead of the combine. Broadcasting oats after the combine resulted in a poor stand and poor growth. Growth of drilled oats at Boone was nearly three times greater than that at any other location probably because of earlier planting. Use of the drill reduced total soil surface cover immediately after oat planting.

Oat plants resulting from the early broadcast and drilled treatments covered 12 percent of the soil surface at Boone. This was from 2 to 4 times greater than the coverage provided by oats at other locations. Regardless, oats did not significantly increase soil surface cover at this sampling date. Soil surface cover will be measured again in early spring. Residues from the oat plants seem to be providing some additional soil surface cover. Oat roots might also help reduce erosion by anchoring surface residues and soil.

Changes in soil structural characteristics following establishment of prairie grass

P. Christiansen, Cornell College; and M.L. Thompson, ISU

Intense cultivation of soil leads to disturbance of native soil structural characteristics, lower organic matter, and increased soil compaction and erosion. This project attempts to determine the rates at which soil structural characteristics change after removing fields from cultivation and seeding them to warm-season prairie grasses.

Soil samples were collected from sites in eastern Iowa that had been planted to prairie grasses for 2, 4, 15, and 24 growing seasons and from adjacent, annually cultivated sites. Total organic carbon content, pH, and wet aggregate stability were generally higher in soils where grasses were growing. Though initially depressed, soil structural stability in surface horizons became greater in the prairie soils after 15 years of grass establishment.

The amount of biomass in shoots at sites seeded to grass was significantly greater than the cultivated counterparts after 4 years of prairie growth. After 24 years of growth, however, shoot biomass had declined to levels similar to that of annually cultivated and native prairie sites. The amount of root biomass at sites seeded to grass had attained levels similar to that of virgin prairie after 15 years. In each instance, root biomass was greater at the prairie sites than at the cultivated sites

Microscopic and image analysis techniques will be employed in 1991 to quantitatively determine the influence of prairie grass establishment on porosity and structural development in soils.

Cropping Systems

Strip intercropping rotations

R.M. Cruse, and M.D.K. Owen, ISU; D.C. Erbach, USDA Agricultural Research Service

This project is developing a cropping system of multiple crop rotations that are economically feasible for a cash-grain farmer. Multiple aspects of cropping systems were studied using strip intercropping, conservation tillage, and crop rotations. Strip intercropping grows crops that are ecologically and physiologically complimentary in contiguous strips to maximize the efficiency of available resources.

This approach often enhances production. For example, in the border position of corn and soybean strips, corn yield increases of 30 to 40 bu/acre have been observed with concurrent soybean yield reductions of only 3 to 4 bu/acre (*Francis et al. 1986*). Under favorable growing conditions both corn and oats yields increased in the corn-oats strip border. Adding legumes to the rotations contributes nitrogen to the system, improves soil physical properties, enhances yields from the rotation effect, potentially reduces pest problems, and improves soil conservation. Conservation tillage in the system may reduce energy consumption and reduce soil loss.

1989 and 1990 results. Research was conducted at the McNay Research Farm near Chariton in southern Iowa, and on the Tom Frantzen farm near Altavista in northeastern Iowa. Table 1 shows monthly precipitation at the McNay farm during 1989 and 1990. In 1989, there was a water shortage during June, July, and most of August. This added to a low soil-water content carry-over from the dry conditions in 1988. In 1990, the situation reversed completely, and most of the time water availability was adequate to excessive.

The results presented here are averaged over the three tillage systems (conventional, reduced, and no-till).

Corn yields were reduced along the oats-alfalfa border in the dry year of 1989. This position had lower soil- water contents over the season because of the extraction by the oats in the adjacent strip during the spring. Corn ears had fewer and smaller kernels in this position.

In 1990, there were no differences in soil water content due to position in the corn strips. Increases in ears/plant, kernels/ear, and kernel size resulted in higher yields in the border rows.

Oat yields in 1989 were higher in the border 3-ft sections than in the center section. The center section had less soil water during May, June, and early July, probably because of more competition for soil water in the center than in the border of the oat strips. In addition, it should be considered that the border zones of the oat strips, compared with the center, have less competition for any growing factor.

In the wet year of 1990, the row-by-row oat yields show both the positive border effect and the lower yields in the wheel tracks. The soil-water content change by position in oats was not shown because, as in corn, it was quite high throughout the season.

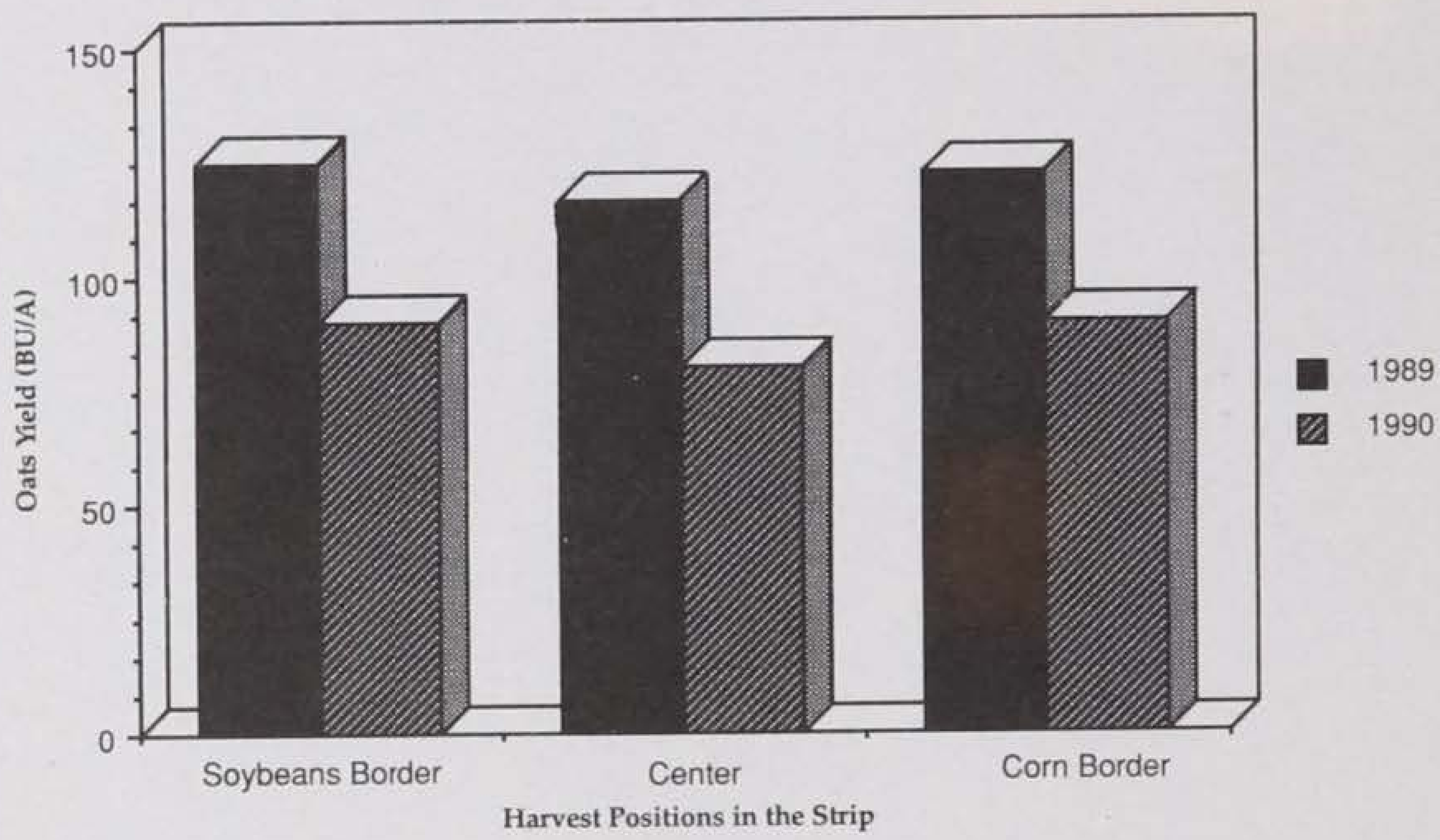


Figure 8. Oat yields as affected by row position in the strip, Frantzen farm, 1989 and 1990.

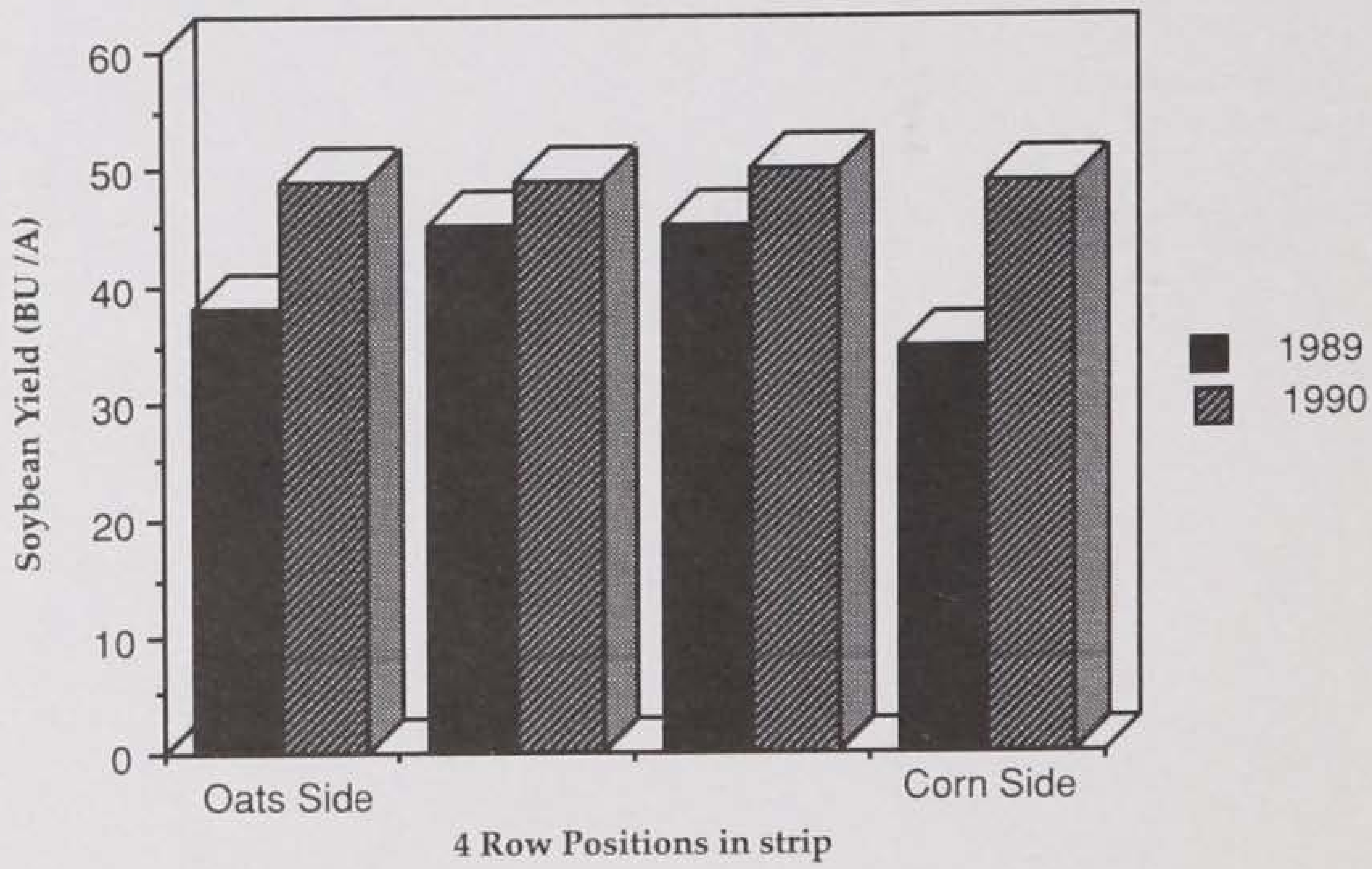


Figure 9. Soybean yields as affected by row position in the strip, Frantzen farm, 1989 and 1990.

Soybean yields, like corn yields, were lower in 1989 beside the oats-alfalfa border, due also to lower soil-water content in this position. In 1990, soybeans yields were lower beside the corn border because of competition for light imposed by the corn.

Corn yields in the four row positions on the Frantzen farm are shown on page 19 of this report. In 1989, the positive border effect, as at the McNay farm, was present in the border with soybeans, but was not present in the border with oats/alfalfa. The agreement between the results of these two distant experiments was probably caused by the same effect: Lower soil water availability in the border with oats/alfalfa.

In 1990, with higher water availability, corn yields showed positive border effects at the Frantzen farm. Figure 8 shows that oat yields tended to have positive border effects both years at this site. In 1989, the differences were significant only at the 13 percent level.

A management problem was present both years at the Frantzen farm. During the first cultivation of the row crops, one or two border lines of oat strips were taken out at several locations along the strips. This not only increased the experimental error but likely resulted in underestimation of the yields in the border sections, as can be inferred from the row-by-row yield evaluation of the McNay farm in 1990.

Soybeans yields at the Frantzen farm (Figure 9) showed a depression in the border rows in 1989 but not in 1990. This suggests that water availability was the most important factor interacting with the occurrence of the border effects between the crops of the rotation, as indicated by the literature of earlier research in strip cropping of corn with soybeans or drybeans (*Francis et al. 1986, Whigham and Bharati 1986*).

Nevertheless, we compared the performance of the border rows with the center rows. For soybeans, a 7-year Minnesota study (*Radke and Hagstrom 1976*) consistently showed higher yields of the center rows of strips alternated with two rows of corn, as compared with just soybeans. This was shown to be caused by a "windshield" effect of the corn rows, which improved the water relations of the soybean rows away from the border. Therefore, it is possible that in the narrow strips in our experiments, an increase in yield of the center soybeans rows could compensate for the yield depression in the borders.

The positive border effects in corn, within the strip intercropping rotation under study, were present when water was not greatly limiting yields. In contrast, the positive border effects in oats will usually occur because the borders of the oat strips have virtually no competition for water, light, and nutrients up to the stage of late grain filling. Similar to corn, soybeans yields were reduced in the border with oats under dry conditions, but not affected by the oats border with adequate moisture. In general, the yield of the soybean row beside the corn border was reduced, but information in the literature indicates that this effect could be compensated by higher yields of the center rows due to "windshield" effects.

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Model Farms Demonstration Project

G. Miller, ISU

Environmental and economic concerns in recent years have increased public pressure on Iowa farmers to develop more sustainable production methods. Knowledge and technology are available to make substantial improvements in the environmental and economic efficiency of crop and animal production. Yet farmers are reluctant to change to new, refined management practices both because of uncertainty about details of the technology and economics and because of an inertia resulting from the past several decades of development of current production systems. In statewide surveys, a large majority of farmers indicate concern for the environment and a desire to change, if necessary, to more environmentally safe management practices.

The process of voluntary change, however, will require that farmers become more familiar with emerging crop and livestock management systems that are shown to work in their area. They must be confident that the new practices are economically viable under conditions similar to their own operations.

The goal of the Model Farms Demonstration Project is to accelerate the voluntary adoption of sustainable farming practices that reduce unnecessary use of fertilizers and pest-control chemicals, reduce agricultural consumption of non-renewable energy resources, and improve soil conservation and management through appropriate tillage systems and recycling of animal-manure nutrients.

The state-wide project, authorized by the Iowa legislature in 1989, established concentrated demonstration and education programs in five areas of the state. Each area focuses on refined, sustainable farming systems appropriate to local soils and landscape characteristics.

The Leopold Center, a principal cooperator in the project, supported the development of conservation tillage and pasture and forage management demonstrations in southeastern and south central Iowa. Along with demonstrations on private farms with local farmers as cooperators, an intensive information effort was started in those areas.

A bimonthly project newsletter, "The Inside Edge," news releases to local newspapers, and interviews with project staff and cooperators on local radio and television programs were used to help increase public awareness of the project and keep cooperators and other interested citizens informed of progress and results.

Publicity also serves technology transfer by encouraging interested farmers to attend field days and meetings where they gain first-hand experience with the new management techniques.

The south central region project includes work in Lucas, Wayne, Clarke and Monroe counties. A full-time pasture and forage management specialist, Gene Schmitz, coordinates the project, with assistance from a project communications specialist, area Extension crop and livestock specialists, the Model Farms Project coordinator, and scientists from Leopold Center research teams on livestock, forages and human systems. In 1990, forage production and pasture improvement demonstrations were established with 16 farmer/cooperators.

Associated field days held in 1990 included: Rotational grazing to increase forage quality and feed efficiency; establishment and management of tall fescue, a cool-season grass, to provide higher-quality forage for grazing in late fall; forage and pasture improvement by legume interseeding and fertility management; determination of the feed value of cornstalks for grazing cattle; alfalfa establishment; and testing of new cultivars for increased feed quality and use in buffer strips.

Results from the first year showed no-till establishment of alfalfa/bromegrass into corn-stalk residue was as efficient as more conventional seeding methods and greatly reduced erosion potential on the seeded acres. In addition, the value of hayland fertility management was proven by a 390 percent and 550 percent increase in hay production with the addition of, respectively, 100 or 200 lbs/acre of a 24-11-11 fertilizer mix on the local, low-testing soils.

The southeast region project is located in Des Moines, Louisa, and Washington counties. The Des Moines County crop production specialist coordinates the project, with assistance from a project communications specialist, county and area Extension staff, the Model Farms Project coordinator, and ISU Extension cropping systems specialists. The seven on-farm demonstrations focus on integrating sustainable crop production and farm management with reduced tillage practices in the somewhat poorly drained soils of the area.

On-farm tillage comparisons include conventional (moldboard plow), deep tillage, reduced till, ridge till, slot, and no-till. Project newsletters and field days also cover related long-term tillage research carried out by the Southeast Conservation Tillage Research Project, the Southeast Research Center near Crawfordsville, and the Southeast Area Community College. Results from the first crop year showed no significant difference in yield of either corn or soybeans under reduced tillage management compared with conventional tillage. Project field days gave local farmers the opportunity for hands-on experience with residue measurement and the presidedress late-spring soil nitrate test, two major new management improvements for conserving soil and reducing excess fertilizer application.

Renovation of established switchgrass with forage legumes

J.R. George, ISU; D.R. Buxton, USDA Agricultural Research Service and ISU

Iowa forage and livestock producers consistently experience a midsummer slump in pasture supply with cool-season grasses. Switchgrass (*Panicum virgatum* L.), a native warm-season prairie grass, offers promise for filling this serious shortfall in available forage. As for any productive grass, switchgrass has a relatively high nitrogen requirement for high yields of top-quality forage. Iowa producers historically have not adequately fertilized grass pastures with nitrogen. Overfertilization also leads to environmental concerns. Forage legumes are a potential solution to these concerns. Research has demonstrated that established cool-season grass swards produce high yields of quality forage when renovated with legumes. Similar studies, however, have not been conducted with tall-growing, vigorous, and competitive grass species, such as switchgrass.

The primary objective of this study is to 1) identify legumes that are compatible with the vigorous growth habit of switchgrass, 2) determine effective methods for successful establishment and maintenance of economic densities of these legumes in established switchgrass, and 3) measure the impact of legumes on resulting forage yield and quality compared with that for nitrogen-fertilized switchgrass. Additionally, early partial defoliation of switchgrass is being evaluated, not only as a management tool to improve the midsummer pasture role of switchgrass, but as a method to minimize competition by switchgrass and enhance legume seedling establishment and legume stand persistence. Experiments underway or planned include:

1. Eleven forage legumes will be interseeded into established switchgrass and results compared with nitrogen-fertilized switchgrass.
2. Six forage legumes will be frost-seeded into established switchgrass and results compared with nitrogen-fertilized switchgrass.
3. Sweetclover and red clover were interseeded into established switchgrass with six partial defoliation treatments of switchgrass in June to evaluate the effect of grass canopy competition during legume seedling establishment.

The first two experiments will begin in 1991. Results from the third experiment, started in 1990, show that legume plant densities in June were generally 10 plants/ ft^2 or less, which is only 1/3 to 2/3 the desirable density in a legume-grass mixture (Table 1). A relatively late seeding date and dry surface soils seemed to result in only modest success for legume establishment. Legume plant survival to September was excellent, with survival of about 75 percent or greater.

Defoliation treatments did not significantly increase legume establishment or survival. Establishment of sweetclover was somewhat greater than for red clover. Forage yield of sweetclover was also somewhat greater than for red clover when harvested in late July. Forage digestibility for sweetclover-grass (52.9 percent) tended to be about 2.3 percent greater than for the nonrenovated plots and the red clover-switchgrass plots. Forage protein tended to be greater for sweetclover-grass (8.6 percent) and red clover-grass (7.3 percent) compared with the nonrenovated check (7.0 percent). Although these forage digestibility and protein values are relatively low, they are not unusual for midsummer on newly renovated grass that received no nitrogen fertilizer. It seems reasonable to expect higher forage quality in 1991, as the legume plants should be well established, more productive, and contribute to a greater portion of total legume-grass yield. Second-year herbage yield, quality, and legume plant densities will be determined, and a new study will be initiated and repeated in 1991.

Environmental effects of two contrasting farming systems in the Clarion-Nicollet-Webster soil association area

T.E. Fenton, ISU

To quantitatively compare environmental and economic effects of alternative farming practices, it is essential to identify landscape features such as topography, surface and subsurface hydrologic (water flow) patterns, parent materials, and soil series upon which the practices are being compared. To determine the effects of soil and parent materials on groundwater movement, the Leopold Center funded a cooperative study between the U.S. Department of Agriculture's Agricultural Research Service and the Iowa Agriculture and Home Economics Experiment Station. Soils at the study location in Boone County are part of the Clarion-Nicollet-Webster Soil Association, which occupies about 20 percent of Iowa. Thus, information collected at this site can be useful for a significant portion of Iowa and the Midwest.

Research is being conducted on two adjacent 80-acre fields owned by Mr. and Mrs. Eugene Baker and Mr. and Mrs. Richard Thompson. The Baker farm is operated by Mr. David Snyder, a local farmer. The southern 40-acres of each field were divided into a grid with 64 squares. A 2-inch soil core was extracted from each grid intersection point for a total of 128 cores.

The cores were wrapped in waxed paper and placed in cold storage until detailed descriptions of the soil and subsoil morphology were made on each core. The descriptions were used to classify each core to the soil series level.

Subsamples were saved for laboratory analyses. Particle size distribution and organic carbon analyses were performed on selected cores. All of the subsamples were analyzed for nitrate, ammonium, total nitrogen, and total carbon. Selected cores were also analyzed to measure particle size and organic carbon. Forty-seven polyvinylchloride (PVC) piezometers were installed at 16 sites along a single

Table 1. Effects of legume renovation and June defoliation of switchgrass on legume plant densities.

	Legume plant density counts					
	June		July	September	Plant survival	
Treatment	South 2/	North 2/	South	North	South 3/	North 4/
	plants per ft²				%	
Legume renovation						
Red clover	6.2	6.2	7.3	5.1	1.20	0.92
Sweet clover	7.3	10.5	7.4	9.3	0.95	0.98
P>F	0.71NS	0.02*	0.96NS	0.04*	0.03*	0.63NS
Initial defoliation 1/						
Check	6.7	10.3	6.3	7.1	0.92	0.83
2-inch early	7.6	8.2	11.8	7.8	1.18	1.05
4-inch early	6.3	8.5	6.8	6.7	1.00	0.85
8-inch early	4.5	8.8	2.5	7.0	1.11	0.76
4-inch late	5.1	5.3	3.2	5.6	1.18	1.16
8-inch late	10.1	9.1	10.7	9.1	1.05	1.06
P>F	0.02*	0.36NS	0.06NS	0.33NS	0.25NS	0.12NS

*,** Significant at the 0.01 and 0.05 probability levels, respectively; NS = not significant
1/ Early = 7 June; Late = 25 June
2/ South and North 2x2 ft quadrats within legume subplots
3/ Survival as a percentage of legume plants in the south quadrat from June to July (the south quadrat was harvested at ground level on July 23...a destructive harvest)
4/ Survival as a percentage of legume plants in the north quadrat from June to September

traverse across both fields that crosses several landscape positions. To describe subsurface flow patterns, water levels in these tubes were monitored weekly or biweekly.

A preliminary model of landscape evolution was developed using the morphological and particle-size data. The analyses showed two layers of erosional sediments overlying glacial till beneath both of these fields. The lower layer was a stratified sand to sandy loam material lying on top of the glacial till. The upper portion of this layer frequently contained alternating thin layers of silt and sand. Draped over the stratified layer and glacial till was a clay loam to silty clay loam sediment. Both of these layers were deposited after the glacial till and may contain buried surface horizons and layers of snail shells. Postglacial sediments were found only in low areas (swales) between hilltops and were generally thickest in the center of each swale. Properties of the stratified sand resembled a stream deposit, but no buried channel was found on geomorphic maps. These sediments were probably laid down by local runoff flowing toward several small depressions on the original glacial till surface. The landscape model will be completed by describing an additional 64 soil cores collected from the northern 40 acres of each field. After the model is complete, relationships between nutrient distribution and groundwater flow will be incorporated to describe interactions among soil properties, hydrology, and farming.

Alternative Energy Sources

Selection of herbaceous energy crops for production in double cropping systems

I.C. Anderson, ISU; D.R. Buxton, USDA Agricultural Research Service and ISU; A.J. Hallam, C.S. Accola, and P.A. Lawlor, ISU

Iowa heavily depends upon imported fossil fuels for agricultural production. The state imports nearly all its energy at great cost to its balance of payments. Biomass fuels are an alternative that can partly replace imported fossil fuels.

This project studies the feasibility of growing energy crops in the state. Attainment of the project goals will provide Iowa with a much-needed third crop, aid in national energy security, help decrease greenhouse gas emissions and other pollutants, and place land idled by government programs into production.

Cropping systems are being evaluated that minimize groundwater pollution and soil erosion with low to moderate levels of inputs. After three years of research at Ames and Chariton, the most promising of 13 systems are winter rye double cropped with sorghum, intercropping sorghum into alfalfa, and perennial switchgrass and perennial big bluestem. The highest yielding systems have produced up to 12.8 tons/acre of dry matter. The economics and erosive potential of each system is being evaluated. To be most effectively used, energy from these crops will need to be converted to liquid or gaseous farms.

Sorghum and corn biomass. Sorghum and corn biomass are two nongrain crops that could be used as alternative fuel feedstocks in a manner that limits their negative features while maximizing positive aspects. From a production standpoint, sorghum is a highly efficient user of water and nitrogen fertilizer. Properly managed sweet sorghum has the ability to store enough sugar in the stock to produce twice as much alcohol as corn grain. Forage sorghum and tropical corn that lack grain have the potential for high biomass yields. We are researching the combustion of biomass by gasification to produce electricity and methyl alcohol.

Our research has shown that sorghum in rotation is capable of producing 20,000 lbs/acre of dry matter containing 8,000 lbs of readily fermentable sugar that is equivalent to more than 600 gallons of ethanol and 12,000 lbs of residue of which part can be used as fuel for distillation and the remainder as a feed.

Special Grants

The extent and nature of Iowa cropping practices

M. Duffy, ISU

By knowing what farmers have on hand and how they are using their resources, the change to sustainable agriculture can be made with the fewest amount of alterations. But the last in-depth survey of Iowa farming practices was conducted in 1975.

So the Leopold Center helped fund an extensive survey of Iowa farmers to find out which specific farming practices are being used on known soil types and landscapes. About 30 enumerators from the Iowa Department of Agricultural Statistics interviewed farmers face-to-face in the first three months of 1990. The results: 1,181 farmers' reports on energy use, crops and livestock, equipment, manure facilities, and application methods of pesticides and fertilizers.

The survey was also funded by the Center for Agriculture and Rural Development at ISU, the Iowa Department of Agriculture and Land Stewardship, and the ISU Extension Service.

Energy use. The findings show that less energy is used to grow food and fiber today on Iowa farms than 15 years ago (Figure 10). The drop in energy use per farm is primarily due to a major shift from gas-powered to diesel-powered machinery. It takes 40 percent more gas to do the same work as diesel.

An average of 4.9 gallons of fuel was used per crop acre, and each farm had an average of 369 acres of cropland, according to the survey. On average, eight trips were made across crop fields each year. The number of trips varied with type of crop and crop rotation.

The average Iowa farm uses nearly three times as much diesel fuel as gasoline in crop production. In 1975, 70 percent of the tractors were gasoline powered and 29 percent were diesel powered. Twenty-three percent of the combines were powered by diesel in that year. In 1989, only 40 percent of the tractors were gas and 59 percent were diesel. Seventy percent of the combines were diesel-powered.

Table 2. Percent of corn acres treated by type of herbicide material.

Material	1979	1985	1989
		%	
Atrazine	33	42	39
Metolachlor	5	31	27
Alachlor	41	33	25
Diacamba	19	20	21
Cyanazine	33	34	18
Bromoxymil	--	3	14
2,4-D	18	19	14

Table 3. Percent of soybean acres treated by type of herbicide material.

Material	1979	1985	1989
		%	
Trifluralin	61	63	60
Bentazon	6	14	31
Glyphosate	--	13	19
Metribuzen	41	43	15
Clomazone	--	--	12
Chlorimuron	--	--	9
Amiben	14	13	4

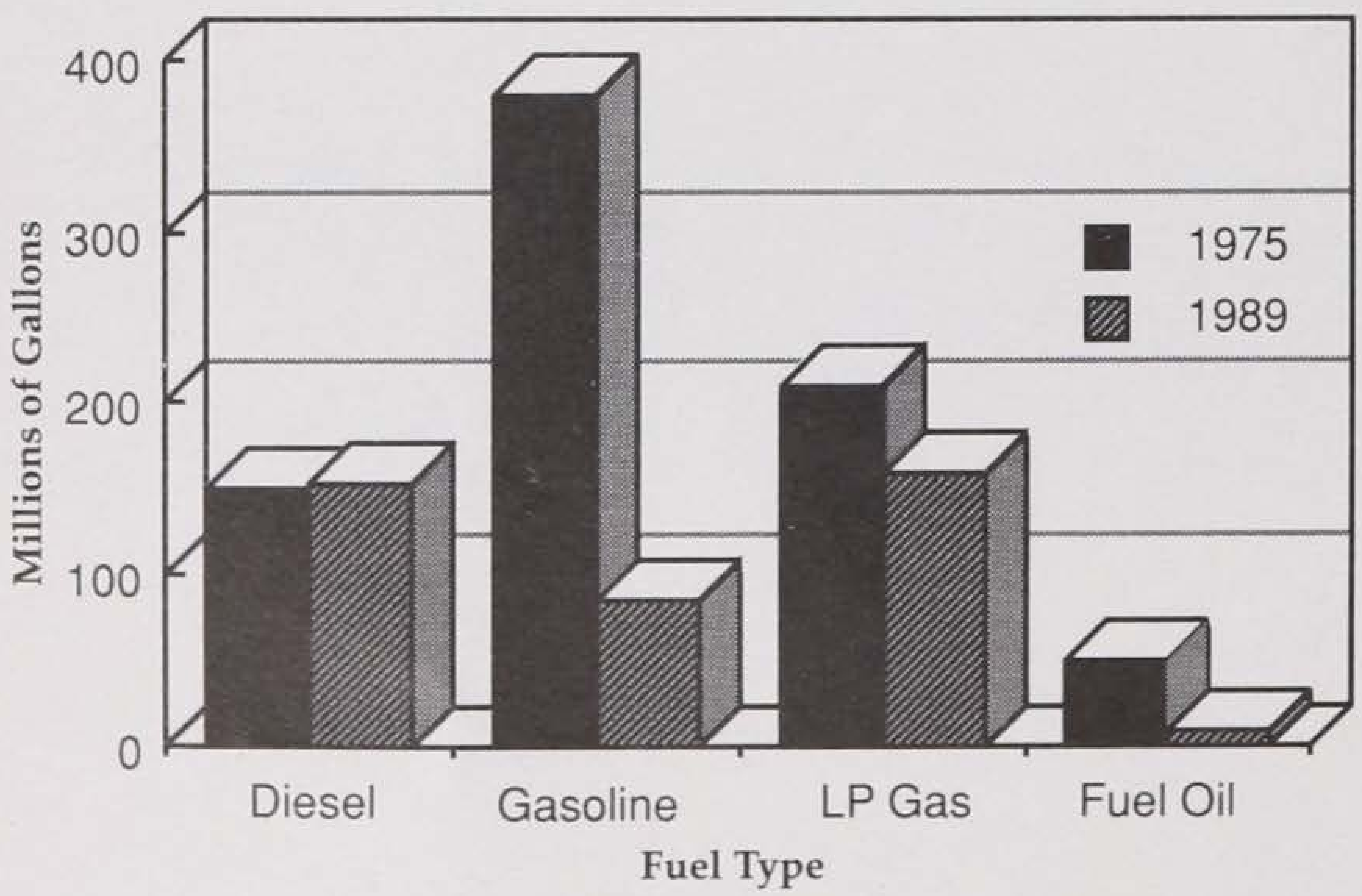

Figure 10. Comparison of selected fuel use on Iowa farms of 1975 and 1989.

The results do not show the indirect use of fossil fuels on Iowa farms, primarily through fertilizers and pesticides.

Conservation. More soil conservation measures were used on farms in 1989 than in previous years. Since 1975, the number of farmers that do not use the moldboard plow has more than doubled: 35 percent of farmers reported not using the moldboard plow in 1989 compared with 10 percent in 1975. An additional 34 percent reported less use of the moldboard since 1984.

In 1975, 65 percent of farmers did not use the chisel plow, compared with 30 percent in 1989. Most farmers said they reduced tillage because of worries about soil erosion.

Almost half of farmers, 46 percent, grow corn on highly erodible land. But 91 percent say they have altered their practices. Seventy-six percent of respondents farm on the contour, 46 percent have terraces, and 28 percent practice strip cropping. Most of this change is because of an increase in conservation awareness and the need to improve farm profitability.

Manure use. Nearly half, 47 percent, of farmers surveyed do not offset their use of commercial fertilizers by nutrient credits from manure applications. Among the 49 percent of farmers that do consider nutrients in manures, just half could tell what credits they allow for. Only 16 percent of those that adjust fertilizer had sampled the manure for nutrient content.

In the last three years, the soil was tested in only 58 percent of fields in Iowa (Figure 11). No soil tests at any time in the last decade were reported in more than 30 percent of fields.

Pesticide use. A full 79 percent of herbicides used were broadcast and only 7 percent were band applied. However, 85 percent of farm insecticides were applied in a band compared with 13 percent broadcast.

Forty-four percent of herbicides were applied before planting, and 40 percent were applied postemergence. In comparison, 86 percent of insecticides were applied at planting time.

Table 3 shows changes in corn insecticide use between 1985 and 1989. A 10-year change in soybean herbicides is shown in Table 4.

Equipment. Iowa farming equipment is showing its age. Two-thirds of all farm machinery is more than 11 years old. The majority of farm tractors, 53 percent, were

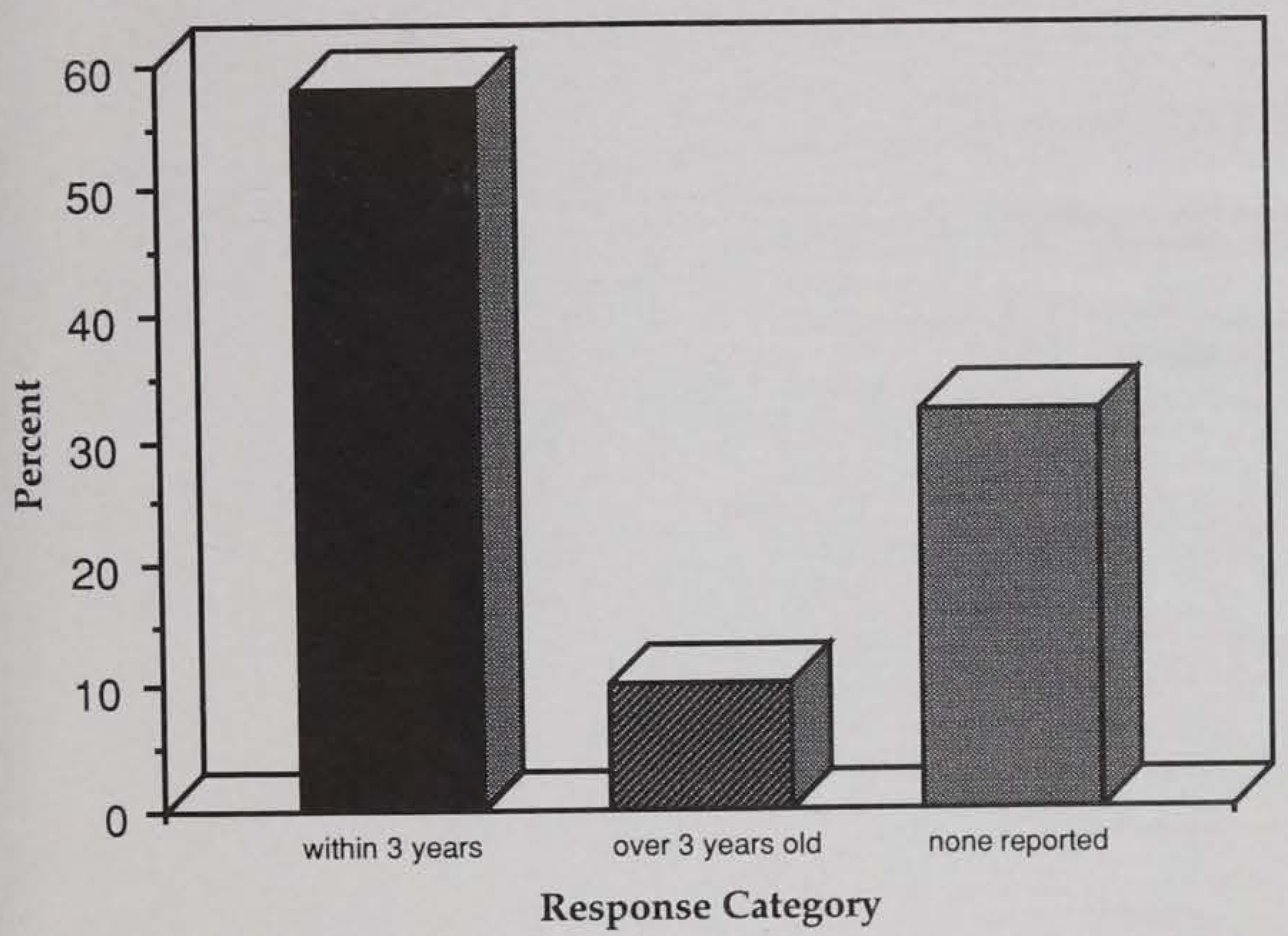

Figure 11. Soil test dates by percent of fields.

built before 1970. Sixty percent of combines are more than 20 years old. Each farm has an average of 3.4 tractors, 2.6 automobiles, and 11.4 various other implements. There were about 4 combines for every 6 farms.

Implications of biotechnology in swine production

K.M. Waggoner and J. Hopper, ISU

Biotechnology has great potential to benefit production agriculture in Iowa. But planning and research are needed to ensure that biotechnology is safe, environmentally sound, economically feasible, and socially acceptable.

Challenging issues in biotechnology and sustainable animal agriculture have fueled much debate in the areas of animal and consumer health, environmental implications of livestock management, social-impact analyses, and the economic revitalization of Iowa livestock production.

This planning grant allows researchers to develop a long-term interdisciplinary study of the role of biotechnology in swine production. The first stage of the project involves developing a data base management system that relates unlike topics in a logical framework. The system will be used to: 1) identify linkages between basic and applied research and technology transfer, 2) identify controversial areas within biotechnology, and 3) begin to develop a research agenda that addresses specific issues surrounding biotechnology in animal agriculture and establishes protocols for carrying out interdisciplinary research effectively.

Research proposals based on this plan will require funding from sources other than the Leopold Center.

Final Reports

The following Leopold Center research projects were completed in 1990. Full copies of the final reports are available from the Center.

Demonstration of the unique slow-release characteristic of anhydrous ammonia fertilizer

A.M. Blackmer, ISU

Nitrate can be lost from the soil by leaching or denitrification during heavy spring rainfall. This results in environmental degradation and economic loss to producers. Slow-release nitrogen fertilizers convert to nitrate more slowly than ordinary nitrogen fertilizers do, thus reducing the potential for leaching or denitrification losses. There also is a possibility that anhydrous ammonia can react in the soil to behave as a slow-release fertilizer.

Two field demonstrations were undertaken to learn more about the slow release characteristic of anhydrous ammonia and how it might be managed to reduce nitrogen losses in the spring. Additionally, samples were taken in late spring when corn plants were 6 to 12 inches tall to demonstrate the effectiveness of the late-spring soil test for use with anhydrous ammonia.

In one demonstration, ammonium sulfate or anhydrous ammonia were applied at rates of 0, 50, 100, 200, and 250 lbs nitrogen/acre during the fall or spring as preplant or sidedress. Ammonium sulfate was broadcast applied and anhydrous ammonia was knifed in each row or in every two rows of corn. A total of 234 plots received ammonia treatments.

The second demonstration involved application of nitrogen-15 labeled anhydrous ammonia at 45, 134, or 223 lbs nitrogen/acre and 15-nitrogen labeled ammonium sulfate at 134 lbs/acre on microplots 5.9 feet by 2.3 feet (a total of 90 plots).

Although severe drought obscured treatment effects in the study, yield responses clearly documented that only small amounts of added nitrogen fertilizers were required to attain maximum yields under these conditions. The results also supported the use of the late-spring soil test with applications of anhydrous ammonia.

Anhydrous ammonia applications resulted in a reduction in stalk-nitrate concentration with later time of application when compared with ammonium sulfate. This may result in a delay in the availability of nitrogen at a time of rapid uptake by corn. Application of one knife of anhydrous ammonia for every two rows of corn decreased stalk-nitrate concentrations when compared with the two-knife treatment at the same nitrogen rate. Both of these observations support the slow release character of anhydrous ammonia.

Soil samples taken at various depths at 6, 19, and 48 weeks after planting indicated that most of the labeled nitrogen that remained in the soil either was incorporated into microbial biomass, plant residue, or soil organic matter or was fixed in clay lattices. Nitrogen in these forms is unavailable for plant uptake and also is protected from leaching or denitrification.

Effect of split nitrogen-fertilizer applications on drainage water quality and nitrate-nitrogen leaching

R.S. Kanwar and J.L Baker, ISU

Nitrate-nitrogen leaching losses to groundwater sources can be minimized by better water and nitrogen management practices in agricultural watersheds. Studies have shown that often 50% or less of the nitrogen fertilizer applied is beneficially recovered in any one crop year. Typically, 15% to 30% of nitrogen from single preplant application to corn is lost to tile drainage. This project investigated if split applications of nitrogen to corn would decrease total nitrogen losses to tile drainage.

Experimental plots were planted to corn in May 1988 using conventional tillage. Nitrogen treatments were a single application of 156 lbs nitrogen/acre or a three-way split application totaling 112 lbs nitrogen/acre (22 lbs nitrogen/acre at planting, 45 lbs nitrogen/acre in June, and 45 lbs nitrogen/acre in July). Soil-water samples were taken from various depths using piezometers and were analyzed for nitrate-nitrogen.

Because of severe drought conditions, water did not flow in the tile lines in 1988, and only limited samples were available in 1989. Data from previous years coupled with 1989 data indicated that there was significantly less nitrate in the tile-drain water from the split application. There were no significant difference in yield between the split and single nitrogen applications in spite of the 28 percent decrease in total nitrogen fertilizer application.

Nitrogen efficiency with no-till and conventional tillage cropping systems for energy conservation and water quality benefits.

R.S. Kanwar, J.L. Baker, P. Singh, and C. Everts, ISU

The influence of soil macropores (open channels, root holes, or worm holes) that are interconnected on water movement and chemical transport in field soils is well recognized. Tillage practices directly affect surface soil-water properties and thus leaching potential. Tillage disturbs macropores, whereas no-till allows macropores to develop and persist.

This field study quantitatively investigated the influence of tillage on macropore characteristics within the top 24 inches of soil under no-till and moldboard plowing. The study focused on both direct and indirect approaches for macropore characterization. Direct measurement of macropores included photographing the horizontal soil surface at different depths of the soil profile and performing automatic image analysis of the photos. Outlines of macropores also were drawn on acetate sheets that were quantified on AUTOCAD, a computerized imaging program.

Chloride breakthrough curves were developed for six undisturbed soil columns from no-till and conventional tillage fields to determine the functional behavior of macropores on preferential flow. Infiltration data were collected at three sites and at soil moisture tensions of 0.0, 1.2, 2.4, and 4.8 inches corresponding to infiltration through equivalent diameter pore sizes down to 0.01 inch. This was performed to evaluate any changes in measured pore size due to changes in moisture content.

Of the direct methods for quantifying macropores, tracing macropores on acetate and digitizing them on AUTOCAD proved to be the most simple and accurate. Macropores in the plowing system had deeper and wider cracks than in the no-till system. However, the total average perimeter of macropores was greater in the no-till system. Breakthrough curves for chloride proved to be very similar to that of nitrate, suggesting that chloride could be effectively used as a tracer for nitrate-nitrogen in the top 24 inches of the Nicollet soil. Infiltration rate was reduced by 50 percent at dryer soil-moisture levels compared with standing water. Initial soil moisture did not appear to affect pore size results.

These results are useful to state and federal water agencies when estimating the potential hazard of particular agricultural chemicals to groundwater. The information is also useful to consultants and extension personnel in recommending nitrogen and herbicide management practices to reduce the potential for groundwater contamination.

Tillage and crop rotation system demonstration for energy and environmental efficiency

R.S. Kanwar, G. Czapar, ISU; R. Fawcett, Consultant; D. Karlen, T.S. Colvin, USDA Agricultural Research Service; S.W. Melvin, D. Stoltenburg, and J.L. Baker, ISU

This project developed a field hydrology laboratory at ISU's Northeast Research Center to determine the potential of various tillage methods and crop rotations to contaminate groundwater with nitrate and pesticides.

Thirty-six, 1-acre plots containing tile drainage lines 4 feet deep were modified in 1989 to sample tile drainage. Drainage lines from each plot were intercepted and routed to one of 10 collection sites. Meter sumps for individual plot interception lines were installed at the collection sites.

In addition, piezometers, flow meters and deep wells were installed to characterize groundwater flow and tile line discharge and to determine whether tile lines prevent leaching of fertilizers and pesticides to deep groundwater.

In 1978, a large conservation tillage experiment was initiated at the Northeast Research Center consisting of four tillage methods (moldboard plow, chisel plow, ridge till, and no-till) and two crop rotations (continuous corn and corn-soybean). Pesticide and fertilizer use records have been collected since then. The network of tile drainage, collection sites, data loggers, meter sumps, piezometers, and observation wells is now completely in place. This field hydrology laboratory is a unique and important asset for researchers in Iowa and the Midwest. Systematic sampling of drainage water is now underway and is further described on page 23 of this report.

Contribution of diverse soybean varieties to the nitrogen needs of a subsequent corn crop

R.M. Shibles, D.E. Green, and E. Escuro, ISU

It is well known that corn benefits from a soybean rotation in two primary ways: Soybeans contribute nitrogen to a subsequent corn crop, and soybeans introduce a positive rotation effect. However, little is known about the effect of diverse soybean varieties on this nitrogen and rotation effect. This study investigated the nitrogen contribution and positive rotation effects of 16 soybean varieties in 1988 and 1989.

Planting corn on previous soybean or oat plots increased corn yields by an average of 25 bu/acre compared to continuous corn. There were no significant differences in beneficial effects of oats or soybeans on corn production. Drought conditions in 1988 reduced soybean production and reduced their atmospheric nitrogen assimilation, which perhaps greatly reduced the nitrogen contribution effect of soybeans. Though the 16 soybean varieties differed considerably in yield and dry-matter production, they did not differ significantly in their positive influence on corn production.

These results are preliminary, and a greater database collected over varied climatic and geographic conditions must be analyzed before final conclusions can be drawn.

Timber-management research and demonstration project

M.S. Honeyman, P. Wray, T.H. Greiner, and M. Huss, ISU

This study demonstrated the use of wood as an alternative energy source for farmers and small industries. It involved constructing a wood-fired, hot-water furnace system to heat a residence and surrounding farm buildings. The study was conducted at the McNay Research Farm near Chariton, Iowa.

The system consists of all the necessary equipment to harvest and burn wood, including tree harvesting equipment, a commercial wood-fired furnace system with chip storage and enclosure building, and heating and drying equipment. The project monitored British Thermal Unit (BTU) usage for heating buildings and drying grain to determine efficient burner sizes and configurations. The demonstration also included safe wood-harvesting practices, timber management, proper heating plant operation, economics of wood burning, and use of an energy plantation.

Trees were planted in 1987 on 10 acres of Conservation Reserve Program (CRP) land to evaluate the suitability of various tree species to the steep, dry sites typical of CRP land. It is hoped that at the end of the 10-year CRP moratorium on harvests, some of the trees will fuel the boiler system. In the meantime, survival and yield data will be collected to demonstrate the potential of energy plantations on marginal farmland.

Irrigation and disease management of vegetables

H.G. Taber, M.L. Gleason, S. Melvin, ISU

Irrigation, fertilizer, and pesticide use account for more than half of the energy input in fresh vegetable production. Drip irrigation, when coupled with black plastic, ground mulch sensing devices as tensiometers, can save more than 60 percent of the water used with current overhead irrigation practices. Because drip irrigation does not wet the foliage, fungicide applications may also be reduced.

This project demonstrated the most efficient irrigation and disease management available for growing tomatoes on the loamy sand soils of eastern Iowa. Treatment comparisons were overhead irrigation versus drip irrigation, bare ground versus black plastic mulch, and traditional disease management versus disease management based on a computer model.

For the 1988 and 1989 growing seasons, which were warm and dry, there was no yield advantage to the high-management trickle irrigation system as compared with overhead irrigation. Also, the use of black plastic mulch offered no advantage. The trickle system used 22 percent less water to produce a pound of fruit compared with overhead irrigation.

In 1989, overhead irrigation outyielded trickle irrigation by 7.3 tons/acre, whereas black plastic mulch reduced yield by 6.9 tons/acre. The primary reason for the lack of effectiveness of trickle irrigation was the high-management skill necessary to operate the system on these coarse, sandy-textured soils. Trickle irrigation supplies a low volume of water under low pressure to 25 percent or less of the root zone. Thus, it was necessary to run the system three or four times a day during June and July to satisfy the plants' water needs. A greater portion of the root zone could have been wetted by adding another emitter line per row, but the cost would have been prohibitive. The high management costs for operating a trickle system and the lack of effectiveness in yield results precluded it from being a viable alternative. The current overhead sprinkler irrigation methods worked best where ample groundwater was available, such as along the rivers in eastern Iowa.

Fungicide treatments did not affect disease incidence in the dry summers of 1988 and 1989. There was no evidence of early blight or Septoria either year, although bacterial canker did appear in mid-July. Yield was not affected by fungicide application in 1988. For 1989, applications of fungicide by the conventional or model-based system significantly improved once-over yield by 19 percent.

There was no significant difference between the conventional system, in which 12 sprays were applied, and the model-based system, in which only five sprays were applied on the overhead-irrigated plots and three sprays on the trickle-irrigated plots. Thus, using temperature, rainfall, and leaf wetness in a computer-based model reduced spray applications and chemical input into the environment without sacrificing fruit yield or quality. Further work on trickle irrigation efficiency for vegetables is being funded from other sources.

Full Circle Forestry in southeastern Iowa

Ron Snyder, Geode Wonderland Resource Conservation and Development, Inc.

The program's objective was to supply landowners in southeastern Iowa with information to manage woodlots and to protect and enhance local soil and water resources.

The Full Circle Forestry concept involved cultivating timberland, harvesting trees, and investing most of the profit back into the forest through timber-stand improvement and new plantings. Full Circle Forestry helps ensure a future supply of high-quality timber products and demonstrates the profitability of managed woodlands.

About 85 percent of forestland in southeastern Iowa is privately owned, with only 10 percent of it managed as a crop. The project's goal was to bring 85 percent of the existing forestland under management within 15 years. By the end of July 1990, 44 landowners were enrolled in the Full Circle Forestry program at some level. A total of 3,308 acres were enrolled, ranging from 5 to 344 acres, and included farmers, nonfarmers, a utility company, and one large corporation.

Incorporating environmental costs into economic injury levels

L.G. Higley and W.K. Wintersteen, ISU

Economic injury levels (EILs) used in Integrated Pest Management programs provide economic criteria for determining when to manage crop pests, but they do not address environmental concerns. This study expanded the EIL concept to include environmental risks when making pest-management decisions.

A model was developed for assessing environmental risks from pesticides, specifically environmental risks associated with single use of a pesticide. Thirty-two common field crop insecticides were selected for analysis in the model. The model assumes risks are determined by objective criteria. The relative importance of risks to different categories and their monetary value are estimated through a contingent valuation survey. Environmental costs determined for each insecticide under consideration were used to calculate environmental EILs.

The model was tested in pest-management programs in four north central states. Results indicate EILs can significantly reduce pesticide use.

Conservation tillage effects on anion and atrazine leaching

J. L. Baker and P. L. Boddy, ISU

Conservation tillage is widely promoted because of its demonstrated benefits for controlling soil erosion. Yet, it is possible that conservation tillage may influence chemical leaching from the root zone. This study considered the effects of conservation tillage on anion, particularly nitrate, and herbicide leaching.

Undisturbed soil columns 8 inches in diameter and 12 inches long were extracted from fields under three different tillage systems: moldboard plow, chisel-plow, and no-till. The columns were used in a rainfall simulation experiment to determine the effects of conservation tillage on agricultural chemical leaching. The anions nitrate and bromide (used as a tracer) and the herbicide atrazine were surface applied to the soil columns one day before rain at rates of 120, 120, and 2 lbs/acre, respectively. A rainfall simulator was used to apply the leaching water because it could approximate drop sizes and energy of natural rainfall.

When chemicals are surface applied, the timing and intensity of rainfall striking the soil can be important in the dissolution and subsequent leaching of those chemicals. It is possible that a light rain occurring right after chemical application might move the chemical into the soil and reduce its later leaching from more rain as opposed to an immediate intense rain. It also is possible that an intense rain might cause more leaching of a chemical on the surface by movement through soil "macropores" (open channels, root holes, or worm holes) as opposed to a longer, more gentle rain. It is commonly believed that tillage can have an effect on the existence of macropores, which were measured in this study.

Four rainfall patterns were used to determine if rainfall, in combination with conservation tillage, affected leaching:

- Rain I was 0.4 inch/hour for 7.5 hours.
- Rain II was 2 inches/hour for 1.5 hours.
- Rain III was 0.4 inch/hour followed a day later with rain at 0.4 inch/hour for 6.5 hours.
- Rain IV was 0.4 inch/hour for 1 hour followed a day later with rain at 2 inches/hour for 1.3 hours. All columns received 3 inches of rain.

Soil adsorption had a dramatic effect on chemical leaching. Concentrations of the nonadsorbed anions bromide and nitrate started high and, depending on rain pattern, increased or decreased somewhat with time. However, for the soil-adsorbed herbicide atrazine, concentrations started much lower and decreased with time. Leaching loss averaged 0.07 percent.

With a gentle rain, anion concentrations started lower and increased slightly with time, with the opposite true for the intense rain. When a wetting rain preceded these two rains, losses were reduced. Interactions between rainfall and tillage showed that no-till had the lowest anion loss with gentle rain but the greatest loss with intense rain (with and without the preceding wetting rain). Both of these results indicate the possible influence of macropores.

A gentle rain preceded by an intense wetting rain produced the highest initial atrazine concentration in the leachate, 11 ppb (ug/L). However, the largest loss (0.089 percent) was for the intense rain preceded by a wetting rain. The lowest loss (0.036 percent) and lowest initial concentration, 3 ppb (ug/L), were for the single gentle rain. Interaction between rainfall and tillage showed that no-till had the lowest atrazine loss with gentle rains but the greatest loss with intense rains. Again, this strongly implicates macropores.

Results of the macropore analysis did not show large differences among tillage type. If anything, chisel plow and no-till had slightly more macropores than moldboard plow. One factor that might have made no-till and chisel plow results similar is that the no-till field in this study was mechanically cultivated each year.

The results show that conservation tillage, with the likely existence of more macropores at the soil surface, may influence chemical leaching depending on rain patterns. Intense rains may cause more leaching with conservation tillage, whereas gentle rains may result in less leaching. Not being able to control rainfall pattern means there is a potential increase in leaching loss with conservation tillage. However, the increase would not be dramatic and could average out with time. The fact that macropores do seem to play a role in chemical leaching opens an opportunity for chemical management relative to their existence.

Financial Report

In fiscal year 1990-91, the Leopold Center operating budget included an estimated $950,000 from nitrogen fertilizer and pesticide fees collected under rules established by the Iowa Groundwater Protection Act of 1987. An additional $600,000 from the Iowa Legislature allowed the Center to support a 74 percent increase above the previous year for competitive grants (Figure 1).

Leopold Center research in 1990 included 40 competitive grants and several interdisciplinary research teams. Expenditures in educational programs supported outreach portions of many competitive grant projects (Figures 2 and 3).

A significant number of Leopold Center grants provide start-up funds for work that may not attract conventional sources of agricultural research funding. No project would be possible without the willingness of the recipient institution or organization to commit staff time, equipment, and facilities.

In fiscal year 1990-91, the Center's competitive grants and interdisciplinary team research supported more than 30 graduate student stipends at various universities and colleges in Iowa. Those graduate students represent a new generation of scientists gaining firsthand research experience in sustainable agriculture.

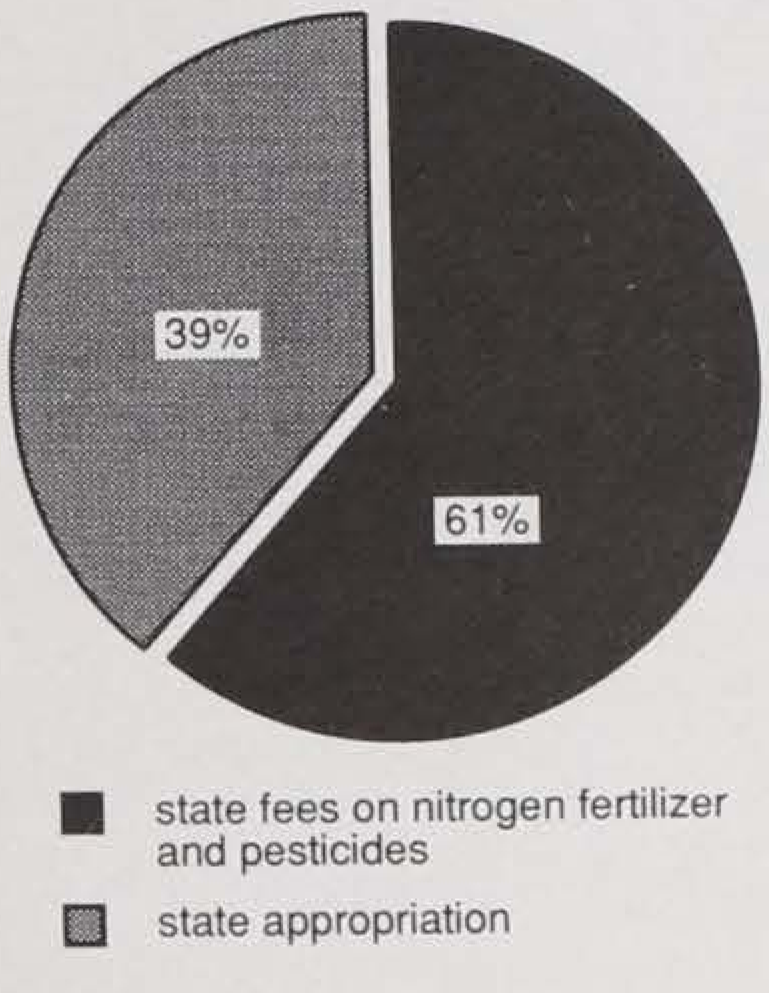

Figure 1. Sources of funding.

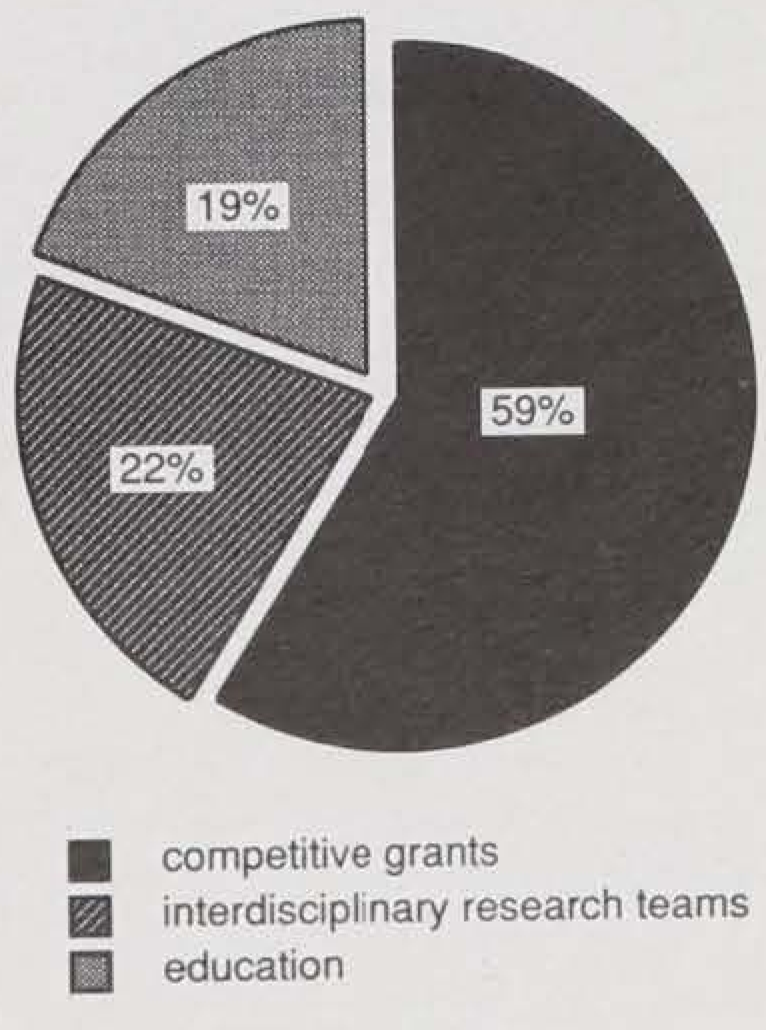

Figure 2. Expenditures by program.

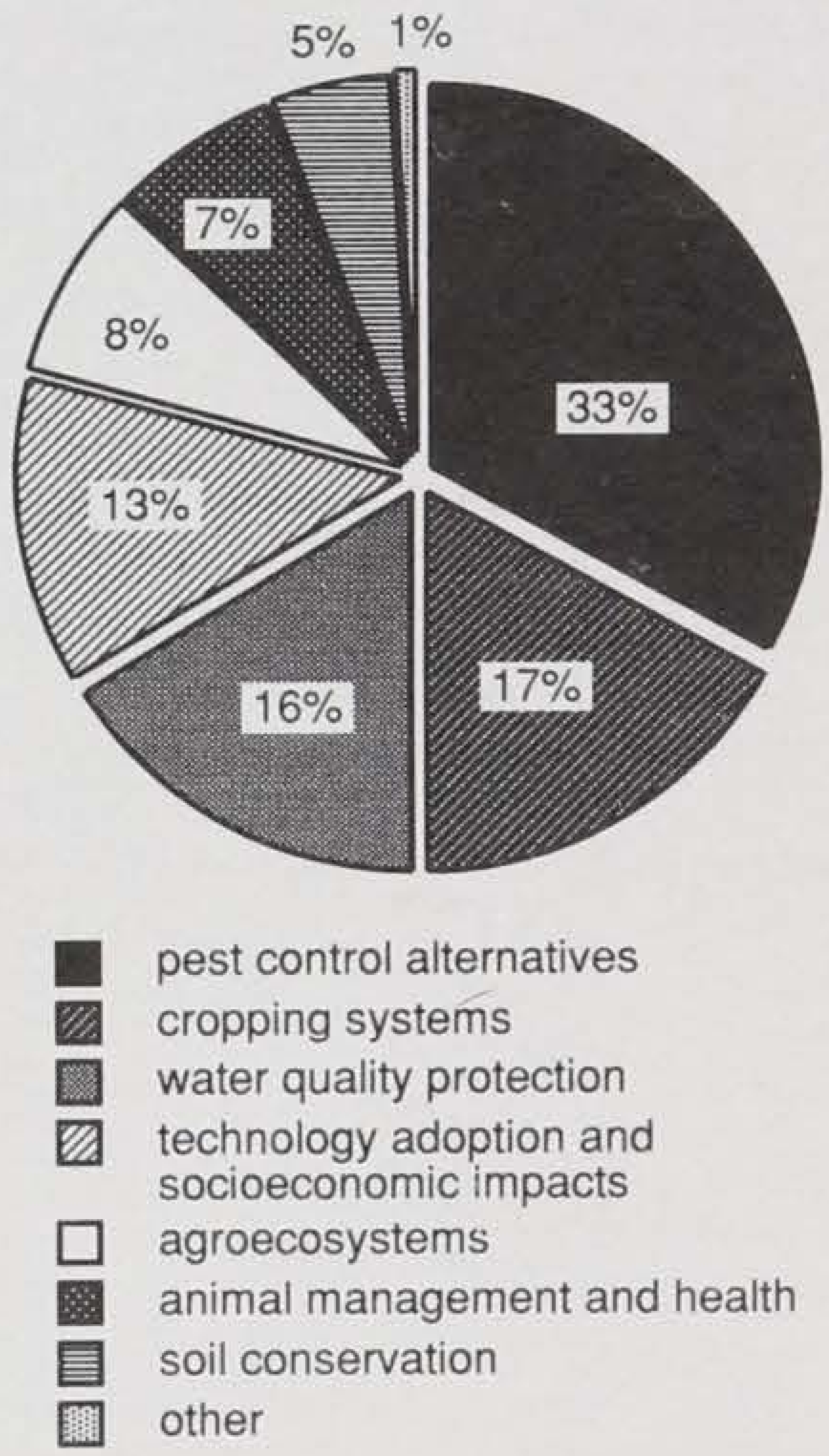

Figure 3. Research expenditures by subject area.