ENVIRONMENTAL ENHANCEMENT THROUGH AGRICULTURE

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William Lockeretz, editor

Proceedings of a conference held in Boston, Massachusetts, November 15-17, 1995, organized by the Tufts University School of Nutrition Science and Policy, the American Farmland Trust, and the Henry A. Wallace Institute for Alternative Agriculture.

Contents

Foreword

The idea of agriculture as a provider of environmental benefits is a refreshing concept. More times than not, agriculture is considered a primary polluter. Since agriculture is the dominant land use in the United States, it is not surprising that it is the largest source of surface water pollution and soil erosion and the largest user of water. These environmental by-products of agriculture are a consequence of the "maximum production" mode of agriculture in the past 50 years.

Production maximization has produced cheap food, concentration, specialization, loss of genetic diversity, and a super-efficient agricultural system in which 15% of our farms produce 80% of our food and fiber. Production maximization undeniably produces both environmental problems and social problems.

This country approaches environmental problems with a medical model. We wait until agriculture is "sick" and then, instead of curing the cause of the illness, we almost always treat the symptom instead, and rush to apply bandages to stop the bleeding. Instead of treating the symptoms of a sickly agriculture, we need to begin to create production systems that are not sick; we need to design production systems that are healthy.

USDA's agricultural research system is under increasing pressure from budgetary constraints and societal pressure to produce "public benefits." As federal support for research tightens, where we place that money becomes more critical for meeting public objectives that are accountable to taxpaying citizens.

Much of the research that USDA funds or conducts is focused on the assumption that society wants a single or primary benefit from agriculture: production maximization. USDA has been highly successful in providing this benefit. but many social, economic, and environmental consequences have resulted, including soil erosion, rural depopulation and water contamination.

Today there are approximately 120 Agricultural Research Service facilities throughout the country, 76 Land Grant Universities, 57 State Agricultural Experiment Stations, and Extension Service offices in nearly every county staffed by over 34,000 non-federal employees. With the drive to balance the federal budget in the next seven years, USDA must be prepared for budgets that are flat (at best), or even declining.

Americans today are more concerned about environmental degradation than production maximization; they are more worried about the federal budget deficit than about famine. Greater demands will be made on scarce public research funds to produce environmental benefits. Rather than production maximization, agricultural research needs to shift to production *optimization* that provides environmental, economic and social benefits from agriculture.

Therefore, our agricultural research system must be oriented in a way that involves multiple disciplines to optimize production efficiency, environmental benefits, and quality of life. Research priorities for the future must become transdisciplinary and targeted at geographic areas that account for the unique ecosystems and populations that interact with agriculture within a bioregion.

Much of U.S. public and private investment in agriculture, research, and extension focuses on maintaining production maximization and treating any sickness that threatens it. It makes sense for private investment to focus on maximizing production and profit, but public investment should focus on optimization of multiple goals, not maximization of a single goal. I propose five outcomes for the public agricultural research and extension system:

1. A healthy, well-nourished population
2. Greater harmony between agriculture and the environment
3. A production system that is highly competitive in the global economy
4. Enhanced economic opportunity for farmers, ranchers, and rural communities
5. A safe and secure food and fiber system.

This book's theme, "Environmental Enhancement through Agriculture", raises a critical question: How do we create agricultural production systems in a way that produces environmental benefits? We need to shift away from a medical model to one where agriculture *improves* the environment.

To create production systems that achieve multiple goals requires that research be conducted in a way that includes multiple disciplines. Our agricultural research organizations, funding, and personnel evaluation systems must be reoriented to require and reward efforts that address agricultural issues from biological, social, economic and environmental perspectives.

It is my hope and expectation that this book will provide us with innovative approaches to shifting our research and extension investments to achieve multiple goals, and in particular, to present opportunities for agriculture to contribute to environmental enhancement.

KARL N. STAUBER
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Introduction

This conference was not the first on the relationship between agriculture and the environment, nor will it be the last. However, it differed from most in how it framed that relationship, asking what agriculture can do to *improve* the environment, not just how it can avoid *degrading* it.

For at least the past two decades, agriculturalists have not been able to ignore the environment; even if they might have wanted to, environmentalists have not let them. The greater interaction between these two groups is welcome, but it often has been uneasy and awkward. At worst, it is overtly antagonistic. But even at its best, the usual goal is compromise. Compared to antagonism, that's an improvement. But *compromise* implies settling for something less than what one really wants, a reluctant acceptance of second-best because one lives in a society with divergent interests. The implication is that although a thriving, productive agriculture and a wholesome, attractive environment both are important goals, working toward one means forgoing the other. Finding an acceptable middle ground between these two legitimate interests might be approached in a civilized, cooperative spirit, which surely beats the harsh rhetoric and brute-force political fighting that prevailed in the past, but it still assumes an inevitable tension between the two.

This conference was based instead on the notion that it doesn't have to be that way. In some ways agriculture already serves environmental goals, and it could do more. The idea behind the conference was to see whether the separate efforts of people already working in this direction might not generate a more comprehensive vision of an agriculture that enhances the environment instead of exploiting it.

Did it succeed? The question must be clarified: Enhance the environment compared with *what*? This book contains many papers about systems that enhance the environment compared with present-day agriculture. But we didn't need a conference to know about such systems. In recent years, both researchers and farmers have offered many examples of innovative methods that are preferable both environmentally *and* economically, such as ecologically based pest control strategies that reduce the use of pesticides while increasing producers' profits. But "environmentally preferable" still usually means only "compared with current agricultural systems." This conference was about a more ambitious goal: an agriculture that is better for the environment even than leaving it alone.

This doesn't mean we are presumptuously trying to improve upon nature (although it might be interesting to speculate in the abstract on what "improve upon nature" might mean). Without venturing into this treacherous territory, we still can think about realistic possibilities for agriculture to enhance the environment—the environment, that is, that we now live in. That environment has been substantially altered by human activities. If agriculture ameliorates environmental problems that originate elsewhere, it can honestly and unpresumptuously be said to enhance the environment. This does not imply that agriculturalists are "improving" upon nature, because the environment they are improving is not that of pristine nature—where does such a state exist, in any case? Rather, we are talking about improving the environment we actually have, the one that already has been altered in so many ways, usually not positively.

This, then, is the expanded explanation of the conference goal: To envision an agriculture that leaves the environment better off, not just compared with present-day agriculture, but absolutely.

Again: did it succeed? Unfortunately, I think the honest answer must be "only modestly."

Some papers clearly qualify. Agriculture enhances the environment when it takes wastes from off the farm and converts them in a nonpolluting way into a valuable soil conditioner. It enhances the environment when it grows a nonpolluting, renewable energy source that reduces our use of fossil fuels—which not only are nonrenewable but also impose considerable environmental cost when they are extracted and transported. It enhances the environment when it provides habitat for a species that has been endangered by nonagricultural activities. It enhances the environment when it provides an aesthetically appealing landscape that the public willingly pays to preserve. And when a farm near a city provides both fresh food and meaningful employment to young people from poverty-stricken urban neighborhoods, there, too, agriculture is enhancing the environment, although the socioeconomic environment, unfortunately, sometimes is left out of discussions of environmental quality.

Many of these papers, though, could more correctly be said to reflect the "reduce agriculture's environmental damage" goal. Nevertheless, they approach this goal in a way that holds promise of even bigger things. The watershed projects described in the first group, for example, all use a different *process* for improving the relationship between agriculture and the environment, one based on improving the relationship between agricultural*ists* and environmental*ists*. It is not just that these groups are talking civilly to each other instead of arguing or litigating. Nor is it just that they have begrudgingly accepted the need for compromise. Rather, they are cooperating because they *both* want to advance *both* sets of interests. The environmental advocates in these projects are not saying: "Here is what we want, and we are going to do whatever we can to get it, regardless of how much it burdens farmers." Conversely, the farmers are not saying: "If we are forced to go along with environmental restrictions, we will, but first we'll try to loosen them as much as we can." Rather, the environmentalists *want* to see farmers thrive, and the farmers *want* to see the environment protected. Their common task now is to figure out how to achieve both these important goals. Such a process is open-ended, potentially leading far beyond the original environmental concern that brought the groups together.

If the result is an agriculture that enhances the environment, farmers will gain not just because the environment has gained. They also will gain by acquiring important political allies. Simply stated, these days farmers need all the friends they can get. (I speak now of the U.S. in particular, but no doubt the same could be said of many other countries.) For a long time after they no longer were a majority, U.S. farmers—more correctly, the agricultural sector as a whole, including input suppliers, processors, the agricultural colleges, and so forth—still had the agricultural policy field to themselves. Most other people did not care to get involved, either because the regarded it as irrelevant or too arcane, or because they harbored good feelings toward farmers and were willing to let them look after their own interests.

But that has all changed. No longer can farmers count on everyone else feeling that what's good for farmers is good for the country. By the actions of some, farmers have been depleting the longstanding reservoir of goodwill they once could draw upon because they were thought to embody worthy agrarian values. Nonfarmers, therefore, including environmentalists, now play a much greater role in agricultural policy-making. Farmers have reacted in several ways. Some are in protracted denial: perhaps because they move mainly in circles that still are in sympathy with them, they just don't get it. Others, portraying themselves as the injured party, lamentably underappreciated and overcriticized, have joined the game of victim politics. Still others, invoking positive-sounding slogans like "property rights," have gone on the attack, rhetorically and otherwise, against environmentalists who would deny them their rights, such as the right to abuse their land.

But despite these misguided responses and nonresponses to the simple reality that agriculture no longer is master of its own house, many farmers are taking a constructive, forward-looking stance, recognizing that everyone has a legitimate say in the kind of agriculture we should have, and that the wisest strategy by far is to turn environmental advocates into their allies rather than their opponents. This means, first, to approach them amicably and cooperatively. Second, it means to educate the public—and by "educate" I mean "educate," although for many previous efforts of this sort, "propagandize" would be more accurate—about the things that agriculture already is doing on behalf of the environment. But most of all, it means *doing* more things on behalf of the environment, so that the public will correctly think of agriculture not just as a source of food, but as a provider of many valuable services.

This is especially true on a local scale, because in some areas, food production alone is not important enough to garner strong support. But if agriculture also provides a solution to a waste disposal problem, or a renewable fuel, or habitat for endangered wildlife, or attractive landscapes, or jobs for city youths, the area's farmers can expect much more public support, something they often need even to survive, let alone thrive.

The argument can be made on a national scale, too. Ironically, our agricultural system's strongest claim on the nation's support—that it furnishes a reliable, abundant and reasonably priced food supply—may no longer be sufficient, precisely because it has been achieved so thoroughly that most people probably don't even think about it. If so, to be assured of the public's continuing goodwill, agriculture must do more to earn it. If the environmental benefits of the alternatives described in this book are not motivation enough for farmers to accept them—for many they will be—the political benefits of being seen once again as the "good guys" should tip the balance.

For whichever reason, agriculturalists should see environmentalism not as a problem, but as a spur to make needed changes that will advance both their own well-being and that of the larger society. Farmers have met comparable challenges in the past, and they have a formidable stock of expertise and technology they can call on to meet the current challenge. And to an increasing degree, they have the motivation. I hope that by showcasing what already has been done and suggesting ways to go much further, this book will help convince farmers, environmentalists, researchers and policy makers that the goal of an agriculture that *enhances* the environment is both worthwhile and attainable.

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Operation Future: Farmers Protecting Darby Creek and the Bottom Line

Dennis W. Hall[1]

Big Darby Creek: A Great Place for Many Reasons

To most observers, Big Darby Creek looks much like any other Midwestern stream. Located in west central Ohio, Big Darby Creek meanders for 78 miles from its headwaters in Logan County through farmland and along a wooded corridor until it ends at the Scioto River south of Columbus in Pickaway County. It has no spectacular features that would have caused the local residents to know they lived near a special place.

The differences began to appear recently, geologically speaking. In the early 1800s, Big Darby was very much like other streams of its size in this region. Diverse species of fish and bivalves (freshwater mussels) could be found in most streams in this area. Today, however, Big Darby Creek stands as a last refuge of native ecological diversity. The stream still supports 86 species of fish and 40 species of bivalves. In addition, its diversity is represented by its 107 Heritage Element Occurrences recorded by the Ohio Department of Natural Resources (ODNR) (Gordon and Simpson, 1994). Heritage elements are culturally or ecologically significant features, including archeological sites, champion trees, and unique biological species or conditions.

Consistent with this diversity, Big Darby Creek is widely recognized by the environmental community. Within just a few years, Big Darby was designated as an exceptional warm water habitat by the Ohio Environmental Protection Agency, a state scenic river by the ODNR, a hydrologic unit area by the U.S. Department of Agriculture, a "Last Great Place" by The Nature Conservancy, and a national scenic river by the U.S. Department of the Interior.

Because of the number of programs and the size of the watershed protection effort, a collaboration of public and private organizations developed. This collaboration is known as the Darby Partners. The Darby Partners meet quarterly and are facilitated by

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[1]Ohio State University Extension and Operation Future, 246 West Fifth St., Marysville, OH 43040. This paper is presented on behalf of the farmer-members of the Operation Future Association and the forty-plus members of the Darby Partners. Special thanks go to the Ohio Chapter of The Nature Conservancy for their willingness to listen and respect the voice of farmers in this watershed.

4the Ohio Chapter of The Nature Conservancy. During these meetings, government agencies and private interest groups share information and plan cooperative activities. The Darby Partners has grown to include over 40 organizations, and is widely recognized as a model for watershed programs across the country.

Agriculture is the dominant land use in this 338,152 acre watershed, but non-agricultural development pressure is increasing. The Honda Corporation constructed a major industrial complex near the headwaters of the stream. The Hellbranch Run, a tributary to the east of Big Darby Creek, has largely been urbanized by the westward growth of suburban Columbus.

Most farmers in the watershed were unaware of the stream's ecological diversity. They valued it primarily as a drainage outlet. Surface and subsurface drainage transformed wet prairies (referred to as "barrens" in the early 1800s) into highly productive livestock pastures and later into cropland for grain production (King, 1981). The increased attention that Big Darby Creek was getting for its scenic and ecological attributes was troublesome and threatening to many farmers in this community. Rumors about what these designations meant and about the unfamiliar outside interests were widely discussed and believed. In this context, and given the public criticism of agricultural nonpoint-source pollution and destruction of wetlands, a strong negative response might have been expected from this farming community.

Operation Future Task Force

With the assistance of county extension agents from Ohio State University (OSU), a small but representative set of farmers from across the watershed came together to understand better the expectations of nonfarmers about Big Darby Creek and to select an appropriate response. Farmers were recruited according to their leadership ability within the farm community. It was not so important that they used best management practices or served in community organizations. Rather, opinion leaders and voices of resistance were specifically sought.

The task force took the name *Operation Future* and met for the first time on February 1, 1991. It included farmers from four of the six watershed counties. These farmers were motivated to act before they were required to do so by regulations, but were still unclear about what they should do. After two meetings, farmers were elected as officers and meetings were held with environmental organizations.

Canoe trip

A defining experience in this study was a canoe trip on Big Darby Creek in which farmers and stream advocates were paired for learning from each other about the watershed. Along the route, several stops allowed significant elements of the stream to be shared. For example, Ohio EPA demonstrated its technique for sampling fish, and introduced the participants to the many native fish species. ODNR shared their expertise in riparian corridors and macroinvertebrate sampling. An OSU mollusk specialist discussed the bivalve population and its significance.

The canoers learned many lessons, but maybe none more significant than the sense of common ground they all shared. The notion that biological diversity had persisted in this agricultural watershed while not in others was recognized as testimony to the farmers' stewardship. A new sense of pride and ownership of the creek's biological diversity began to emerge in the farming community. A fundamental shift occurred, with the farmers beginning to see their role as making a great place even better. This contrasted with the feeling that they were going to be lambasted for water quality problems.

Strategic planning

A one-day strategic planning retreat was scheduled by the task force to focus the farmers' efforts. To help guide farmers in this planning and to encourage further leadership in environmental protection, letters of encouragement were sought from agricultural and stream-related organizations. Operation Future task force members received letters from leaders in regional planning, soil and water conservation, and the Kellogg Foundation. OSU's Vice President for Agricultural Administration kicked off the retreat with a challenge to the farmers, and personally complimented them for their willingness to serve in this role.

During the retreat, participants adopted the mission of linking economic with environmental soundness to improve the quality of life in the agricultural community of the Darby Creek watershed. They developed priority activities, focusing on four basic areas: organizational development, environmental education, farm profitability, and public relations and policy.

Consistent with OFA's mission and priorities, a model (see Fig. 1) was developed to illustrate graphically how Operation Future seeks to enhance quality of life. This model shows farmers' overlapping interests in competitiveness, environmental soundness, and responsiveness to the social and political issues of the day. While the outside circle does not have a title, it serves as a reminder to focus on motivational strategies, not just educational subject matter. This approach is significant in that Operation Future's desired outcomes are changes in practice and personal development, not just knowledge gained.

Operation Future Activities

Organizational development

Operation Future took two big steps in 1993: first, it became the nonprofit Operation Future Association (OFA); second, it received a grant from the W.K. Kellogg

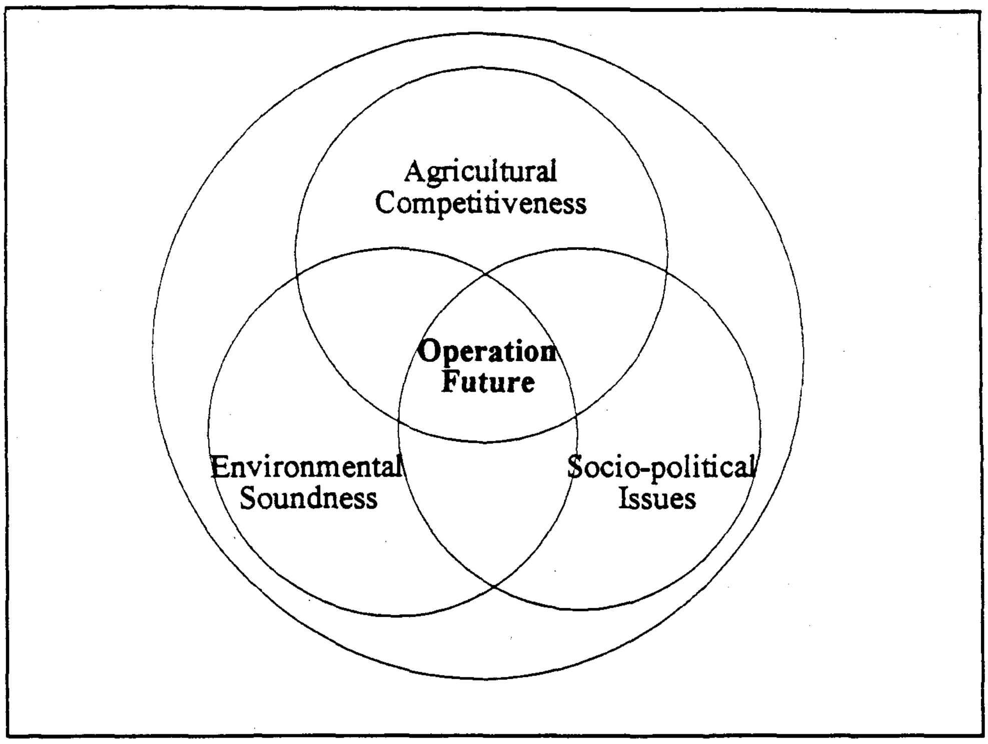

Fig. 1. Symbolic representation of Operation Future.

Foundation. Farmers from all six watershed counties make up its Board of Directors. The Kellogg grant made it possible for the board to hire an executive director to provide leadership for OFA activities.

OFA's annual meetings are major events for watershed farmers. Over 450 tickets were sold for each of the last two meetings. John Deere of Columbus and JD Equipment were corporate sponsors for these events, which allowed OFA to bring in prominent keynote speakers. In 1994, the keynoter was Orion Samuelson, a popular agricultural broadcaster from Chicago. In 1995, Baxter Black, a cowboy poet from Colorado, entertained the audience.

Environmental education

A high priority for OFA was to repeat the canoe trips for other farmers in the watershed. To date, nine trips have been conducted and over 300 different people have participated. Farmers have recruited their neighbors and representatives from government, the mass media, and environmental organizations. Collaborating agencies and participants have reported that these events have had a significant impact on how they view the stream. One farmer, for example, reported that his canoe trip was "the beginning of my enlightenment." In addition, a district soil conservationist has frequently said that "farmers who have participated in the canoe trips come to my office and ask the 'right' questions."

An important subgroup of OFA is the Drainage and Stream Quality Committee. These farmers work to balance the crop production needs of the area with ecosystem protection priorities. Their meetings focus on topics such as stream channelization and riparian corridor preservation, subsurface drainage and wetlands protection, and changes in hydrologic characteristics over time. The collaborative work seeks gain/gain outcomes.

Farm profitability

OFA also has conducted many field days and other farmer educational programs. Besides environmental topics, these events have focused on conservation tillage (including no-till) and nutrient and pesticide management. Two "Farm of the Future" field days have been conducted in cooperation with agribusiness, attracting large numbers of farmers. Nearly 400 people attended in 1994, and about 300 in 1995.

Agribusiness has played an important role in these and other field days in which OFA has participated. The 1994 "Farm of the Future" field day was cosponsored by the Monsanto Company. In 1995, OFA assisted the Du Pont Company with a "Neighbors" field day on an OFA member's farm. The 1995 "Farm of the Future" field day was supported by five agrichemical companies, two seed companies, a farm supply company, a regional and a local cooperative, and a local crop consultant. It also was cosponsored by two adjacent watershed programs.

Public relations and policy

An important role that OFA members serve is to represent farmers' views on environmental issues. This role is carried out during meetings of the Darby Partners with field staff of the Darby hydrologic unit area, other government officials, and the public. In these settings, OFA members suggest and support practical and economical approaches to stream protection.

OFA members take this responsibility seriously and have worked hard to understand watershed management and ecosystem protection. For example, OFA conducted two tours to Washington, D.C. to understand better the political interests working to shape the Clean Water Act and the 1995 Farm Bill. Tour participants (52 in all) have met with administrators of relevant government programs and a wide variety of interest groups. These farmers have gone to Washington not to lobby for a particular point of view, but to meet the leaders who are likely to influence national policy. The reasoning is that if farmers are to be effective in avoiding undesirable regulation, it is important that they know not only what the environmental community deems important, but why.

Tours to other parts of the country have become an important component of OFA's annual program. These tours focus primarily on different watershed management programs across the country. OFA toured the Mississippi River basin (primarily in Illinois and Missouri) the year after its once-in-500-years flood. Another tour went to the Chesapeake Bay watershed. Besides learning about the underlying factors that shape these watershed programs, OFA members enjoy meeting face-to-face with other farmers facing similar environmental challenges. This sharing of experiences and approaches has been valuable to both OFA members and the host communities.

OFA also has supported many programs to educate youth and nonfarmers. This support has ranged from financial contributions to educational events hosted by farmer-members on their farms. Four programs have involved more than 1,350 adults and children in programs such as "A Drive in the Darby" and "Kids and the Environment." Nonpoint-source pollution and its prevention are major topics in these programs. Also, during the OFA Annual Meetings, the Board of Directors recognizes a few of the more than 200 teachers trained in topics related to Darby Creek.

Membership

Operation Future now has over 100 farmer-members who farm an estimated 30% of the critical areas in the Darby watershed. Although this membership is impressive, OFA seeks to continue growing and increasing its influence. A strategy of having board members hold small discussion meetings with farmers in their area has been successful in this outreach objective. Not only has it identified new members, but it also has helped to identify and clarify the challenges these farmers experience. For example, before these meetings, illegal dumping by nonfarmers on agricultural lands was not recognized as a major concern.

Accomplishments

A result of Operation Future has been the construction of an effective bridge between the agricultural and the environmental communities. Rather than simply promoting voluntary approaches to protect the environment, OFA members have rolled up their sleeves and demonstrated voluntary action. A fault of our program has been that we have not been diligent about quantifying specific accomplishments. In areas where we have good data, however, we see impressive results. For example, a goal of the Darby Creek Hydrologic Unit Area (HUA) program was to reduce sediment entering the stream by 50,000 tons per year (see Table 1). Tillage transect studies show that farmers have adopted conservation tillage rapidly since 1992. In 1995, sediment entering the stream from farms was reduced by an estimated 35,000 tons simply from the increase in crop residues on the soil surface. This accomplishment alone represents 70% of the HUA goal. In addition, USDA helped to install nearly 250 acres of trees, three new wetlands, and forty new filter strips covering 92 acres on 9.5 miles of stream corridor.

This work was not done by any one organization. It has relied heavily on several partners: USDA's Natural Resources Conservation Service and Farm Service Agency; OSU Extension; Soil and Water Conservation Districts; and many more. An important and unique contribution by OFA is that because of the example set by its farmers, it now is socially desirable for farmers to participate in this ecosystem protection effort. Given the contentious nature of the project when the program started, this is a significant achievement.

This outcome has been noticed by the media and many public organizations. Operation Future was featured in such national publications as *Farm Journal*, *Progressive Farmer*, and *The Nature Conservancy*. Coverage in the last of these is probably the most prized by OFA members. It is one thing for farmers to tell other farmers they are doing good work to enhance our environment, but it means much more to know that a conservation organization said that to it 730,000-plus members. Besides national publications, Operation Future is featured regularly in local media.

The Darby Creek watershed program and its partnering efforts have been a model for many agencies and projects across the country. OFA, a unique participant in the watershed program, is frequently recognized as such. Some examples in which Darby Creek was identified include: a case study by the U.S. Department of the Interior of programs to protect endangered species; a study by the U.S. Government Accounting

Table 1. Conservation achievements and goals for the Darby watershed.

Year	Conservation Tillage (1,000 A)	Sheet and Rill Erosion (1,000 tons)	Reduction in Erosion from Baseline (1,000 tons)	Reduction in Sediment from Baseline (1,000 tons)	% of Goal
Baseline	45.0	2,195	N/A	N/A	N/A
1992	46.4	2,187	8	0.5	1.0
1993	90.1	1,952	243	17.0	33.8
1994	120.5	1,787	407	28.5	56.6
1995	139.0	1,688	507	35.5	70.4
Goal	178.4	1,475	720	50.4	—

Office; and a research program on ecosystem management by the University of Michigan. OFA has met with several watershed program leaders in Ohio and elsewhere, and has made presentations at the following meetings: Watershed '93; a Great Lakes Forest Policy Conference; a Soil and Water Conservation Society Conference on the 1995 Farm Bill; a National Watershed Conference sponsored by the National Watershed Coalition; a multistate Biological Diversity Short Course for foresters; and the annual meeting of the Minnesota Chapter of The Wildlife Society. OFA also has responded to over 35 different individual requests by providing written and video materials.

The Emerging Challenge of Land Use Changes

Some 1.4 million people live near this watershed. Increasingly, these people are moving into the watershed and along the stream. Large automobile and motorcycle assembly plants are located near the headwaters of the Darby watershed, and residential pressure has been increasing. In addition, Big Darby Creek is less than 20 miles from downtown Columbus. Protection efforts promoting Big Darby Creek as a special place may have increased the demand for residential property along the stream.

Farmland preservation has become an important issue, with farmers and nonfarmers struggling to know how the watershed can retain its agricultural nature. Township officials, zoning boards, and real estate developers are becoming the new target audience. Operation Future members will be valuable allies with the conservation community in helping to explore practical strategies that will protect Darby Creek and farm income.

Before 1990, farmers in the Big Darby Creek watershed were largely unaware that they lived and farmed along a stream that was recognized internationally for its biological diversity. Within a few short years, they have gained a new appreciation for the stream and have joined to keep this place special. Once regarded as the "bad guys," farmers today are recognized for their positive role in remediating the adverse effects of land use changes and nonpoint-source pollution. Thanks in part to the proactive leadership of area farmers and a diverse partnership of interest groups and agencies, Big Darby Creek is regarded as a great place, getting even better.

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The Watershed Approach to Integrating Agricultural Production and Water Quality Enhancement

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Introduction: The Project

The Herrings Marsh Run Watershed Project in North Carolina was initiated in 1990 as one of 16 water quality demonstration projects funded by the U.S. Department of Agriculture. Demonstration projects are one component of a broader strategy of the USDA Water Quality Initiative designed to "protect ground and surface water from potential contamination by agricultural chemicals and wastes, especially pesticides and nutrients" (U.S. Department of Agriculture, 1989). The Herrings Marsh Run Watershed was selected as a demonstration site because of perceived water quality degradation resulting from agricultural practices. The North Carolina Division of Environmental Management has designated Herrings Marsh Run as "support threatened" because of biological oxygen demand, nutrients and sediment from diffuse sources. This is the second severest level in a four-level rating of surface water's suitability for its intended uses; it signifies that stringent management is needed for the water to be usable.

The project is being carried out by an interagency team consisting of personnel from the Cooperative Extension Service, Natural Resources Conservation Service, Agricultural Research Service, and Farm Service Agency. Its objective is to encourage more rapid voluntary adoption of management practices and technologies that are economically efficient in reducing agriculture's impacts on surface and groundwater, with documented water quality benefits. Accomplishment of this objective requires producers to adopt best management practices (BMPs). This paper presents some results of BMP implementation and surface and groundwater monitoring after five years of project activities.

Setting

Geology, soils and hydrology

The study watershed is typical of much of the Atlantic Coastal Plain region of the southeastern United States. Soil parent materials are marine and fluvial sediments

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containing mixed sands and clays. Most soils in the watershed are sandy and well drained. The landscape is moderately dissected, consisting of gently undulating uplands and gentle valley slopes.

Two aquifer systems constitute the groundwater in the project area: the Surficial aquifer and the Cretaceous aquifer. The Surficial aquifer is the saturated portion of the upper layer of sediments, typically 7 to 17 m thick. It is unconfined; that is, its upper surface is the water table rather than a confining bed. Many shallow wells tap the Surficial aquifer, which is particularly vulnerable to contamination because it is close to the surface. Furthermore, the depth to the Surficial aquifer fluctuates seasonally; it is at or near the surface in late winter and early spring.

The Cretaceous aquifer is a grouping of several of the oldest and deepest sedimentary deposits lying directly over the basement rock. It includes confined aquifers and is 130 m thick or more. This aquifer is the source of deep, productive wells.

Agriculture

The 2,100 ha watershed contains about 1,100 ha of cropland. Major agricultural crops are: corn (350 ha); soybeans (200 ha); wheat (200 ha); tobacco (100 ha); cotton (100 ha); and vegetables such as cucumbers and sweet potatoes (150 ha). The crop diversity gives rise to extensive use of fertilizers and pesticides. About 50 different chemicals are used, an obvious cause of concern regarding water quality.

Swine and poultry are intensively produced in the watershed and are the leading sources of agricultural income. Confined operations are standard. Large amounts of waste are generated by these operations.

Although soil testing is widely accepted and generally practiced by growers in the watershed, careful and precise nutrient management is a new concept. Current annual nutrient use is estimated at 120 t (metric tons) of N, 54 t of P, and 200 t of K. The animal industry in the area produces enough waste to supply over one-half the nutrients needed by crops. Enough fresh manure is generated each year to supply about 50 kg/ha of plant-usable N, but 98% of the N applied to cropland is in mineral form, such as ammonium nitrate.

The sandy soils, fluctuating water table, and intensive crop and livestock operations are conducive to surface and groundwater contamination. Animal wastes from confined swine and poultry operations are potential sources of N, P, and organic contaminants, as are the large amounts of mineral fertilizers used in addition to animal manures. Pesticide use also is high.

Best Management Practices

Nutrient management is a high priority of the project because of the natural setting and the agricultural enterprises described previously. Nutrient management plans have been developed for over 80% of the watershed's cropland. Recommended nutrient management practices include: sampling of soils, plant tissues and wastes; crediting for nutrients in animal manures; calibration of application equipment; and split applications of fertilizers, especially N.

Pest management plans have been developed for over 60% of the cropland. Improved pesticide management practices include integrated pest management, selection of pesticides to minimize soil and water contamination, proper pesticide application rates, and safe pesticide handling practices.

Waste management planning entails site selection for crop production facilities and for manure handling, collection and treatment systems. Practices for water quality protection emphasize good manure handling and storage, off-site transport of manure, and on-site management of manure as a plant nutrient source or feed.

The project is investigating innovative waste management practices. A constructed wetland system has been developed to simulate a natural wetland for removing contaminants from swine wastewater. Alternatives are being explored for dealing with dead animals. Composting of dead poultry is a promising technique. The composting process breaks down organic wastes into stable, safe, humus-like materials that can be spread on land.

Producers are being surveyed to track land use and land treatment activities at the field and watershed level. Separate surveys are used for cropping and animal production, and the BMPs employed in both are identified and described. Costs of BMP implementation also are recorded for each farm.

The cropping survey is designed for making nutrient and pesticide recommendations. Data are recorded on the following: soil mapping units; leaching indexes; results of soil, plant tissue, and waste analysis; application rates and methods for nutrients and pesticides; tillage practices; and seeding rates. Five-year cropping and yield histories also are obtained. The livestock survey tracks production rates, feed consumption, and waste management details for each enterprise.

Water Quality Monitoring Methods

The project has monitored the water quality of streams, using four continuous sampling stations. Groundwater data have been obtained from over 100 monitoring wells and private water supply wells. The exact locations of monitoring points were confirmed using global positioning technology. Locations of the four continuous monitoring stations for stream discharge and water quality data are as follows: site 1 is at the watershed exit; site 2 is along a tributary downstream from intensive swine and poultry operations; site 3, which is used to determine background levels, is along the main stream flowing through woodlands at a location with few upstream inputs; site 4, upstream from site 1, monitors the eastern portion of the watershed.

Samples have been collected continuously at sites 1-3 since October 1990. The sampler at site 4 was installed in August 1991, and sampling has been continuous since then. Water samples have been collected hourly and combined into eight-hour composites. They are analyzed for nitrate, ammonium, total Kjeldahl N, orthophosphorus, and total P. Stream discharge is recorded by the U.S. Geological Survey (USGS).

Monitoring wells were strategically placed to evaluate the impacts of specific land use practices on the quality of shallow groundwater. Well bottoms were placed on an impermeable layer or to a depth of 7.5 m if an impermeable layer was not found. The wells are monitored monthly for nitrate and selected pesticides. Current well sites include a swine waste irrigation field, cropped areas where nutrient and pest management practices are being implemented, the site where dead turkeys are composted, and a pasture receiving composted turkeys.

Biological monitoring is conducted annually at site 2 by the North Carolina Division of Environmental Management (DEM). Benthic macroinvertebrates are collected using DEM's standardized quantitative collection techniques. The aquatic fauna is inventoried, the primary output consisting of a species list with indications of relative abundance (rare, common, abundant) for each taxon. Unstressed streams have a diversity of species, while stressed streams have fewer species. Water quality ratings are based on the abundance and characteristics of the least pollution-tolerant invertebrate groups. Streams are classified as Excellent, Good, Good/Fair, and Fair.

Results

Selected stream monitoring data are shown in Table 1. Mean nitrate-N concentration in the surface water leaving the watershed (site 1) and in a tributary (site 2) was respectively two- and fourfold higher than background (site 3). Daily nitrate-N concentrations at site 2 sometimes exceeded 10 mg/L during the first year of sampling, probably because of overapplication of waste water to fields. Since July 1991, the maximum nitrate-N concentration at site 2 has been 8 mg/L. Over four years, a gradual decrease in nitrate has been observed at both site 1 and site 2.

Ammonium-N concentrations in water leaving the watershed (site 1) and in the tributary (site 2) were respectively two- and fivefold higher than background (site 3) over the four-year sampling period. During the first two years, ammonium-N concentrations at sites 1 and 2 exceeded limits considered harmful to humans (0.5 mg/L) and fish (2.5 mg/L). These high levels indicate that a significant amount of animal waste has been discharged into the waterway. Ammonium-N at sites 1 and 2 has decreased sharply since February 1993.

Stream flow data from the USGS gauging stations were integrated with the stream monitoring data to calculate the mass loading of nitrate-N and ammonium-N. In 1991 and 1992, nitrate-N leaving the watershed (site 1) averaged about 30 kg/ha per day. The tributary (site 2) received about 20 kg/ha per day from its subwatershed. These levels have decreased slightly with time. Baseline biological monitoring data indicated a bioclassification of Fair at site 2. Subsequent data have elevated the bioclassification to Fair/Good.

Nitrate-N concentrations in groundwater at six monitored sites are shown in Table 2. The high levels at Farm B are probably due to continuous land application of swine wastewater since 1986. The spray field is inadequate for retaining all the waste produced by the swine operation, which has expanded. The elevated nitrate-N concentrations at Site F may be due to earlier contamination from the neighboring poultry houses. The slightly elevated nitrate-N concentrations at Farms A and C probably are related to excessive N fertilization. Farms D and E appear to have appropriate nutrient management, since their nitrate-N concentrations are less than 10 mg/L.

Groundwater samples were collected from 92 monitoring wells in 1993 and 1994, and analyzed for alachlor, atrazine, and metolachlor. Immunoassay tests over 18 months

Table 1. Mean daily nutrient concentrations (mg/L) for four stream monitoring stations on Herrings Marsh Run (Stone et al., 1994).

	Station Sites			
	1	2	3	4
NO_3-N	2.01	5.34	1.18	1.26
PO_4-P	0.14	0.54	0.06	0.07
NH_4-N	0.15	0.42	0.08	0.18

Table 2. Mean monthly NO_3-N and NH_4-N concentrations (mg/L) in groundwater monitoring wells in the demonstration watershed (Stone et al., 1994).

	Nitrate-N		Ammonium-N	
Farm	Mean	Std. Dev.	Mean	Std. Dev.
A. Continuous corn, no waste	10.9	6.4	0.25	0.3
B. Grassland, swine waste	72.7	64.9	16.5	16.2
C. Row crop, no waste	16.8	4.1	0.27	0.28
D. Row crop, poultry compost	5.6	5.5	0.29	0.42
E. Row crop, poultry litter	6.5	1.2	0.28	0.34
F. Poultry compost site	11.1	8.7	0.44	0.97

showed small amounts of these three herbicides in a few wells. There seems to be a seasonal pattern, with these herbicides detected more frequently from April to July.

Alachlor was the most frequently detected herbicide, occurring in about 14% of the samples. Most of the wells where alachlor was detected had concentrations much lower than the maximum contaminant level. (This is the standard established by the U.S. Environmental Protection Agency for municipal water systems, computed from a maximum lifetime exposure; for alachlor and atrazine it is 2 ppb and 3 ppb, respectively.) Despite high use of atrazine, only a few wells (5%) had positive immunoassay detections. Metolachlor also was detected infrequently (5%). Although these herbicides are applied heavily in the watershed (700 to 850 kg annually), current pest management BMPs used by local farmers and applicators appear satisfactory for maintaining acceptable groundwater quality.

Farmer Impacts

Farmer participation and cooperation have been excellent throughout the project. A key to success was the inclusion of farmers in the planning stage. Before the project began, meetings were held in which its goals, objectives, and expected benefits were explained to farmers, local government and business leaders, and others.

Farmers have become better informed by their participation in the project. For example, a poultry producer collects data on the dead turkey composter for the local Extension Specialist. Discussions of such data and interactions with numerous scientists and specialists visiting the site have increased the producer's knowledge of the composting process. In turn, he shares this knowledge with other poultry producers in grower meetings, "country store" conversations, and other settings.

The demonstration project is positively affecting the adoption of BMPs. Several farmers have said that the project has been influential in their decision to implement BMPs such as grass waterways and nutrient management. The project has heightened awareness of water quality issues not only for farmers, but also for the people in the local communities.

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Padilla Bay Proposes a Unique Community Partnership for On-Farm Agriculture and Estuary Research and Education

Colette DePhelps[1]

Introduction: Agriculture and the Environment in Padilla Bay

In Skagit County, Washington, rapid urban growth in and around the cities of Mt. Vernon and Burlington is bringing in many people with a different view of agriculture and its relationship to the local environment. While most Skagit County residents are likely to be concerned both with protecting local natural resources and with maintaining agricultural production, they may not realize that factors contributing to nonpoint-source water pollution and other environmental issues of concern extend far beyond the farm (Fig. 1). External factors affecting agriculture/estuary ecosystems ultimately can affect the quality and quantity of agricultural products produced locally and the overall economic and ecological viability of the region. Concerns about agriculture's potential harm to wildlife habitat and water quality prompted the Padilla Bay National Estuarine Research Reserve to propose a unique venture into community-based agriculture and estuarine enhancement and preservation.

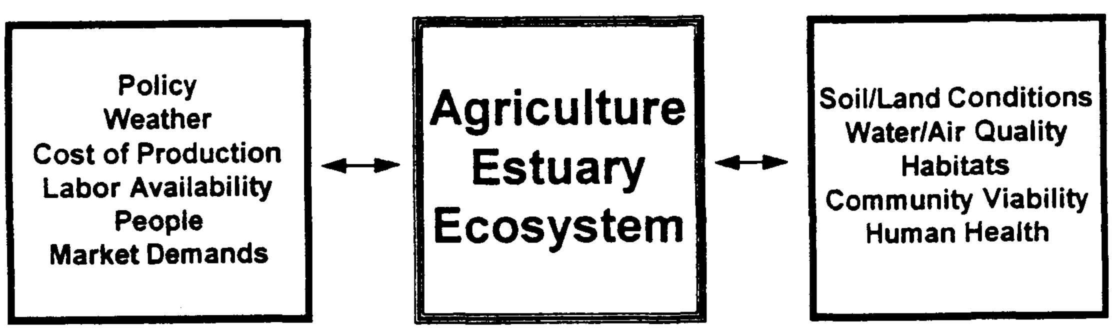

Fig. 1. Agriculture/estuary impacts: Two dimensions. Community groups interact in complex ways affecting the stability of the agriculture/estuary ecosystem. (Adapted from Gliessman, 1990).

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Padilla Bay National Estuarine Research Reserve

Established in 1980, the Reserve is located in a northeastern bay of Puget Sound. Padilla Bay's small coastal watershed of about 23,000 acres sits in the north lobe of the Skagit River delta. The Padilla Bay estuary encompasses one of the largest intertidal beds of eelgrass *(Zostera marina* and *Z. japonica)* on the west coast of the United States, and adjacent land areas provide important habitat for many aquatic and terrestrial species, both migratory and nonmigratory.

This shallow, orphaned estuary no longer receives fresh water from the Skagit River, which altered its course nearly ten thousand years ago. Instead, surface waters originating in the residential, industrial, timber, and agricultural lands of the upper Padilla Bay/Bay View watershed drain into the bay through a series of drainage sloughs, most of which are remnant high water routes of the Skagit River. With agriculture using over half the land in the watershed, there is substantial potential for it to pollute surface and groundwater, and ultimately the marine waters of the bay.

Water quality and agriculture

Since the diking of the perimeter of Padilla Bay in the late 1800s, agricultural production has flourished within the Padilla Bay/Bay View watershed. Common crops include potatoes, peas, cucumbers and beet seed, which are rotated annually. There have been few studies of water quality in the watershed, but surface water quality and its impact on the health of the intertidal eelgrass beds is of concern to the area's researchers and residents.

There is evidence that agriculture is contributing to pollution of Padilla Bay's surface drainage channels by adding significant amounts of nutrients and suspended sediments (Cassidy and McKeen, 1986; Bulthuis, 1993a,b). A surface water survey of the watershed conducted in early 1993 for the Padilla Bay/Bay View Watershed Planning Committee showed that both agriculture and development are nonpoint sources of pollution (Skagit County Dept. of Planning and Community Development and the Washington State Dept. of Ecology, 1993). However, a 1989 pesticide study concluded that pesticide levels in sediment and agricultural runoff were not high enough to harm the eelgrass communities in the bay (Mayer, 1989; Mayer and Elkins, 1990). Although pesticide contamination does not appear to be a problem, the studies showing pollution by nutrients and suspended sediments, combined with the discovery of how agriculture and development contributed to the decline of Chesapeake Bay's eelgrass beds, alerted the Padilla Bay Reserve to the potential threat facing the estuary (Horton and Eichbaum, 1991).

The potential of an agriculture/estuary research and education program

Because of the possible water pollution from nonpoint sources, the Washington State Department of Ecology, which administers the Padilla Bay Reserve, asked the College of Agriculture and Home Economics at Washington State University (WSU) to help them investigate the need for and benefits of an agriculture/estuary research and education program centered in a Reserve-owned demonstration farm. If the initial investigation showed such a program would be beneficial both for protecting water quality and enhancing agriculture's viability in the region, the Reserve would also request WSU to assist them in planning its design and implementation.

This paper summarizes a 1993 feasibility study undertaken by WSU and the Reserve to determine the potential for an on-farm research and education program and to develop a community-based planning strategy for designing, implementing and evaluating program activities. Included is an update on the status of the program and a discussion of why strong community involvement is important when setting the agenda of an institutionally managed on-farm research and education program.

Addressing Local Agriculture and Estuary Issues Through On-Farm Research and Education

In late spring and early summer of 1993, I and a small team from the WSU faculty and the Reserve staff explored the opportunities and constraints of a Padilla Bay research and education program (DePhelps, 1993). This effort included an extensive literature review and a series of telephone interviews and focus groups with estuarine and agricultural scientists and local community groups interested in agriculture, the Padilla Bay estuary, and water quality. The feasibility study showed that Skagit Valley farm and nonfarm residents and the regional scientific community felt that such a program could benefit both the local community and the environment by developing site-specific land management practices that protected water quality while enhancing agriculture's viability.

Because of the strong support and encouragement received from the study participants and the Washington State Department of Ecology, the Reserve decided to develop the program. In early summer of 1993, it bought an option on 100 acres of farmland adjacent to the marine waters of the bay. After completing several environmental and economic assessments of the property, the Reserve bought the farm in 1994.

The Reserve-owned farm

The Reserve-owned farm is central to the emerging research and education program. The farm will be the primary site for program-related on-farm research and educational activities. The Reserve recognizes that an advantage of on-farm research is that unlike small-plot research on a university experiment station, it takes place on farmers' fields under local environmental conditions with machinery that farmers use daily. As a result, management practices developed on-farm will be incorporated more easily into a local farmer's existing management system. What is learned on-farm can be shown to both farmers and community members through field days, workshop demonstrations, and features in local newspapers and newsletters. This way, not only do farmers benefit from local research, but the public also benefits by learning more about local agriculture and what farmers are doing to protect the environment.

Since the Reserve farm will be used for both commercial production and on-farm research, careful consideration is being given to how it will be managed. The Reserve recognizes that farm managers must have credibility not only with program planners, but also with members of the larger agricultural community, who will be evaluating its outcomes and deciding whether to adopt the resulting recommendations. If other farmers view the Reserve farm's managers as biased toward either the environment or agriculture, they are likely to be skeptical about the research results and consider the recommendations unsound.

This concern has led WSU and the Reserve staff to consider collaborative farm management that draws heavily on varied sources of community expertise to design, implement and evaluate on-farm research, develop educational strategies, and disseminate results. The Reserve is now considering leasing the farm to a local grower who would both farm it for profit commercially and work with a diverse project team to design and implement related on-farm research and educational activities. WSU and the Reserve staff believe that this high level of community involvement can both increase local farmers' interest in leasing the farm and improve the credibility of on-farm research results.

However, such an arrangement can create a conflict between managing the farm for research and managing it for profit. An example is how to allocate the costs of machinery used both for production and for research. And what if the researchers want the farmer to do something that interferes with profitability? The operational plan currently being developed will include ways to maximize the opportunities presented by the farm while minimizing these conflicts.

Community Participation in Planning a Research and Education Program

Besides recommending the development of an on-farm research and education program, the 1993 feasibility study suggested that the Reserve establish a research and education planning group, and proposed several activities it might undertake (Fig. 2).

Proposed planning group activities

The first proposed activity is for the entire planning group to learn about the concerns and perspectives of its members and the larger community and about agriculture and the estuary (Fig. 3). New insights into the relationships among the community,

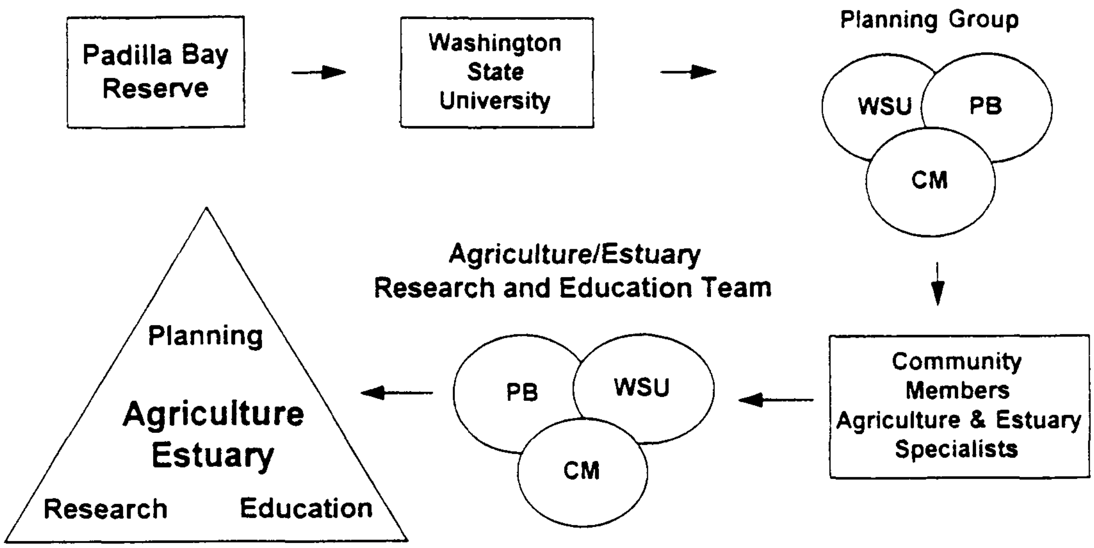

Fig. 2. Forming an agriculture/estuary research and education planning team. [WSU: Washington State University; PB: Padilla Bay Reserve; CM: Community members.]

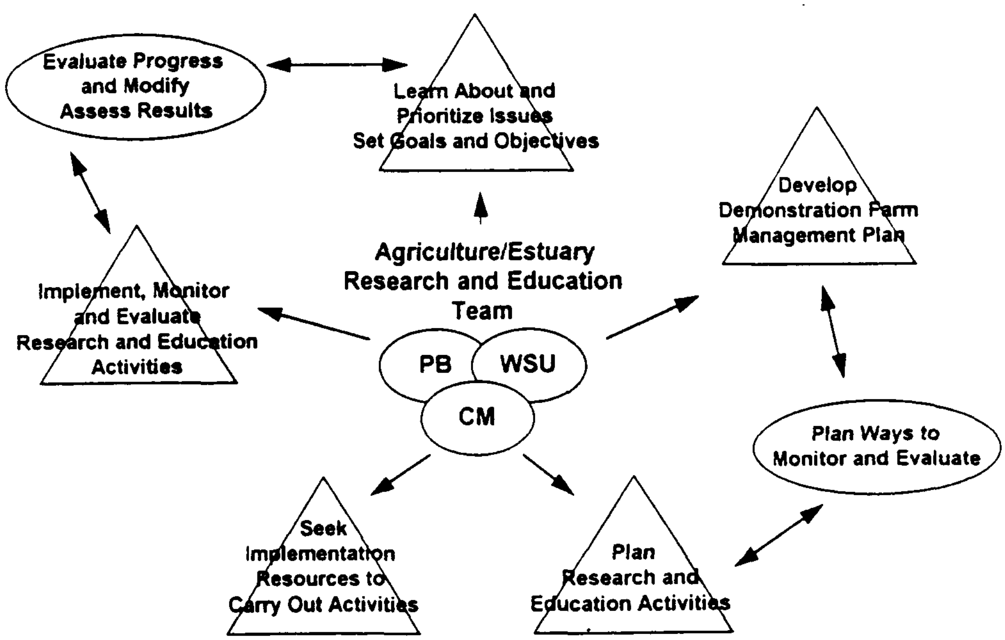

Fig. 3. Activities in planning and evaluating an agriculture/estuary research and education program. [WSU: Washington State University; PB: Padilla Bay Reserve; CM: Community members.]

agriculture, and the estuary can be used to set priorities for environmental issues of concern in the watershed. On the basis of those concerns, the group will be able to establish the program's preliminary short- and long-term goals and objectives.

The second proposed activity discussed in the feasibility study is the development of a detailed plan for managing the Reserve's demonstration farm. To identify and develop on-farm research and educational activities that will include the concerns of the larger community, the study suggested that the planning group consider increasing its membership to include more farmers, research specialists and community members who are actively involved in the issues the program is likely to address. After carefully considering what each might add to the planning process, the planning group might decide to invite six to eight such people to participate in the remainder of the planning process as members of an Agriculture/Estuary Research and Education Team, along with the original members of the planning group.

Bringing these diverse groups together will be an educational activity for everyone involved. This is because forming the Agriculture/Estuary Research and Education Team will create a forum for examining issues that otherwise might be discussed in separate circles. As described by Chambers (1989), the multi-directional learning environment created will be very different from the "top-down" approach traditionally use by university researchers and educators and by regulatory agencies. Not only will it *allow* information to flow from the community to the researchers and agencies, as well as in the opposite direction—it will actively *promote* this two-way interaction.

Thus, this team approach will transcend traditional one-way communication; although Reserve and WSU personnel might facilitate meetings and discussions, the other team members will have equal involvement in and control of the planning process. This will provide a balanced atmosphere for community members, agency personnel and WSU specialists to learn together about important natural resource issues and problems while allowing persons with different perspectives to express their views, listen to the views of others, and develop informed opinions. Through this dialogue, each team member will get a broadened view of the total agriculture/estuary ecosystem. Forming the Agriculture/Estuary Research and Education Team also will help team members achieve the following:

- improve communication among Skagit County interest groups
- increase their understanding of commercial farming practices and the Padilla Bay estuary
- educate each other by sharing personal knowledge and experience
- design, implement, and evaluate on-farm research
- encourage local participation in educational and information dissemination activities.

The next two recommended tasks, identifying and evaluating research needs and identifying the educational needs of specific audiences, are integrated activities that should involve members of the larger community. These tasks will require development of research projects addressing community concerns identified at the beginning of the planning process. The study suggested that the team begin formulating educational strategies that target the sources of these concerns. Each research and educational activity should include ways to promote community involvement and facilitate community support.

A well-planned assessment of whether research and education activities are meeting the goals and objectives is just as important as planning the activities themselves. Each activity should allow for periodic evaluation by the research and education team and other participants and be flexible enough to allow continuous modification and improvement. When planning for evaluation and modification, it helps to remember that the problem-solving process is cyclical, not linear, with feedback loops throughout (Fig. 3).

Developing an operational plan

In 1995, the Reserve built on the planning recommendations of the feasibility study by seeking grant funds to develop an operational plan for the farm. In January 1996, the Reserve, in collaboration with WSU, began preparing a plan that will address the recommendations of the feasibility study, particularly to look at ways to develop collaborative partnerships and to compile data on the physical characteristics of the Reserve-owned farm.

By convening a planning process with strong community involvement and shared decision making, the Reserve will build a local coalition that pools a variety of resources, expertise, and information. This coalition can develop a group of local advocates for protecting estuarine and agricultural resources within the Padilla Bay watershed and can help establish a crucial base of community-wide support for addressing environmental issues associated with agriculture and the estuary.

Community Involvement in Environmental and Agricultural Research and Education

There is a wide difference of opinion among researchers and educators about how community members should participate in environmental and agricultural research and education. Levels of community involvement range from none to equal involvement and collaborative partnerships (Biggs, 1989). The goal of the planning process is to make better decisions by insuring that an array of local concerns and a range of research and education alternatives are considered. When local citizens take responsibility for the long-term health of their region's natural resources before the situation becomes critical and regulatory agencies intervene, they become active stewards of the land. When this is done collaboratively, rather than individually, the mechanisms they devise and the associated actions have a greater chance of achieving long-term sustainability because the process fosters ownership, commitment, and mutual learning (Greenwood et al., 1993).

For example, in some areas of Skagit County, groundwater is contaminated with nitrates, but county residents disagree over the source. Urban and suburban homeowners suspect agricultural fertilizers and livestock wastes, while farmers and ranchers believe the contamination may come from faulty septic systems. There is little data to determine the true source. Bringing community members together to learn about nitrate sources, to undertake research to determine the true sources, and to educate each other and the larger community about how nitrate contamination may be avoided is a way to prevent further contamination, protect human health, avoid blanket regulations, and build community understanding and support for local research and education programs.

Building such support will be integral to the success of an agriculture/estuary research and educational program at the Padilla Bay Reserve. Strong community involvement in conceptualizing and planning the program will allow local citizens to devise locally acceptable and appropriate solutions to environmental problems through community-based research and education. The community involvement strategy described above creates partnerships among community members, the Reserve staff, and WSU researchers and extension specialists, thereby providing local support for the on-farm program. The primary strength of building collaborative partnerships is that it brings into all aspects of the research and education process a wider range of community members who might affect or be affected by the sustainability of the agriculture/estuary ecosystem.

In this kind of process, community people have a participatory decision-making and leadership role rather than just their traditional advisory role (Chambers, 1989; Whyte et al., 1991). This proactive involvement will not make the job easier for the manager of the Padilla Bay National Estuarine Research Reserve. However, it will result in a program that has a better chance to be directly applicable to the region's agricultural systems and to protect the entire estuarine ecosystem—including the agricultural lands—and the diverse aquatic and terrestrial species that require a healthy estuary. This should increase community enrollment in educational activities and enhance the acceptance of the research results. The community-based planning process also should diffuse any potential conflict among team members as the program moves ahead, because communication patterns and ground rules will have been established (Boyle, 1981).

In a time of dwindling state and federal research and education budgets and increasing public expectations, building collaborative partnerships is of great value to universities and government agencies. It allows them to pool their limited resources to support activities in areas where they have joint interests and responsibilities, while avoiding needless duplication. Also, as more granting organizations require substantial community involvement in planning and implementing the programs they support, universities and agencies must explore ways to increase community involvement in the planning process.

Conclusion

Although the Padilla Bay Reserve has only begun developing its on-farm research and education program, the planning and implementation strategy it developed in 1993 provides a valuable model for other organizations interested in involving community members in solving local environmental and agricultural problems. The interface between agriculture and the environment can be a very volatile community issue. The value of community-based planning lies in its potential to dispel urban-rural conflicts over environmental issues while developing locally acceptable solutions.

By involving the local community in identifying, developing, implementing and evaluating agricultural/environmental research and education, the Reserve is shifting from the traditional hierarchical, top-down approach toward a more participatory applied research process that merges research with education. The result will be a multidimensional team whose members can learn from each other and work cooperatively to create innovative solutions to many kinds of community natural resource issues. In a region with significant agriculture on the urban fringe, the community-based approach to problem-solving and education developed by WSU and the Padilla Bay Reserve has a much greater chance of preserving and enhancing the agriculture/estuary ecosystem than if either institution were working alone.

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Watershed Protection: A Better Way

Richard I. Coombe[1]

The New York City water supply system is the largest surface storage and supply complex in the world, covering over 1,900 square miles (1,216,000 acres). The watersheds yield 1.2 billion gallons of water daily. Besides its own residents, the city supplies drinking water to one million residents of upstate counties and millions of daily commuters and visitors to the city.

The water traditionally has been of such high quality that it has been singled out for awards. However, the natural beauty of the watersheds and their proximity to New York City has encouraged land development. The mid-Hudson valley and the Catskill Mountain regions of New York State are among the most beautiful and desirable places to live in or visit in the entire country. Close to the city, development has been very rapid, resulting in high-density subdivisions and increased pollution. Since the Second World War, suburban development has caused serious degradation in the Croton system, the oldest and closest of the city's watersheds.

Since 1990, the Watershed Agricultural Council has been working to aid rural residents of the New York City watersheds in taking voluntary actions to reduce pollution risks. Its unique program and partnership structure provide a model for a new and better way to protect America's rural surface and groundwater supplies.

Historical Overview

In 1850, a growing, thirsty New York City looked northward for a clean, reliable source of potable water. The Croton system (1850) supplies 10% of the city's water; the Catskill (1920-30) and Delaware (1950-60) systems provide the other 90%. New York City, through the power of eminent domain, took over the valleys and forced entire hamlets and the surrounding farmers to move to the hillsides. Historical neglect and broken promises fostered tension between watershed residents and New York City regulators, leaving a legacy of distrust and even hatred of the city.

In 1906, New York State law gave New York City the right to oversee and regulate upstate watersheds. In 1953, the city updated and upgraded its watershed regulations but

[1]Watershed Agricultural Council, RR 1, Box 74, NYS Route 10, Walton, NY 13856-9751.

chose an enforcement strategy of benign neglect. In 1986, the Federal Safe Drinking Water Act required filtration of surface water systems. Think of the difficulty of New York City complying with the Safe Drinking Water Act. Imagine filtering 1.2 billion gallons of water daily!

The 1989 Surface Water Treatment rule specified circumstances and conditions that require filtration of drinking water derived from surface sources, and set criteria that would allow water suppliers to avoid filtration. The rule set specific standards for microbial contaminants, including bacteria, viruses and protozoan parasites. The cost to filter New York City's water was estimated at $5 to $8 billion for construction, and $200 to $500 million in annual operating costs. Therefore, the city sought to avoid these costs by establishing a traditional program to protect its watershed through regulation and land acquisition.

Confrontation

In 1990, a discussion draft of new regulations for the watersheds was released by the New York City Department of Environmental Protection (DEP). The residents of the watersheds were asked to accept superimposed, costly, and onerous regulations. The traditional watershed protection methods of strict regulations, enforcement by police power and land acquisition again were being used to protect the city water supply to save $5 to $8 billion dollars in filtration costs.

The residents of the watersheds saw a clear and present danger to life as they knew it, a threat to their roots, hopes and dreams. Again, a new generation was to be abused by an unsympathetic city.

Especially hard-hit were the farmers of the Catskill and Delaware watersheds. The discussion draft required farmers "to eliminate the surface runoff of storm water from grazing areas into any watercourse. . . . Discharge of drainage from barnyards, feed-lots, and yarding areas into any watercourse . . . is prohibited" (New York City Department of Environmental Protection, 1990, pp. 27-28). *Watercourse* was defined as "any perennial river, stream, creek, spring, pond, lake, wetland." In short, if strictly enforced, the 1990 regulations doomed agriculture as a land use in the New York City watersheds. In addition, agriculture was singled out as a source of nonpoint pollution and blamed as a major source of giardia and cryptosporidium.

The stage for confrontation was set. A series of debates took place between Commissioner Albert Appleton of the NYC DEP and members of the agricultural community. As a member of the New York State Assembly, I argued vigorously against the regulations.

My perspective was straightforward. The highly developed, suburban Croton watershed (Westchester, Putnam and Dutchess counties) required filtration. The Catskill and

Delaware watersheds, which were less densely populated, were so clean that the water met the criteria for avoiding filtration. The current low density land use patterns based on agriculture, forestry, and tourism indeed were desirable land uses, as demonstrated by the quality of water supplied from the Catskill and Delaware watersheds.

If the 1990 regulations had been adopted and enforced, agriculture and forestry would have been forced to sell to the highest bidder. The resulting subdivision of the land would have "Crotonized" the Catskills, degrading the city's water supply and insuring that filtration would be required. We believed that crops, grassland, and agriculture are environmentally preferable land uses to subdivisions. Civil War loomed.

Action

An alternative to filtration under the Surface Water Treatment Rule was for the city to develop a comprehensive watershed management program. Any such program needs local cooperation and support.

Adversity fosters creative invention. The city was facing $5 to $8 billion in filtration costs, and the watershed farmers were facing elimination. The stage was set. High motivation based on self-preservation and survival, plus a willingness on both sides to take risks, led to dialogue. DEP Commissioner Appleton and the agricultural community agreed to establish an interagency/farmer task force to be convened by the New York State Department of Agriculture and Markets to address the 1990 draft regulations. The challenge for the policy group of the Ad Hoc Task Force was to recommend regulations and programs that would protect New York City's water supply while sustaining the long-term viability of agriculture in the watersheds. Agriculture was quickly acknowledged as a preferred land use.

The Task Force had three goals: to improve mutual understanding of the laws and public policies that shape the city's watershed program; to review and advance the scientific basis of farm planning conceived to protect water quality, and especially the farmers' business interests; and to explore ways in which the city might work in partnership with farms and the network of agricultural support institutions to encourage a sustainable farm economy in the watersheds while achieving the city's water quality objectives. The challenge for the Technical Support Group was to provide technical information and provide practical input on ways to address the agricultural elements of policy.

The following consensus was developed by the Task Force. Farming in the New York City watersheds presents a complicated environmental management problem. Farm practices potentially are a significant source of nonpoint-source pollution, and present a risk of introducing pathogens. Farm practices to control pollution are critical for meeting the city's antidegradation objectives and the avoidance criteria of the Federal Surface Water Treatment Rule and the State Filtration Rule. On the other hand, farming is a preferred land use with significant long-term environmental benefits, and the city wants to take all appropriate steps to support it. This represents a significant challenge, since agriculture is a rapidly declining industry in the region. However, with the application of the best scientific understanding, we hope this decline can be reversed while we meet water quality aims.

The Task Force concluded it would be far better for New York City to "withdraw the proposed regulations on agriculture" and implement "a voluntary, locally developed and administered program of best management practices" (Ad Hoc Task Force, 1991, pp. 4-5). Compulsion will not succeed with fiercely independent farmers, and the program should be voluntary, providing incentives to farmers to participate. A clause dealing with willful and negligent pollution remains in the regulations.

Since late 1992, we have been developing and implementing demonstration "Whole Farm Plans" based on scientific research and technical data for ten pioneering farms in five counties. The plans apply and test multiple ways to manage pathogens, nutrients and sediment. The plans also aid farms as businesses. We are monitoring and evaluating the process very carefully so that it will develop according to New York City's and our farmers' needs.

As a result, a comprehensive farm management program was established under the title "Whole Farm Planning Program." The program is endorsed by New York State agencies, New York City, the farmers themselves, and the U.S. Environmental Protection Agency.

Whole Farm Program

Our vision is clear: Maintaining well-managed agriculture is a superior way to protect water quality in the New York City watersheds as part of a comprehensive watershed protection program. Voluntarily involved farmers, aided technically and financially to match their business activities more closely to New York City's needs, are among the best water quality protection agents that New York City can have. The high quality of the water yielded by the Catskill and Delaware system watersheds, which is sufficient to meet federal criteria for avoiding filtration, is supported by the current low-intensity land uses and land management patterns, including agriculture.

Phase I

The program is proceeding in two phases. Phase I was funded at a level of $5 million of combined resources; Phase II is funded at $35 million. Phase I goals included:

- Developing, testing and demonstrating on at least ten farms, the Whole Farm Planning/BMP (Best Management Practice) Approach.

- Training the County Project Teams in each of the eight counties within the NYC watershed in the Whole Farm Planning/BMP approach.
- Implementing the more direct portions of the Whole Farm Plans, such as barnyard runoff control, manure storage, stream fencing, and obvious soil erosion control measures, on all the demonstration farms within two years.
- Encouraging at least one demonstration farm to implement within the two-year Phase I period all the agreed-upon structural and management practices called for in the Whole Farm Plan, especially those related to water quality.

Every task involves participants from multiple organizations and requires a great deal of attention to communication and coordination. The NYS Soil and Water Conservation Committee has acted as an umbrella program administrator. This role includes operational oversight, interagency coordination, and disbursement of funds. Under this umbrella, the County Project Teams (Soil and Water Conservation Districts, Cornell Cooperative Extension, and the Natural Resources Conservation Service) and the Technical Support Team contain most of the program's personnel. These teams cooperate in developing pilot Whole Farm Plans, with county staff and pilot farmers leading, and in crafting a scientifically credible planning process, with the Technical Support Team leading.

A Whole Farm Plan is the program's main means for partnership between an individual farmer and the city. Though the motivation for them is water quality needs, they are best viewed as extended farm business plans. The extensions depart from traditional practices in two directions: management and structural steps that adapt many farming practices to the watershed's sensitivity to pathogens, nutrients, sediments, pesticides, and other environmental contaminants; and incentives that reinforce the farmer's role as an active agent of water quality protection. These extensions serve both the farmer and the city.

Each Whole Farm Plan must be tailored to fit the site and the business affected. A plan contains best estimates of the specific farming practices that an individual farm needs to meet water quality and business goals. To give confidence that the water quality goals can be met, the soundest science must be used in selecting the BMPs and tailoring them to the particular farm. Because the quality criteria for drinking water in New York City's unfiltered system are so strict, the Whole Farm Plans must cover animal pathogens, sediments, nutrients (especially phosphorus and nitrogen), pesticides, and other substances that directly or indirectly affect human health. Much of the effort in Phase I has been devoted to crafting efficient yet reliable ways to forecast the effectiveness of candidate BMPs so that the best ones can be selected with confidence.

During Phase I, County Project Teams, cooperating farmers and the Technical Support Group devised ten plans. The Watershed Agricultural Council (WAC) reviewed or approved the ten plans wholly or partially. All are being implemented with 100% cost coverage by New York City, up to a total of $1 million for the ten demonstration farms.

Phase II

Phase II is an ambitious program to sign up 85% of the 500 farms in the New York City watersheds to participate voluntarily in the Watershed Agricultural Program. Whole Farm Plans must be developed on each participating farm and BMPs prioritized. Implementation of the BMPs on each participating farm is the ultimate goal of the program.

In reaction to the decentralized leadership during Phase I and the need to empower those being affected, WAC was strengthened. WAC is the program's governing body and policy maker. A not-for-profit 501(c)(3) corporation, it consists of nineteen farmer and agribusiness leaders from across the eight-county New York City watershed region, and the Commissioner of the NYC DEP. WAC also includes eleven ex officio advisory members drawn from government and private organizations.

WAC entered negotiations with the NYC DEP to administer, develop and implement a Whole Farm Planning/Best Management Practices implementation program consistent with the city's goal of controlling and remediating agricultural sources of water pollution and the farmer's goal of agricultural viability. On August 23, 1994, a $35.2 million five-year contract was signed to provide a voluntary program to protect water quality and maintain farm viability in the New York City watersheds.

On September 16, 1994, at the Menke pilot farm, Commissioner Marilyn Gelber of the NYC DEP said the following:

> Today we are formalizing a far-reaching, public-private partnership which provides the foundation for increased environmental protection in the New York City watershed through a voluntary program that has become a national model of what government and private citizens can do when working together.

As chair of WAC, I expressed the view that

> this partnership between watershed residents and New York City sends a signal that continued economic stability for watershed dairy and livestock farmers and watershed protection are not exclusive and can benefit everyone through voluntary means and common understanding.

This program is unique in its origins and approach. Because there is no complete example to draw from, no one believes it will be an automatic success. Neither of its basic goals—healthy water consumers and healthy farms—can be achieved either simply or cost-free. Phase I of the program has been systematically building experience, data, scientific foundations, and interorganizational ties to make sure that the full-scale Phase

II, which began October 1, 1994, ultimately can deliver positive results to both the city and the farming communities.

The Program's Mission and Objectives

The Watershed Agricultural Program rests upon the fundamental principle that well-managed agriculture is a superior way to protect water quality. Its mission (Watershed Agricultural Council, 1995) has been stated this way:

> To assist the agricultural community in adopting operational and management techniques which environmentally protect water quality, as well as enhance economic competitiveness and viability. The program will champion a Whole Farm Planning process that strengthens working relationships between landowner, New York City, local, state, and federal government, and the agriculture-support infrastructure.

The program's primary objectives are the following:

- To allow the New York City water supply to continue to meet water quality protection policies of New York State, City and Federal law.
- To promote improved understanding of the impacts that innovative, practical, field-tested solutions to individual farm situations have on water quality.
- To encourage a high level of voluntary project participation by demonstrating, promoting, and educating producers on the economic and environmental benefits of Whole Farm Planning.
- To advance the reality that a vibrant agricultural economy of well-managed farms is preferred and is compatible with maintaining and protecting water quality in the watershed.
- To foster community pride, enthusiasm, and empowerment through local leadership and involvement in a nationally recognized, innovative, cooperative approach to a highly complex environmental situation.
- To identify, develop and present farmland retention incentives that recognize the benefits of a strong agricultural base to the local economy and the watershed communities.

To achieve these objectives, the program works according to the following principles:

- It began with the desire to meet water quality protection policies to ensure continued safe drinking water for nine million consumers of water from the New York City water supply system.

- Well-managed farms are the building blocks of the program. Whole Farm Plans combine water quality protection measures with business-strengthening measures to fulfill the program's dual purpose of water quality protection and business enhancement.
- A vibrant agricultural economy depends on those well-managed farms, a supportive infrastructure, and effective marketing of farm products.
- The program is voluntary and is based on incentives, such as withdrawal of the city's proposed regulations for agriculture. The program seeks to attract participation of 85% of the watershed's farms by 1997. If that goal is not met, then the city and the Watershed Agricultural Council will review progress to determine what changes may be needed, including the implementation of a regulatory approach to protecting the water supply from agricultural pollution.
- Local leadership will improve participation by keeping the "ownership" of the program within the watersheds. WAC is the key nongovernmental, farmer-guided leader.

WAC has conducted several policy and operational activities, including free, voluntary soil analysis of all watershed farms to encourage awareness of the program and to foster nutrient management. WAC also reviewed and approved all Phase I Whole Farm Plans submitted so far by the County Project Teams, and developed a definition of a "farm" to ensure that the program's domain is legally defined.

Effective Partnerships for Comprehensive Watershed Management

The Watershed Agricultural Program begins with the interests of New York City and the watershed agricultural community, forming a partnership between farmers and water consumers through the intermediaries of WAC and the NYC DEP.

WAC and DEP have implicitly taken responsibility for meeting the needs of their counterparts' constituencies. Thus, WAC includes New York City water quality provisions within Whole Farm Plans in a way the city can count on. DEP pays farmers' water quality protection costs so that they can afford to implement the needed measures. To some degree, DEP will build awareness and support in the city for the farmers' interests, and WAC will build awareness and support in the watershed for DEP's water quality protection interests.

The interorganizational team that has been developing in the program represents another form of partnership. Several federal, state and county government agencies have been working with individual farmers, the city, Cornell University and others to take advantage of the different strengths such a diverse group can provide. WAC itself represents a public-private partnership, with voting membership drawn from watershed farmers, watershed agribusinesses and DEP, plus nonvoting membership from a cross-section of public and semipublic entities.

The Regional Whole Farm Planning Design and Engineering Teams and the local Best Management Practices, Construction and Outreach Teams, consisting of personnel from local Soil and Water Conservation Districts, Cornell Cooperative Extension, and the Natural Resources Conservation Service, represent another type of partnership, a traditional one that is especially important to the development of Whole Farm Plans. These County Team personnel have long-standing, positive working relationships with individual farmers.

Keith Porter, Director of the Water Resources Institute at Cornell University, has coordinated the scientific aspects of the program. He believes that preventing pollution from farms has a definite cost. For the program to succeed, water quality needs must be reconciled with the economic constraints and interests of the farmer: there must be gain to balance pain. The solution relies upon an exhaustive examination of the farm as a whole. Whole Farm Planning requires the coordinated expertise of agricultural economists, agricultural engineers, soil scientists, animal scientists, crop specialists, veterinarians, microbiologists, pest management specialists, and hydrologists. Integrating all these scientific disciplines is difficult but necessary.

Whole Farm Planning starts out by evaluating three opportunities to prevent pollution. The first is the pollution source, such as barnyard areas, silage systems, stored manure, and sheds containing chemicals: if a source is managed in way that eliminates or reduces the release of contaminants, risks to water quality are diminished. The second is the farm field over which contaminants may be transported to a watercourse following precipitation and runoff: transport across the field is reduced by releasing contaminants only when there is no runoff, or by reducing the amount released, or by managing soil and crops to minimize the effects of runoff. The third opportunity is at the watercourse itself: buffer zones may be kept on stream margins to prevent contaminants from reaching the water. This evaluation is a rational way to identify and rank the risks posed by farming activities. Options for management then can be selected to minimize risks and costs.

Two protozoan pathogens, giardia and cryptosporidium, are problems. We require knowledge about animal sources of these protozoa and their environmental fate. Little is known about dairy farms as a cause of microbial pollution of water. An interagency pathogen group, including Cornell scientists, is studying the incidence of the parasites in dairy herds, and their possible control. An associated group is evaluating methods to identify critical hydrological areas on the farms.

The program hopes to prioritize, test, and validate Best Management Practices that control pollution through a Whole Farm Plan to protect water quality. Whole Farm Plans include strategies to deal with pathogens, nutrients, sediment, animal and crop management, and farm viability. This is the first project ever to deal with all these issues as they relate to agriculture and the environment.

WAC's Mission and Goal Statement clearly promotes and expedites voluntary use of these BMPs. WAC has institutionalized and formalized the empowerment of rural residents so they can take action to reduce pollution risks. This protects farm families' ground and surface water supplies, as well as those of urban water users. The Whole Farm Program protects natural resources from agricultural and other rural pollution. In addition, WAC clearly demonstrates and promotes a true public/private partnership to establish and foster education and implementation of pollution prevention practices, to adopt proven technology, and to remove barriers to voluntary prevention of pollution.

This experiment in home rule and self-government is a far better alternative to the traditional approach of regulation and land acquisition to protect water quality. Farmers have never before been challenged to prevent pollution to secure such a high quality water supply. In the past, farmers have been asked to remediate problems, not prevent them.

WAC believes that farming is a preferred land use on the rural-urban fringe, with significant long-term environmental benefits compared with subdivisions. With continued hard work and true partnership, we have the potential to become a national model for watershed protection based on local decision making, scientific evidence, and shared responsibility.

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Sustainable Farming Practices Benefit Minnesota Landscape

Dana Jackson and George Boody[1]

Introduction: Agriculture and the Midwestern Environment

What have we come to expect of rural landscapes in the Midwest? In the Corn Belt of the upper Midwest, most people expect to see large fields of corn, a seemingly endless monotony broken only occasionally by fields of soybeans. When Europeans first settled the Midwest, it was a wilderness of prairie, forests, clear streams, and herds of buffalo. Now the Midwest is dominated by human uses, interrupted by a few patches of prairie or woods around lakes or rivers, harboring a few remnants of native species. Citizens passionate about preserving wildlife and natural habitats concentrate on other places, those dramatic expanses of land where more of the original landscape remains, such as the Boundary Waters Canoe Area in northern Minnesota or the rugged mountains of Colorado and Montana. The agricultural Midwest, especially the Corn Belt, is accepted as a sacrifice area, like an open pit iron mine or an oil field, providing areas for extraction of basic raw materials that humans must have.

The loss of biological diversity is not the only environmental consequence of creating the Corn Belt. Soil erosion, contamination of groundwater and surface water by agricultural chemicals, intensification of flooding because wetlands have been drained to make fields, and higher silt loads in rivers are the consequences of modern Corn Belt farming. Much of the resulting corn, in turn, is used as livestock feed, particularly for the tens of thousands of hogs kept in confinement buildings, where their manure falls between slats in the floor and is then pumped into lagoons the size of football fields and 20 feet deep. Nitrogen in the manure is then a waste, not part of a cycle. Breeches of these lagoons have spilled manure into adjacent fields and streams, killing fish. Promoters of these operations still assure the public that engineers can construct absolutely secure lagoons, that animal scientists will solve the odor problem from the huge quantities of hog manure, and that state pollution control agencies will monitor whether too much nitrate is getting into groundwater. But largely unasked are bigger questions about

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impacts on the broader ecosystem, community vitality, and the future of family farms and the land.

The Land Stewardship Project, its constituents, and other organizations in the sustainable agriculture movement ask: Why invest so much in technologies to mitigate pollution from agricultural systems? Instead, why not make the system nonpolluting, more diverse, and aesthetically appealing? Why not develop agricultural systems that enhance the environment while producing food that people need and providing a decent living for farmers?

Since overproduction has been a problem, perhaps we should restore large sections of land to its original vegetation. However, we are talking about millions of acres of land in the Midwest. Not only would such restoration projects be prohibitively expensive, but removing the land from economic use would deny millions of people the ability to earn a living. Moreover, we need the land for food production. The reality is that people are not going to abandon agriculture in the Midwest. We will continue to use the land to grow crops and produce livestock. But we can change how we farm and greatly improve the landscape that has been created by modern, conventional agriculture.

The Land Stewardship Project (LSP), a Minnesota-based membership organization, works with farmers who are developing an ecologically sound relationship between agriculture and the natural world. They understand that their land is part of a larger whole and that how they manage it will affect the landscape around them. They farm using practices that not only prevent soil erosion and water pollution, but also work more in harmony with natural cycles and encourage biological diversity. On such farms it is possible for wildlife to coexist with crops and livestock and for the landscape to harbor native plants. At the same time, farmers produce crops and livestock at a profit and support their families.

In this paper we describe two influences that have led some farmers in Minnesota and other parts of the Midwest to establish more sustainable practices that enhance the environment. One is a system of decision making in farm management called Holistic Resource Management™ (HRM). The other is a method of raising livestock called *management-intensive grazing* (MIG). Whether used together or separately, HRM and MIG have improved the quality of life for farm families and have benefitted Minnesota's landscapes.

We also will discuss two areas of work by LSP that support the application of HRM and MIG. The first is the Biological, Social and Financial Monitoring Project, the second a several-faceted project in western Minnesota to restore wetlands and improve water quality in the Minnesota River and its tributaries. A very important feature of both efforts is that they are grounded in a process of working in community, through partnerships and collaborations.

Holistic Resource Management (HRM)

HRM is a system for managing resources that was developed by Alan Savory, who founded the Center for Holistic Resource Management in Albuquerque, New Mexico, in 1984. It is a process of goal setting, decision making and monitoring that is being adopted throughout the world. In association with the Center for HRM, the Land Stewardship Project offers several courses in Minnesota each year. The introductory course, "Farming for Profit, Land and Family," has been taught to 300 farmers, state agency personnel, and farming consultants. LSP also has taught an advanced course called "Wealth Generation." Course participants have been interested in applying HRM to vegetable farms, mixed crop and livestock farms, and farms managed by the Minnesota Department of Natural Resources.

Holistic Resource Management contains four elements that distinguish it from conventional farm management models and provide managers with strong incentives to make environmentally sound decisions. First, it teaches a basic recognition of ecosystem processes that the farm depends on: the water cycle, the mineral cycle, succession, and energy flow. Farmers are led to think about the impacts of their decisions upon these four processes. Second, HRM places a high value on biological diversity. Third, it directs the farm family to develop a three-part goal, one part of which is a vision of how they want the landscape to look far into the future. Finally, practitioners consider the effects of any proposed action or choice of enterprise upon the culture and society. They must ask: Will this action help us strengthen our community?

These principles are consistent with profitable farms. The model includes extensive financial planning, with an emphasis on reducing the costs of production and achieving maximum net returns. The Land Stewardship Project, in cooperation with the Energy and Sustainable Agriculture Division of the Minnesota Department of Agriculture, conducted case studies of four sustainable farms in Minnesota, comparing their financial records with the averages reported by the regional Minnesota Farm Business Management Association. Three of the farmers who practice holistic resource management were shown to be earning sufficient net income to support their families at a level considered acceptable among farmers in the region. Their profit margins, expressed as a fraction of gross cash revenue, were 21%, 25% and 60% (Chan-Muehlbauer et al., 1994, p. 3).

Five Steps to Practicing HRM

There are five basic steps in the practice of Holistic Resource Management (Kroos, 1995, sec. 1, p. 5):

1. Define the *whole*. The concept of the *whole* includes the people, land, and money involved in or affected by management decisions. Relatives living off the farm

and one's neighbors can be included in the whole, as well as other land or streams that will be affected by what is done on the farm.

2. Identify the effectiveness of ecosystem processes on the farm and the farm's dependence upon them. This step requires farmers to consider how the water cycle and mineral cycle are working on the land. They note succession patterns, such as changes in communities of plants or soil organisms. Farmers also observe energy flows and ask how effectively their farm captures and uses solar energy.
3. Develop a vision for the future. Persons defined as part of the whole collaborate in creating a three-part goal. The first is a definition of the quality of life they seek; the second is a description of the characteristics of production systems that will support that quality of life and result in profit; the third is a vision of what they want the landscape to look like far into the future.
4. Select the tools or actions to achieve the goal. These include the plant and animal production systems to be used, the money and labor available, and technology and human creativity. Practitioners apply a set of questions or testing guidelines to determine if their decisions are ecologically, financially, and socially sound and will lead to achievement of the three-part goal.
5. Employ a planning process. Make production and financial plans, monitor how well these plans are working, and adjust them and replan as needed.

LSP's training team, which includes three farmers who practice HRM, discusses these five steps with participants in the three-day introductory course. They emphasize the importance of careful planning, and provide worksheets that require an estimate of the time that various enterprises will take and a projection of expected revenue and expenses, rather than just records of expenses as they incur. These are all put together into a whole-farm financial plan for an integrated farming system. Participants are urged to ask themselves frequently whether their systems are helping them reach their three-part goal and to look for the weak links in their system that must be managed better.

Management-Intensive Grazing (MIG)

Management-intensive grazing (sometimes called *grass-based farming*), is a method of feeding livestock that is becoming increasingly popular around the country. In Minnesota, many farmers have reduced the amount of land in corn, soybeans and alfalfa or have quit growing some of these crops entirely. Instead, they grow grass or grass/legume mixtures that are harvested by livestock rotated among many small paddocks (also called *pads*). They pasture their animals as many months in the year as possible, often purchasing the supplemental feed grains or alfalfa that they need. In the upper Midwest, MIG is being widely adopted for dairy herds, but farmers also graze beef cattle, sheep, poultry and hogs.

The significant feature of this method is that animals are allowed to graze intensively in one paddock for a short time and then are moved to another. Pastures are divided into sections by electric fences, and water is piped to each section as needed. This system imitates the behavior of migrating buffalo herds before European settlement on the plains and prairies. The length of time that animals graze a particular paddock depends on many factors, an important one being the rate at which the forage recovers after being grazed. The system does not involve a fixed prescription; rather, it varies with individual farmers and conditions. However, on all farms the emphasis is on high productivity and dense, high-quality forage, with a diversity of grass and legume species. Soil types, weather and stocking rates influence the size of paddocks and the length of time they are grazed. Farmers practicing MIG must become good observers of their land and everything that happens on it.

Some farmers still put cattle or sheep on one pasture for continuous grazing. Those who have switched to a paddock system claim that having animals graze intensively results in thicker stands of grass. Moreover, it is all grazed down, instead of favorite patches being overgrazed while others are left to mature with no grazing. Animals usually are put into the grass when it reaches optimum height and nutritional value.

Environmental Benefits of MIG

Cows in most conventional Midwest dairy farms are confined in "loafing barns" or corrals between milkings and are never allowed out to graze. Some dairy farms have 500 to 1500 cows confined in one operation; these cows usually are milked three times a day and may receive injections of bovine growth hormone to increase production. All feed is brought to the cows, and all the manure is pumped out of manure pits or scraped and hauled out of the barns to be spread on fields. Conventional dairy farmers work very hard producing corn and alfalfa to feed their herds and incur high capital costs for equipment and barns.

Less land in corn and soybeans is needed per cow with MIG. Corn and soybeans are far more susceptible to soil erosion than grasses, so when land is converted from these crops to permanent pasture, soil erosion is reduced. Also, less fossil fuel is consumed to operate machinery. Some grass-based farmers don't have much "iron," as they say, having sold most of the machinery they formerly needed for field crops. With less land in crops, they can share machinery with neighbors or employ custom harvesters. Less land in corn and soybeans also means fewer applications of insecticides, herbicides and fertilizer, decreasing the potential for contaminating surface and ground water.

Manure is much less of a problem on grass-based farms. Cows spread it themselves, whereas in confinement operations it is stored in large holding tanks and spread by the farmer. Studies are looking at the impact of manure deposition and nitrate movement on the environment under MIG (Land Stewardship Project, 1995, p. 2).

Farmers report seeing more grassland birds, such as the bobolink *(Dolichonyx oryzivorus)* and dickcissel *(Spiza americana)*, after replacing row crops with grass pastures. Preliminary results from the Agriculture Ecosystems Research Project at the University of Wisconsin show that rotationally grazed pastures provide better bird habitat than continuously grazed pastures and are used by many more birds and bird species (Undersander et al., 1994, p. 3). Some farmers have begun to "rest" certain paddocks, and do not graze them until after the nesting season. The increased area of permanent grass, combined with Conservation Reserve Program land that has been in grass for several years, also has created large habitats for game birds. Additional habitat is created when fields where trees had been bulldozed out along drainages are converted to pasture, with the trees growing up again along small creeks.

On well-managed grassland, erosion is less than with cropland, more water soaks in where it falls, and less sediment washes into streams. Land planted to grass along a stream can be grazed while serving as a buffer strip between the fields and the stream. On some streambanks that are grazed intensely for short periods, livestock trample sharp banks that tend to be undercut during high water. The bank eventually becomes a gradual incline with a thick grass cover that secures the soil. Fisheries biologists have observed that these changes result in narrower, deeper streams that are beneficial to a variety of fish and invertebrates (Land Stewardship Project, 1995, p. 3).

The Monitoring Project

Management-intensive grazing, especially as part of an integrated farming system designed with Holistic Resource Management, has been gaining wide acceptance. Farmers in Minnesota have learned the method by attending grazing workshops, establishing their own grazing clubs, and attending field days arranged by LSP and the Sustainable Farming Association. MIG could directly benefit the almost half of Minnesota's farmers who raise ruminant animals (38,000 with cattle and 3,600 with sheep, some of whom also raise cattle, out of a total of 85,000; Minnesota Agricultural Statistics Service, 1995, pp. 5, 67).

As more farmers turn to MIG, representatives of conservation groups and natural resource agencies also have been attracted by its great potential for reducing soil erosion, improving water quality, and providing improved habitat for terrestrial and aquatic species. To speed the adoption of MIG and other sustainable agriculture systems, farmers and agency policy makers need to document that these systems actually improve the environment and enhance the farm's profitability and quality of family life. Currently, farmers and researchers do not know enough about what to monitor to determine a farming system's environmental effects. Monitoring often is limited to testing for a single pollutant, such as the popular herbicide atrazine.

LSP believes that integrated biological indicators are needed for measuring environmental improvements so that farmers can gauge for themselves the impacts their practices are having on the farm and nearby streams. Also, the impacts of farming practices on the lives of farm families often are ignored.

To meet this need, LSP assembled a 25-member team to develop and test a set of indicators of sustainability on six farms that have adopted MIG. The team includes farmers, researchers from the University of Minnesota and Iowa State University, private consultants, and staff members from LSP, the Minnesota Institute for Sustainable Agriculture, the Minnesota Department of Agriculture and Department of Natural Resources, and the U.S. Fish and Wildlife Service. The team has worked together to identify measures for evaluating the ecological and financial health of the farms and the impacts of MIG on the quality of life of the farm families.

In 1993, the team began specifying the methods and protocols to be used in monitoring, and in 1994 conducted first-year biological monitoring. Researchers have established 60 permanent plots on the six team farms and in paired fields in the same or adjacent counties that have similar soil types but are in conventional pasture or row crops. They have been collecting biological, physical and chemical soil quality data from those plots and observing pasture species and ground cover. Volunteer naturalists recruited by the U.S. Fish and Wildlife Service are surveying each team farm for breeding birds, frogs, and toads. Farm wells have been sampled and precipitation records kept. Fisheries scientists are surveying streams passing through four of the team farms and one paired farm to analyze the effects of MIG on streambanks and on invertebrate and fish populations.

Developing an interdisciplinary team that works creatively together on such a diverse set of tasks is a key goal of the monitoring project. Another important goal is to develop an affordable kit of indicators that other farmers can use to monitor the sustainability of their farms. Farmers will play a large role in designing and testing this kit, which might include a financial analysis procedure, a questionnaire on family life, tools and instructions for testing soil and water, and a handbook for identifying plants, birds, frogs, and insects.

Farmers participating in this study have become lovers of diversity and astute observers of wildlife, learning to identify their farms' birds, earthworms, frogs and toads, and even aquatic insects. Such farmers are contributing to establishing a better working relationship between farming and the natural world by consciously integrating their human-managed systems with natural systems. A recent newsletter distributed to monitoring team members contained the following notes in a column called "Farmer Observations":

> Mike saw first red clover blossoms on June 6. Mike saw a hummingbird on clover in his extended rest pad. He suggests that each farmer photograph their rest areas and notice the smell intensified by flowering plants.

Ralph says that fescue, timothy and red top are the predominant grasses in his pastu- this summer; bluegrass is not holding up. Ralph saw two baby bobolinks on J 4. He noticed the young are bunching up and may move soon.

Watershed Enhancement through Sustainable Farming Practices: Changing Community Attitudes

A sound working relationship is needed between farming and the natural world in the Minnesota River watershed. Each day, the river carries 2700 tons of sediment, mainly from agricultural runoff, as it flows past Mankato, Minnesota, on its way to the Mississippi River in St. Paul. This is equivalent to one dump truck load every half minute (Minnesota Pollution Control Agency, 1994, p. 2). Before European settlement, western Minnesota was mostly prairies and wetlands that captured and held rainfall. Today, rainfall drains from feedlots and fields of corn, soybeans, and sugar beets, carrying soil, agricultural chemicals, and bacteria into streams.

Tiling and draining wetlands to convert them into farm fields has contributed to another problem: downstream flooding. Heavy rainfall no longer is stored on the land. Instead, it drains quickly through field tiles, filling streams. In the past, the Army Corps of Engineers contributed to Minnesota River flooding by straightening and channelizing its tributaries so that water moved through the system faster. However, a Corps flood control project on the Lac Qui Parle River was stopped in 1994 when the state administrative judge, agreeing with critics who argued that there were better alternatives to building levees and excavating floodway channels, recommended denying permits for the project.

One of these critics was an organization called Clean Up Our River Environment (CURE), a grassroots group that LSP helped organize in 1993. CURE's mission is to focus public awareness on the Upper Minnesota River and to restore the river's water quality, biological integrity, and natural beauty. LSP and CURE have provided information about alternative farming practices that would decrease flooding and improve river quality, such as creating grassland buffer strips along the river, replacing corn fields with permanent pasture for management-intensive grazing, and using HRM as a management tool. LSP has taught five HRM courses in western Minnesota and will continue to offer them. LSP also has encouraged the formation of neighborhood HRM management teams to foster dialogue that reinforces the concept that farms are part of a larger ecosystem and a larger human community. LSP, with the Sustainable Farming Association of Western Minnesota, also has sponsored grazing workshops, field days on farms employing MIG, and grazing circles so that farmers can share information and experience.

LSP joined with nine other organizations and federal and state agencies to form the Chippewa River Stewardship Partnership (CRSP) in 1994. Over 95% of the original wetlands in the lower Chippewa River basin have been drained; in the entire Minnesota

River Watershed, the Chippewa has the lowest levels of macroinvertebrates, such as mayflies and caddis flies, which are sensitive to pollution and are key indicators of water quality (Chippewa River Stewardship Partnership, 1995, p. 3).

Much of the Chippewa River Basin lies in Minnesota's Second Congressional District, which is among the most agriculturally dominated districts in the nation. It is a stronghold of independent small- and medium-size family farmers. In the tradition of independent farmers, each operation has been a separate entity, and farmers have chosen their crops and methods without thinking much beyond their farms' boundaries. Collectively, their independent decisions to tile fields have affected the whole watershed. There is a need to develop community processes that will lead to greater cooperation for conservation in the watershed.

The CRSP has promoted wetland restoration on private lands through easements held by the Minnesota Land Trust, a private group more accepted in the area than government agencies. A vocal segment of the population believes that government regulations restrict their personal property rights too much. They are suspicious of federal or state natural resource agencies and often are openly hostile to government employees. Some of these attitudes have been strongly held over several generations, and CRSP has provided opportunities for bringing them out in public discussions about private ownership rights and responsibilities.

From November 1994 through March 1995, CRSP held a series of monthly public meetings with 30 farmers and landowners in the basin to discuss water quality, wetlands, and flood-related problems. The meetings resulted in a set of recommendations for incentive-based solutions to improve land management practices, restore wetlands and floodplains, and change farm and wetland policies.

Conclusion

The influence of HRM and MIG and the large areas of grass that are replacing row crops in Minnesota, combined with processes for fostering community dialogue about agriculture and the environment, are encouraging signs that sustainable agricultural practices can benefit Minnesota landscapes.

As one HRM trainer often comments: "When people take HRM, the biggest change takes place between their ears." This change includes a greater consideration of how their land-use decisions might affect the larger landscape and the people who live there. HRM's system for setting goals and making decisions involves the participation of relatives and neighbors, not just the farm family. In choosing how to achieve those goals, the HRM practitioner asks how the action will affect the whole culture and society. Responsibility to both the natural ecosystem and the human community is part of the HRM philosophy.

LSP believes that people must work together as a community to bring about the changes in agriculture that will enhance the environment. Governmental agencies cannot do it alone through regulation and enforcement. Environmental organizations cannot do it alone through education and lobbying. Individual farmers cannot significantly change the broader ecological context. However, partnerships and collaborations among farmers, rural citizens, private nonprofit organizations, universities, and farm and environmental agencies can develop the public dialogue that opens minds to change.

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Marin Coastal Watershed Enhancement Project: A Cooperative Approach to Adapting Nonpoint-Source Pollution Guidelines to Local Conditions

Ellen Rilla[1] and Stephanie Larson[2]

The riparian habitat in coastal Marin County has deteriorated significantly since the early part of this century. Agricultural practices are often cited as a primary cause of this degradation. Public perceptions of agricultural practices and the resulting criticism of agriculturists have polarized community factions and hindered cooperation in solving resource management problems. Some agricultural practices undoubtedly have contributed to resource degradation, but management varies widely, and there are many examples of sound resource management on agricultural land in coastal Marin County.

Although agricultural management practices have greatly improved over the last 20 years, agriculture's viability is threatened by increasingly restrictive regulations. In response to recent amendments to federal water quality laws, Regional Water Quality Control Boards will begin regulating nonpoint-source (NPS) pollution on rangelands unless landowners voluntarily improve water quality.

Several watershed enhancement programs have been conducted in coastal Marin County since the early 1980s. Despite their benefits, these projects have primarily focused on repair of localized erosion problems, but have not significantly affected agricultural management practices. They have been administered by local nonprofit agencies and Resource Conservation Districts. Technical assistance and cost sharing for improved management practices and erosion repair also have been available to individual landowners through USDA's Natural Resources Conservation Service and Agricultural Stabilization and Conservation Service (now part of the Farm Service Agency).

Project Goals and Objectives

The Marin Coastal Watershed Enhancement Project was designed to address NPS pollution on a local level. A primary focus of the project is to provide landowners with the resources they need for cooperative, voluntary compliance with water quality regulations. This approach will minimize regulatory involvement in local land management.

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Project goals include improving water quality, fish habitat, and natural resources in western Marin County through voluntary adoption of appropriate management practices. Specific objectives include: helping landowners identify water quality problems; demonstrating existing examples of good management; providing information on management practices that maintain or improve water quality; and assisting with monitoring programs.

This two-year project was funded by the Marin Community Foundation, a local private foundation. The Foundation was interested in funding a project that would bring stakeholders together for cooperative watershed enhancement, addressing their goals for environmental quality and land conservation.

What is Nonpoint-Source Pollution?

Pollution is defined in the California State Water Code as "an alteration of the quality of the state waters by waste to a degree which unreasonably affects either of the following: (1) The waters for beneficial uses; (2) Facilities which serve these beneficial uses." The Federal Clean Water Act (CWA) identifies categories of pollution as either point- or nonpoint-source. Point-source pollution is an observable, specific, and confined discharge of pollutants into a water body. Examples include dairy waste ponds, food processing plants, and agrochemical processing plants. In contrast, NPS pollution consists of diffuse discharges of pollutants throughout the environment.

Low levels of nonpoint-source pollution occur naturally, such as from erosion and, to a lesser degree, nutrient production from nondomestic animals. However, common management practices increase these types of pollution. Nonpoint-source pollution from rangelands can be exacerbated by grazing, road building, mining, and recreational activities. Grazing can be a source of excessive sediments, nutrients and pathogens. Concentrating animals in riparian areas allows nutrients and pathogens to be deposited directly into waterways and can cause streambank erosion and sedimentation (George, 1992).

Statewide and nationwide, sediment is considered the primary form of nonpoint-source pollution from rangelands. However, in Marin County, because of the high concentration of livestock in dairies, animal waste is the greatest pollution concern from either point or nonpoint sources. Pollution of Tomales Bay by dairy waste has become an increasing public concern because of its presumed damage to shellfish production, a $2 million industry in the bay.

Description of the Project Area

The project area encompasses the watersheds of three major coastal streams within Marin County, north of San Francisco. These include Walker Creek, Lagunitas Creek, and many smaller tributaries to Tomales Bay and the Marin County portion of Stemple Creek/Estero de San Antonio, which flows into Bodega Bay.

The watersheds encompass approximately 232 square miles (148,480 acres), primarily in agricultural ownership. The Lagunitas Creek watershed is unique, with an estimated run of 500 Coho salmon *(Oncorhyncus kisutch)*, or 10% of the state's current Coho population. The Walker Creek watershed drains into Tomales Bay, one of the prime estuaries remaining on the West Coast. It also is listed by the State Water Quality Control Board as an impaired water body. Stemple Creek becomes the Estero de San Antonio, and is part of the Gulf of The Farallones National Marine Sanctuary. Federal lands within the Golden Gate National Recreation Area and the Point Reyes National Seashore fall within the project area. These federal lands were not specifically addressed by the project at the onset, though park staff actively participated in landowner outreach and education. With the change in park superintendents midway through the project, the boundaries of the study were expanded to include the park lands encompassing Olema Creek. The project area also includes land covered under proposed federal legislation to expand the seashore park by 38,000 acres by purchasing development rights from willing landowners.

The predominant agricultural uses are dairy, sheep, and cattle operations ($40 million per year) interspersed with small commercial horse operations in rural residential settings. Conservation easements exist on 25,000 acres because of an aggressive campaign by the Marin Agricultural Land Trust, a private agricultural conservation organization.

Regulatory Agency Involvement

Federal and state laws regulating NPS pollution have been in existence since 1977, but until recently, regulatory agencies have focused on controlling point sources. Federal laws that have driven efforts to reduce NPS pollution are the Coastal Zone Act Reauthorization Amendments (CZARA) of 1990 and amendments to the CWA of 1977 and 1987. CZARA affects all types of land use but focuses on agriculture because the U.S. Environmental Protection Agency (EPA) believes that agriculture is the primary nonpoint source of pollution. CZARA applies to all lands within coastal zones nationwide and to the entire state of California.

EPA has authority to implement and enforce the CWA, and with the National Oceanic and Atmospheric Administration has joint authority to approve state NPS pollution programs related to CZARA. CZARA requires each state's water resource agency to establish coastal NPS pollution programs that are consistent with guidance specified by EPA. The guidance is an EPA document that describes management practices intended to reduce NPS pollution to acceptable levels.

In California, planning and enforcement authority for NPS pollution is passed from EPA to the State Water Resources Control Board (State Water Board), then down to the nine Regional Water Quality Control Boards. In 1988, the State Water Board produced a nonpoint-source management plan for California. This plan outlines three management approaches for addressing NPS pollution problems. This is commonly referred to as the "three-tiered" approach, with successive enforcement tiers increasingly emphasizing regulation. Tier One, described as "Voluntary Implementation of Best Management Practices," encourages landowners to use available technical assistance voluntarily to assess and improve management practices that affect water quality. Tiers Two and Three involve enforcement by the Regional Board.

The Nonpoint Source Management Plan did not adequately address some nonpoint sources, and is being amended. This process includes preparation of a rangeland grazing plan for California (Clawson and Humiston, 1994). The plan will specify a strategy for either individual landowners or watershed management groups to address NPS pollution on rangelands. This proposed strategy uses Tier One compliance and is based on the assumption that if landowners demonstrate a significant effort to reduce water pollution through voluntary measures, enforcement will not be necessary. The primary element of this strategy is preparation of water quality management plans by all rangeland owners or operators.

July 1995 was the deadline for the State Water Board to have a nonpoint-source management plan that complies with federal water pollution laws. There is an eight-year period for implementing this plan. By 2003, landowners will be expected to have reduced NPS pollution significantly through voluntary compliance.

Involvement of Resource Agencies and Community Advisory Committees

An important aspect of the project is that local government agencies and private support groups work together to assist landowners with NPS pollution issues. Participating groups include: University of California Cooperative Extension; the Natural Resources Conservation Service; the Marin Agricultural Land Trust; the National Park Service; and the Marin County Resource Conservation District. To insure that the project is practical and meets the needs of agriculturists, a local sheep and beef producer was hired to help with landowner outreach.

A team of six staff members from these groups provides day-to-day project coordination. This eliminates program duplication, and the coordination of efforts insures efficient flow of information between regulatory agencies and land owners.

A thirty-member advisory committee representing the community, producer groups (from shellfish growers to dairy operators), regulatory and resource agencies, and environmental organizations provides general guidance and oversight. The committee met at the start of the project to discuss and amend project goals and objectives. Members are kept up-to-date on progress through informational memos between meetings. Members were interviewed before the project to get their views of the problem and of potential solutions and possible pitfalls.

Landowner Outreach: Assessing Needs and Concerns

Input from agricultural landowners has been obtained through personal interviews and informal public meetings. Key landowners, who either control large tracts of land or are outgoing and influential, were contacted and interviewed personally to assess their knowledge of nonpoint-source pollution regulations and to get a feel for the types of support that are most needed. Many of these interviews were done by a local rancher.

Following the interviews, two informal potluck meetings were held for livestock and dairy producers. A local rancher helped conduct the meetings, providing a comfortable environment for other landowners to express their opinions. These meetings provided a forum for members of the two producer groups to air concerns and discuss issues.

Primary concerns discussed at these meetings included: a feeling that they were being over-regulated; confusion over the roles of regulatory agencies; lack of understanding of water quality laws; lack of understanding of management problems that contribute to NPS pollution; and concern that agriculture has been unfairly targeted. The greatest needs for assistance included: financial support to make improvements; political support; technical assistance; coordinated information on all aspects of NPS pollution; and the improvements themselves, such as fencing, water source development, and erosion repairs.

The meetings were effective in generating a feeling of unity. They also encouraged agriculturists to take a proactive stance in planning for nonpoint-source pollution regulations.

Encouraging Organized Local Compliance Efforts

After the staff members gathered information from landowners, they developed several workshops in response to the need for technical information. They planned and implemented a ranch planning short course held evenings and weekends for 50 ranchers. The course included setting short- and long-term goals, an inventory of facilities and natural resources, an assessment of their current ranch condition, and planned management and monitoring practices. Participation was high and the evaluations indicated that the participants found the workshop worthwhile. Using specific feedback, workshop leaders also could incorporate more materials into the ranch plan workbook. Since the workshops, several ranchers have completed their plans and others have requested copies of completed plans and suggested that future workshops be held. Several evaluation comments stated that participants never expected that ranch planning would be so beneficial to their overall operating goals, since they came expecting that they were just trying to comply with NPS pollution regulations. They indicated they were very pleased with the results.

Products from the project also include technical handouts, a creek care guide, and an accompanying report assessing watershed conditions and recommending future watershed enhancement projects. The technical fact sheets were adapted from materials gathered from water quality NPS pollution efforts around the state and nation, including the Tillamook project in Oregon and the Chesapeake Bay on the East Coast. The fact sheets include the names of all cooperating resource agencies, and master copies are provided to each agency to use with their clients. Again, the idea is for information to be provided with a common and coordinated voice. In response to landowner requests for information on NPS pollution issues, the Marin Agricultural Land Trust began publishing an informational newsletter for all rural landowners in Marin County. Staff members from the various resource agencies contributed articles. The Land Trust has published three issues to date and has agreed to continue this important communication link with landowners.

The creek care guide, when completed, will be distributed to rural landowners and residents of the project area. The agency team participated in its development and will receive copies for use with their clients. A positive offshoot of this coordinated effort is the expressed interest of the Urban Run-Off Program in the eastern, more urban portion of Marin County to adapt and use some project materials. This program is a multi-jurisdictional effort to comply with the urban aspects of NPS pollution.

The final product is the report and action plan that describes the project area's historical water quality, summarizes work done to date, and proposes future action in the watersheds. The advisory committee worked in three half-day sessions over eight months to brainstorm, set priorities, and make final recommendations for future action. They worked in small teams that included a broad cross-section of interests, from regulatory to environmental. The 88-page document is in its final draft. It should form the starting point for future watershed proposals, especially when foundation funding is sought. The Marin Community Foundation will use the priorities set for future watershed projects as their funding guidelines. Several proposals to the foundation are awaiting publication of the final report.

Next Steps

At the beginning of the project, key factors for success were determined to hinge on the following:

- involvement of the agricultural community in project decision making
- attention to concerns and needs from landowner meetings and interviews
- recognition by regulatory agencies of local voluntary efforts
- continued cooperation of support agencies in the team approach
- willingness of landowners to recognize problems and comply proactively.

Follow-up interviews 18 months later indicated that agencies, staff members and landowners have become more aware of NPS pollution and what needs to be done. They all mentioned that just coming together and building consensus was an important accomplishment of the project. Ranchers mentioned that there was a good balance of environmental, water quality and agricultural interests, and that they truly wanted to improve their operations. Ranchers asked for more workshops and technical assistance, while agency and environmental representatives and staff members had a wide range of suggestions about how to reach more people. All those interviewed said the effort needed to continue in some fashion after the formal project funding expired.

One shortcoming was the lack of economic assessment. Most of our educational efforts in the workshops and field days focused on technical feasibility. Do the expected benefits from investing in a management practice exceed the anticipated cost? Is cash flow sufficient to pay for the investment? As a result, staff members have applied for research funds to develop a cost-benefit analysis of various practices for these specific watersheds.

EPA is encouraging the use of their Watershed Protection Approach to meet water quality goals (U.S. Environmental Protection Agency, 1994). A clear advantage is that EPA prefers to fund projects that are watershed-specific. Also, regional water quality assessments are based on watershed boundaries, which often coincide with regulatory agency boundaries. This approach could easily be combined with the politically determined Resource Conservation Districts by encouraging watershed representatives to work directly with the Districts.

Both EPA and the State Water Board recognize that NPS pollution compliance programs are best accomplished in partnerships at the local level. The Marin County Resource Conservation District is an obvious agency to carry out the priorities established in this project, since it has been running watershed enhancement projects for 14 years and has a proven record in working with landowners and obtaining funding. Regional EPA staff members have recently approached it about developing operational working agreements between the district and selected agency partners. It is hoped that these agreements will continue the work that this project initiated.

A similar effort is just starting in the Russian River watershed directly to the north. Project coordinators have requested use of the materials and some staff time to assist them with organizing a similar collaborative process for their advisory committee and conducting the ranch planning and water quality workshops in that watershed.

More information can be obtained on the Marin, the Russian River, and other projects through the California Watershed Projects Inventory. The database and Geographic Information System are at the World Wide Web site http://ice.ucdavis.edu, providing a tool for sharing watershed level projects throughout California.

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Buffalo River Tributaries Watershed Project

Dennis Hackbart[1]

The Project and Its Setting

The Buffalo River Tributaries Watershed Project is an example of a "win-win" strategy that addresses deeply felt environmental concerns while endeavoring to nurture an agriculturally based way of life. The project provides incentives (cost sharing) for voluntary adoption of recommended land treatment measures that will help protect the Buffalo River from contamination by animal wastes while sustaining an agriculturally based economy.

The Buffalo River derives its name from the buffalo that once roamed in the north central section of Arkansas. The turquoise-colored water begins in the Boston Mountains and Ozark National Forest in southwest Newton County, Arkansas, and flows freely for 150 miles to its confluence with the White River in Baxter County. Along the way, the Buffalo River descends 2,000 feet from an elevation of 2,385 feet, passing 600-foot-high bluffs, waterfalls, massive boulders, cave openings, and hairpin turns (Arkansas Democrat Gazette, 1994).

The Buffalo's history is as colorful as its waters. In 1938, the U.S. Army Corps of Engineers was authorized to dam the Buffalo as part of the White River Basin Flood Control Plan. Between 1950 and 1960, opponents successfully blocked attempts to build two dams on the river. Prominent among them was Dr. Neil Compton, who in 1982 would write *The High Ozarks: A Vision of Eden*, nominated for the Pulitzer Prize for non-fiction. During the heat of the battle to save the river in 1962, former U.S. Supreme Court Justice William O. Douglas floated it and came out strongly in favor of preserving it. Meanwhile, the Ozark Society was formed. In 1965, then Governor Orval Faubus wrote: "The Buffalo River is one of the greatest examples of the majesty of God's Creation. The beauty of the region cannot be adequately described in any of the many languages of man" (Arkansas Democrat Gazette, 1992).

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Because of the efforts to save the Buffalo River, President Nixon signed a bill on March 1, 1972, designating it as the nation's first National River "for the purposes of conserving and interpreting an area containing unique scenery and scientific features and preserving as a free-flowing stream an important segment of the Buffalo River in Arkansas for the benefit and enjoyment of present and future generations" (U.S. Department of the Interior, 1993). The signing ceremony took place 100 years, to the day, after President Ulysses S. Grant signed a bill creating Yellowstone National Park as the nation's first national park (Arkansas Democrat Gazette, 1994).

Buffalo National Park (a term used synonymously with Buffalo National River), which is administered by the National Park Service, covers 13,300 acres. The park, essentially a corridor bisected by the river that is about 150 miles long and between one and five miles wide, attracts about one million visitors annually. Recreational activities include swimming, boating, fishing, backpacking, horseback riding, hunting, and canoeing. Canoe float trips are the most popular use, but hiking and horseback riding are increasing as the trail system expands. Long-distance hiking opportunities are provided by the Ozark Highlands Trail, which crosses the Ozark National Forest and extends to the Buffalo National River.

The river has a diverse fish population and is home to at least 59 species, many of which, like the smallmouth and Ozark bass, are found only in streams with good water quality. The sport fishery is dominated by sunfish (Centrarchids) and catfish (Ictalurids) (U.S. Department of Agriculture, 1995, p. 67).

Land cover in the 872,000 acre Buffalo River Watershed consists almost entirely of forest land (79%) and grassland (21%). The area has very little tillable land. The economy and land use of the watershed are reflected in the predominant land cover: forestry and agriculture are the principal industries.

Agriculture, the primary industry, is concentrated in the Buffalo Tributaries Watershed. This watershed, which has an area of 230,000 acres, consists of the drainage areas of six Buffalo River tributaries that empty into the middle reach of the river. Livestock production (dairy and beef) on about 400 privately owned farms has been the mainstay of the local economy for generations.

Livestock have access to the streams for watering and are often observed standing in the streams. Several pastures are overgrazed and do not retard runoff as much as possible. In recent years, woods have been cleared from steep slopes and replaced by grass. However, it is not feasible to manage grassland properly on slopes greater than 15%.

Trouble in Paradise

Unfortunately, all is not well in this bucolic scene of cattle peacefully grazing on the grassy hillsides or along the Buffalo's tributary streams, while canoeists enjoy a float down the beautiful Buffalo River. There is concern about the river itself, with rainfall events periodically leading to high levels (spikes) of coliform bacteria from nonpoint sources (livestock).

These spikes are projected to become more frequent as coliform bacteria increase because of the increasing numbers of livestock in the Buffalo River Watershed. They are likely to cause the river to be closed frequently for water contact activities. The annual value of recreation could diminish by an estimated $600,000 by the year 2000.

As previously stated, efforts of the Army Corps of Engineers in the 1940s and 1950s to construct dams on the river for flood control were opposed by environmentalists, who felt strongly that the river should be left in its natural state. The issue was eventually resolved when Congress declared it a National River.

Establishment of the Buffalo National River caused another conflict. The National Park Service, in gaining ownership of the river corridor, displaced farms that had been in family ownership for generations. The park acquired some of the area's more productive agricultural lands (bottom lands used for hay and pasture). As many displaced farm families left the community, small neighboring towns blamed their declining populations on the park. Some of the resentment that developed when the park was created in the 1970s lingers in the 1990s.

The concern for water quality in the Buffalo River represents a classic example of tension between environmental (i.e., recreational uses of the river) and social and economic interests (i.e., livestock production on the upstream watersheds). The environmentalists believe that the livestock producers (small farmers) should be held accountable for nonpoint-source pollution of the Buffalo River; in contrast, the small farmers believe that they work hard, are raising their families, are entitled to the American dream, and deserve to be left alone, as have generations before them.

Alternative Means to Address Concerns

Recent efforts to deal with concerns over nonpoint-source pollution of the Buffalo River led to three radically different strategies. The first two pitted groups against each other, while the third involved cooperation.

The first strategy would use public policy to control land use of the watersheds. This strategy might involve the government purchasing the watersheds (a very expensive proposition) or mandating certain land use restrictions. A moratorium issued by the Arkansas Department of Pollution Control and Ecology currently prevents installation of new liquid animal waste systems in the watershed. This is a small step toward a mandated strategy. Coercion or buyouts of existing farms would not be accepted readily by the community, and would likely open old wounds and create new ones.

The second strategy would take a "laissez-faire" or "business as usual" approach. This would relieve the anxiety of the farm families concerned about the heavy hand of government; however, nonpoint-source pollution would continue to degrade the quality of the Buffalo River's water. The future of the river, a beautiful resource and a significant place for water-based recreation, would remain in jeopardy. This strategy would not be acceptable to those concerned with the environment. Although it would relieve farm owners' and operators' anxieties about their personal farm operations, it would also worry them because they, too, love the Buffalo and do not wish to see it destroyed.

A third strategy, the one that was selected, involved interest groups working as partners, not adversaries. The objectives of this strategy were to reduce agricultural nonpoint-source pollution of the Buffalo River and its tributaries, while sustaining or increasing agricultural production. This strategy used voluntary changes in agricultural management, with financial assistance, on the part of private farm owners and operators. It was spelled out in the "Buffalo River Tributaries Watershed Plan/Environmental Assessment" (U.S. Department of Agriculture, 1995). An accompanying project agreement that calls for federal cost sharing at a 75%/25% rate using Public Law 83-566 funds was signed by the Natural Resources Conservation Service (NRCS) and the project's sponsors (three local conservation districts).

The Win-Win Plan

A model was developed based on the size and location of animal concentrations, access of livestock to streams, and the ability of watershed grasslands to affect runoff, absorb nutrients, and control erosion. The model helped identify and quantify sources of pollution, thus allowing the targeting of significant nonpoint sources.

The NRCS planners worked with the project sponsors, interested state and federal agencies, environmental groups, and a local steering committee composed of farmers living in the project area. They identified and evaluated the effectiveness of various land treatment measures in priority areas of nonpoint-source pollution. Efforts were made to identify land treatment measures (Best Management Practices) that addressed water quality concerns, were cost effective, and were acceptable to the landowners involved, since voluntary acceptance by landowners is a key to the program's success. These measures included:

- *Animal waste management systems* to manage liquid and solid wastes, including runoff from concentrated areas, in a manner that does not degrade air, soil, or water resources; elements include roofs over confined animals, waste storage structures, sediment basins, waste treatment lagoons, and suitable land application processes.
- *Livestock exclusion* from streams and streambanks by installing fences and buffer strips.

- *Livestock watering facilities* that include spring developments, pipelines, and freeze-proof tanks, to eliminate the livestock's need for access to streams by providing an ample supply of clean water.
- *Filter strips*, areas of grass or trees adjacent to and paralleling streams, that are protected from livestock, and that remove sediment and nutrients from runoff or waste water by filtration, deposition, infiltration, adsorption, decomposition, and volatilization. These strips will be about 100 feet wide.
- *Conservation easements* involving the acquisition (purchase of perpetual easements) of real property rights by the project sponsors to perpetuate, restore, or enhance the natural capability of the floodplain by preventing or reducing impairment of water quality by agricultural activities (e.g., prevention of livestock access to adjacent streams and grazing of filter strips).
- *Improved pasture management* to increase the vigor of the forage stand and permit more of the desirable plants to produce seed by rotating grazing using fences to divide pastures into several small paddocks with adequate water supplies and moving the livestock from paddock to paddock; livestock numbers will not exceed the capacity of the resource. Improved pastures will be more productive and less subject to erosion; they also will take up more nutrients from animal wastes that otherwise would be carried to the streams.
- *Tree planting* involving the re-establishment of trees on steep areas that were previously deforested and seeded to grasses. Because grasslands on steep slopes (over 15%) cannot be managed properly and are therefore subject to severe erosion, trees will be re-established to stabilize the soil.
- *Streambank stabilization measures*, including vegetation and cedar tree revetments to protect banks of streams against scour and erosion to reduce downstream sediment loading, maintain stream size, and protect the land.

The Buffalo River Tributaries Watershed Plan Environmental Assessment calls for the voluntary installation of needed measures over a 10-year period. Long-term contracts between the landowners and the Natural Resources Conservation Service will permit cost sharing (up to 75% of the costs) by using P.L. 83-566 funds for the installation of mutually agreed upon and recommended conservation measures.

The recommended measures are identified in conservation plans developed for individual farms. The estimated cost of the project over the 10-year installation period is about $4 million, including federal costs of about $3.1 million. Besides this cost sharing, the NRCS will provide technical assistance to the watershed landowners. The landowners will be responsible for maintaining the installed measures.

Expectations

Implementation of the recommended watershed protection plan should control the nonpoint-pollution sources that threaten the Buffalo River. The NRCS estimates that the project will yield about $600,000 worth of annual recreation benefits and will enhance the (unmonetized) value of fish and wildlife habitat through water quality and riparian protection.

Besides helping to control nonpoint pollution without harming the area's livestock industry, installation of recommended land treatment measures is expected to increase annual agricultural income by about $300,000. The pastures will become more productive and the threat of waterborne livestock diseases will diminish.

The most important expectation is that once implemented, the Buffalo River Tributaries Watershed Project will prove that an agriculturally based economy can peacefully coexist with an environment that can be enjoyed by man. The farmer and the environmentalist can be friends.

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The Zuni River Watershed Act: An Ecosystem Plan

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The Project Setting

The Zuni River Watershed in New Mexico is almost entirely agricultural. The land is used mainly for livestock grazing and timber production, but there is some cropland in valleys next to streams and arroyos. Although the crop fields are small, culturally and economically they are very significant.

Overgrazing, excessive timber harvest, and indiscriminate road construction in the late 1800s and early 1900s severely degraded the area's natural and cultural resources. This degradation in turned caused additional resource damage because of accelerated soil erosion, gullying, headcutting, and loss of water. Although the area historically supported varied agrarian cultures, resource damage has limited its residents' ability to maintain their lifestyle.

This paper describes a project to develop a plan to protect and rehabilitate the area's resources to provide a sustainable agrarian lifestyle. Its procedures and methods are very important because of historical patterns of contention and mistrust and because of cultural diversity. The plan will complement other efforts within the watershed, allowing ecosystem planning and management.

The project covers 412,000 acres upstream from the Zuni Reservation. It is in two Major Land Resource Areas: the Arizona and New Mexico Mountains; and the New Mexico and Arizona Plateaus and Mesas. The area, which is west of the continental divide and drains into the Colorado River Basin, lies in both Cibola and McKinley Counties, generally southwest of Grants and southeast of Gallup, New Mexico (see map) (Dietrich, 1994 & 1995).

The Zuni River watershed has been settled and claimed by various groups in recent history. Currently, land held under a variety of ownerships is intermingled throughout the watershed (Table 1).

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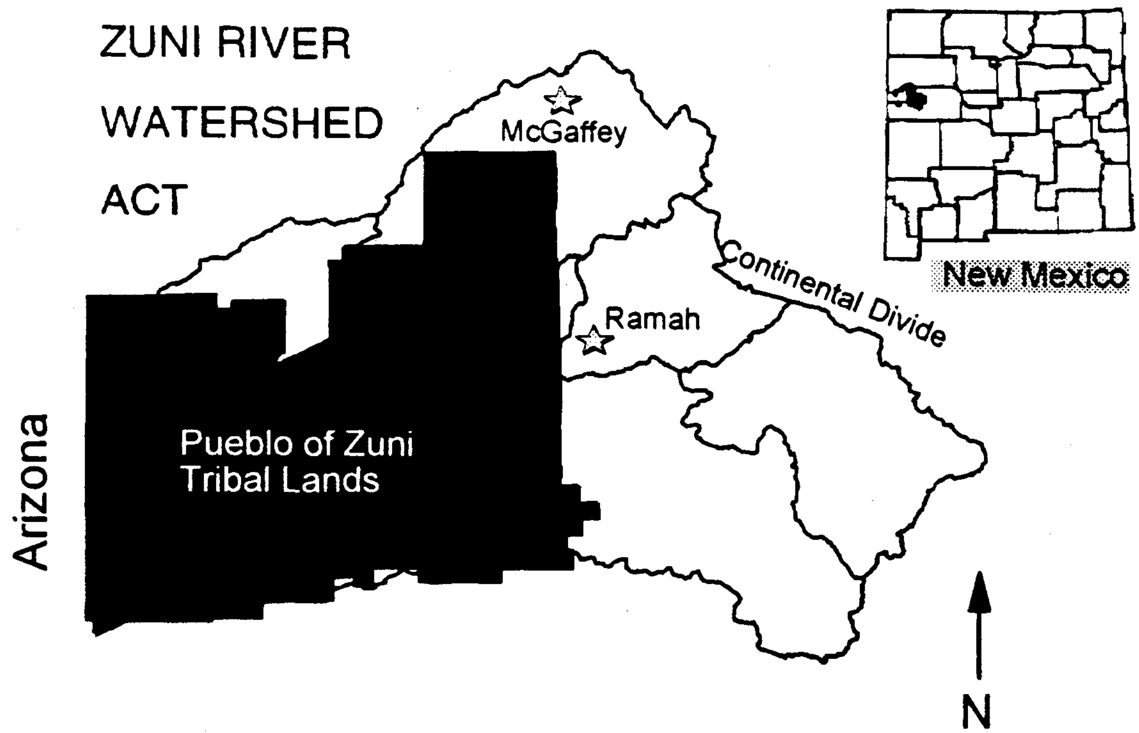

Table 1. Land management status in the Zuni River Watershed.

Status	%	Acres
Privately Owned	49	203,096
Ramah Band of the Navajo Tribe of Indians	18	72,314
Navajo Nation	5	20,688
State Owned	8	34,412
USDA - National Forest	17	69,803
USDI - National Park Service	<1	1,175
USDI - Bureau of Land Management	3	10,511
Total	**100**	**412,000**

History

The earliest evidence for human use of the Zuni area dates from the Paleo-Indian period before 5000 B.C. (Ferguson, 1991). Between A.D. 1250 and 1300, a major change in settlement pattern occurred as people aggregated into very large, well-planned pueblos or communities ranging in size from 250 to 1200 rooms. Zuni Pueblo is one of these later sites, and was probably founded around A.D. 1350.

The Zunis historically claimed a much larger area within what is now New Mexico and Arizona. They developed and used a variety of suitable systems for floodwater irrigation, growing mostly corn. Reports by early explorers described the Zunis as having as much as 10,000 acres of corn under cultivation after the arrival of Americans, mostly in small fields. They produced enough to maintain a two-year supply of food and to build a large agricultural trading business. In fact, during the 1850s, the Zunis sold thousands of bushels of corn to the U.S. military.

In 1848, New Mexico became a territory of the United States. In 1849, the first U.S. Indian Agent to the Pueblos visited Zuni; a year later the Zunis signed the Pueblo Treaty of Agent James S. Calhoun, which promised them sovereignty and protection of their tribal land. However, the size of the Zuni reservation changed over time as land was taken or added by the government. In the 1940s, the Zunis had a chance to file a case before the Indian Land Claims Commission, but did not do so. The Navajo claimed all the Zuni reservation lands, and the Indian Claims Commission accepted the Navajo claim. In 1979, the Zunis were permitted to file a separate land claim in the U.S. Court of Claims. This suit was tried in 1981, and in 1987 the Court of Claims issued a Finding of Fact that 14,835,892 acres of Zuni land had been taken without payment. In 1990, an out-of-court settlement was reached under which the Zunis would receive $25 million for their lost aboriginal territory.

In 1981, the Zunis also filed a claim against the United States for damages to Zuni trust lands. In 1990, President Bush signed Public Law 101-486, the Zuni Land Conservation Act, which appropriated $25 million to the tribe for dismissal of the damage claim. The funds were put into a permanent trust, with the interest to be used to develop and implement a permanent plan for the sustained development and rehabilitation of eroded lands throughout the Zuni watershed. The first part of this plan has been completed by the tribe.

Currently, there are six recognized cultural groups within the watershed: the Zunis, the Navajo Nation, the Ramah Band of the Navajo Tribe, the Ramah Mormon Community, Hispanic ranchers, and homesteaders. These are the cultural groups that have been present in the watershed for at least two generations. Because of the differences among them, no comprehensive or ecosystem planning has ever before been attempted. On the contrary, resource use and conservation actions that benefitted one group often did harm to others. This has resulted in a climate of mistrust, contention, and litigation.

Zuni River Watershed Act of 1992

Because of past actions, resource concerns, and the recognized need for watershed planning, local tribes and groups worked with Congressional representatives to write the Zuni River Watershed Act. Passed and signed in 1992 as Public Law 102-338 (102nd Congress, 2nd Session), the act included these findings:

- In the past century, extensive damage has occurred in the Zuni River Watershed. This included severe erosion of agricultural and grazing lands, reduced productivity of renewable resources, loss of nonrenewable resources, and loss of water.
- The Zuni River Watershed upstream from the Zuni Indian Reservation includes Federal land, State land, Zuni Indian Trust land, Navajo Indian Tribal Trust and fee land, Ramah Band of the Navajo Tribe of Indians Trust lands, individual Indian allotment lands, and private land.
- The implementation of a watershed management plan within the Zuni Indian Reservation will be ineffective without the implementation of a corresponding plan for the management of the portion of the Zuni River watershed that is upstream from the Zuni Indian Reservation.
- An effective watershed management plan for the Zuni River watershed requires voluntary cooperation among the Soil Conservation Service, Forest Service, Bureau of Indian Affairs, Zuni Indian Tribe, Ramah Band of the Navajo Tribe of Indians, Navajo Nation, State of New Mexico, and private landowners.
- All persons living within the Zuni River watershed will benefit from a cooperative effort to rehabilitate and manage the watershed.

The act requires that a study, plan, and report be submitted to Congress no later than four years after funds were made available. The plan components include:

- A watershed survey describing current natural and cultural resource conditions
- Recommendations for watershed protection and rehabilitation on both public and private lands
- Management guidelines for maintaining and improving the natural and cultural resource base on both public and private lands
- A system for monitoring natural and cultural resource conditions that can be coordinated with the system developed by the Zuni Indian Tribe
- Proposals for voluntary cooperative programs that implement and administer the plan
- A project plan that outlines tasks necessary to implement the plan, recommends completion dates, and estimates the costs of the tasks

- A monitoring plan that outlines tasks for monitoring and maintaining the watershed, and estimates the annual cost of performing the tasks.

Organization

Starting in fall 1992, the USDA Soil Conservation Service (SCS) and the Soil and Water Conservation Districts began the planning process by hosting several public meetings to discuss the act and the implementation of its requirements. After the first meeting, SCS recognized that because of the act's requirements, the history of contention between groups in the area and the need for ecosystem planning, it was extremely important to develop a suitable process to carry out the act. Participants agreed that SCS would serve as the lead agency (Dietrich, 1994 & 1995).

The project is unusual in that it includes all interest groups in the decision making, operates by consensus, uses neutral facilitators, and takes account of cultural and social values during the entire planning process. The public meetings within and around the watershed continued through 1993, without funding from Congress. The participants agreed that the project would be carried out with the following structure.

Advisory committee. This committee was established to provide input and advice on carrying out the act. It is a loosely formed committee of agencies, tribes, and groups with interests in the watershed. The committee presently has about 30 members. It works by consensus, and meets at least annually to review progress, provide input and advice, and provide an increased opportunity for public participation.

Work group. This group is made up of representatives from each of the eight entities named in the act: the Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service); the Forest Service; the Bureau of Indian Affairs; the Zuni Indian Tribe; the Ramah Band of the Navajo Tribe of Indians; the Navajo Nation; the State of New Mexico, and private landowners. The Advisory Committee agreed that this group would be the decision-making body and would provide guidance in carrying out the act.

The work group operates by consensus, using an independent facilitator, with the NRCS representative providing leadership. It meets about once a month to provide guidance, make management interpretations and decisions, and develop and carry out work plans and budgets.

Technical teams. After discussing the requirements of the act and how to complete the necessary actions, the work group decided to incorporate technical expertise by organizing technical teams on ten key subjects. This method also was selected to allow coordination with the planning methods being used by the Zunis on their tribal lands. All teams operate by consensus. They develop plans and budgets that recommend actions and activities to the work group. They determine the data that must be collected and the data collection methods to be used.

Technical teams were formed to cover the following subjects: agriculture and cropland; archeology; cultural values; forestry; geographic information systems; hydrology/erosion; range; social and economic values; soils; and wildlife. Generally, the teams responsible for natural resources compile historical data, identify current status and plans, and describe the current condition of the particular resource. They also identify resource problems, opportunities, and future needs. The Cultural Values and Social and Economic Values teams identify the values of groups and individuals, respectively, and collect information about their plans, concerns, and interests. They work with other teams to insure that recommendations meet watershed groups' needs and desires and that cultural sensitivity is maintained. There are over seventy technical specialists who are members of these ten technical teams, representing a total of more than twenty tribes, groups, landowners, and local, state, and Federal agencies.

Coordinator. A full-time coordinator has been leading day-to-day operations since 1993. The coordinator provides support to the advisory committee, the work group, and the technical teams. The coordinator supervises and directs the Field Resource Inventory Teams as they collect resource data. She serves as a clearing house for the planning effort and develops and distributes newsletters to over 800 people.

Field resource inventory teams. These teams are each made up of two or three people from cooperating tribes, groups, and agencies. Three teams are collecting data in assigned sub-watersheds. Team leaders are professional technical specialists, knowledgeable about natural resources and data collection within the planning area. Members are fully trained by the appropriate technical teams to use the selected data collection methods. The Field Resource Inventory Teams locate selected sampling sites using aerial photography, maps, and global positioning systems. They collect resource data using data collection worksheets and instructions developed by the technical teams. The collection sites are based on the statistical sampling system designed for the planning area.

Study Plan

Since 1992, the advisory committee, work group, technical teams, and coordinator have participated in many group and individual meetings with the area's residents and other interested people. These meetings provide opportunities to have people learn about the act, and to gather information about how people want the act to be carried out. The act requires the involvement and voluntary cooperation of watershed residents, landowners, and managers.

After gathering information, the work group decided to organize the planning process by dividing the area into five sub-watersheds. They set priorities for the sub-watersheds based on knowledge and recommendations of local residents and technical experts.

The work group provided guidance to the technical teams on what to study and how to determine current resource conditions. The technical teams concluded that available data did not provide enough information to determine the current conditions. However, they agreed that where appropriate, existing data would be used in the planning process.

The work group and technical teams then started exploring ways to collect the data needed to determine the status of cultural and natural resources within the planning area. Each team proposed methods to collect needed data. Based on the expressed needs of five of the technical teams, and considering the time and resources available, they agreed that a statistically valid sampling design would be developed for collecting natural resource information.

The other technical teams are using various methods to collect the needed data. The inclusion of the Cultural Values and Social/Economic teams is a unique part of this planning effort. The former will involve tribes and other cultural groups to insure that all activities are culturally sensitive, including the final plan and report. The latter is holding small focus group meetings with identified stakeholders within the planning area. These meetings are intended to inform the people about the act and to collect information about their concerns, needs, desires, and interests. All information gathered will be shared with other technical teams, the work group and the advisory committee to insure that planning efforts involve area residents and address their concerns.

To design the statistical sampling system, the work group enlisted a national statistician of the NRCS. The statistician met several times with various groups—technical team leaders, work group members, and people knowledgeable about the planning—to gather information on needs, methods, and planning area physiography. He then designed a stratified, nested, random sample system to provide the natural resources data needed for carrying out the act. He has also helped design the database to be used with the geographic information system (GIS) to provide analyses for the planning organizations and interested people. The work group agreed on a policy to maintain the confidentiality of the locations of the field data. However, the aggregated data will be available for review and use by interested parties.

Data analysis will be accomplished with assistance from the geographic information systems technical team, using the database and GIS. Raw data will be entered into the database and analyzed as requested by the technical teams. Computer software will be used to determine the reliability of the data answers, which will change with the number of variables used in the analysis. The technical teams will develop proposals for rehabilitation and protection of resources, based on analysis of field data and existing information, while considering area residents' needs, concerns, desires, and cultural values.

Plans

In accordance with the act, and using input from other sources, the technical teams and work groups developed an outline plan and report outline. The plan and report required by this act must involve watershed residents and must propose voluntary programs to implement and administer the plan. The plan will have three major parts:

- *Executive Summary*. A 15 to 20 page nontechnical report that uses graphics to show study results.
- *General Plan*. A comprehensive watershed plan covering all components of the act, written by an interdisciplinary team that integrates the recommendations of all technical teams.
- *Technical Appendices*. A compendium of basic data, detailed analysis techniques, assumptions, methods, and substantiating data from each technical team.

In all phases of developing the plan, public participation is an overriding consideration. One section of the plan will provide information about public participation and involvement, intent, concerns, interests, and expectations. This plan must be the watershed residents' plan, because it is they who will implement the necessary actions to rehabilitate and protect the resources.

Budgeting

The Congress authorized necessary appropriations to carry out the act, but did not specify how funds would be dispensed. Questions about budget amounts and spending methods sparked considerable debate early in the organizational process. The advisory committee and work group members finally agreed that people would be reimbursed for completing work items, including participating in some meetings and work sessions.

In 1993, the work group estimated that about $4 million would be needed to complete the four-year planning effort. For fiscal year 1994, the act was funded by Congress at $300,000. In late 1993 and early 1994, the work group and technical teams developed their work plans and budgets. Because of cooperation, efficiencies, and better planning, the budget estimate decreased to just under $2 million.

Funding for fiscal year 1995 was $300,000, about 50% of what was requested. In late 1994, the work group and technical teams revised the plan of work and lowered the proposed budget to $1,516,000 for the four-year planning period. The revised plan of work and budget took existing budgets into account, requiring that some planned activities be reduced. As a result, the number of resource-sampling locations has been reduced to be compatible with the available funds. At present, the funding level for fiscal years 1996 and 1997 is not known, but the funding requested to carry out the act's requirements is expected to be provided.

Expected Results

The data collected so far show some ecosystem problems within the Zuni River Watershed. However, in the last 50 years the watershed has started to heal itself from previous overutilization. We believe the plans being developed will provide a basis for accelerating this rehabilitation and ensuring long-term agricultural sustainability. The involvement and participation of the diverse cultural groups will help ensure support and implementation. An agrarian lifestyle can be sustained in the watershed through culturally sensitive ecosystem management.

In this project, the process is as important as the results of the planning effort. The groups must learn to live and work together to ensure a healthy ecosystem that will sustain economical agricultural production. The participants all believe that this process is a model applicable to other ecosystem planning efforts. The continued participation of all people, along with full consideration of cultural and social factors, is necessary for successful implementation.

Summary

The Zuni River Watershed Act of 1992 requires that tribes, private landowners, and agencies work cooperatively to develop an ecosystem plan. This act is new and different. It requires each participating entity to examine itself and to cooperate with a variety of new and old partners. Appropriately, the act requires that social and cultural values and resources receive full consideration in the process, as they should in ecosystem planning.

The plan required by the act will serve as the final report to Congress. The plan will outline recommendations for protection and rehabilitation of cultural and natural resources in each sub-watershed. These recommendations will address the needs and desires identified by watershed residents to provide for sustainable use. The plan also will provide the best proposals for voluntary cooperative implementation of management guidelines and for monitoring watershed conditions.

We leave as a parting thought the vision statement developed for this project: "To conserve, protect and rehabilitate cultural and natural resources within the watershed for ecologically sustained use to provide a positive economic return while giving full consideration to people's cultural and social values."

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Collaborative Problem Solving in Cameron County, Texas: The Coexistence Committee

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Background: Agriculture and Biodiversity

Some of the most productive agricultural regions in the United States are also among the most biologically diverse. Cameron County, Texas, is a good example. Cotton production and processing are the county's most important sources of economic activity, employment, and tax revenues; the county also has fostered wildlife habitat important to six endangered species. Wildlife conservationists are concerned about two threats to the quantity and quality of wildlife habitat in Cameron County. One is urbanization: the population in south Texas was predicted to double from 1990 to 2020 (Rosson et al., 1995). The second threat is agrochemicals, especially those used on cotton. There is a scientific basis for the concern that exposure to pesticides harms wildlife populations, although toxicological risks have been definitively quantified for only a few species and agroecosystems (Robinson, 1991).

The Endangered Species Act (ESA) of 1973 was amended in 1987, broadening its jeopardy clause to include provisions involving pesticide use that might harm endangered species or their habitats. The U.S. Environmental Protection Agency (EPA) was charged to work with the U.S. Fish and Wildlife Service (FWS) to identify high-risk species and cropping patterns. Cotton farming near the habitat of the aplomado falcon *(Falco femoralis)* in Cameron County, Texas, was one of several situations targeted by EPA and FWS scientists.

Agriculture and endangered species protection have clashed elsewhere. Debates over joint uses of land for farming and for wildlife habitat bring into sharp focus the trade-offs between economic development and environmental conservation. Many communities have been torn by controversy over priorities regarding economic growth, environmental quality, and redistribution of property rights. What distinguishes Cameron County is the collaborative problem-solving process developed by a dedicated group

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of community leaders determined to learn to coexist. The purpose of this paper is to tell the story of the Cameron County Agriculture and Wildlife Coexistence Committee and to analyze its innovative approach. Lessons learned may be of interest to others seeking problem-solving approaches that jointly serve agricultural and environmental interests.

Genesis of a Collaborative Problem-Solving Process

In October 1987, EPA circulated a draft proposal to ban 17 pesticides in an effort to protect the endangered aplomado falcon. The area potentially affected corresponded with the boundaries of Cameron County, but this political delineation excluded some adjacent land with similar ecosystem attributes that also was considered important habitat for the bird. The Agricultural Extension agent for Cameron County, Terry Lockamy, organized an ad hoc group to study the proposed changes in pesticide regulations. Included were Texas A&M University scientists, Extension educators, agrochemical dealers, and cotton farmers. They predicted that the pesticide ban would cause the county to lose between $125 and $350 million per year.

Growers were concerned about the economic viability of their operations. Also, many were angered by some aspects of the process. For example, word of the proposal came to them indirectly, and EPA did not seek their reactions; the ESA allowed a "spare no cost" approach without considering its impacts on farmers or others; although endangered in the U.S., the aplomado falcon was reportedly abundant in parts of Central and South America; the county's farmers had cooperated with FWS in bringing in a program for releasing the aplomado falcon, and now felt penalized for that cooperation; the countywide zone for special regulations seemed excessive and arbitrary. Some environmentalists found these concerns reasonable, and believed that for the ESA to remain viable in the long term, its proponents would have to protect endangered wildlife in ways that the citizenry would find prudent and just.

In November 1987, the Cameron County Extension Service's Field Crop Committee, a group of growers that advised the county agent, drafted a letter to over one thousand of their fellow growers. The committee apparently was aware that Extension should be neutral in questions of public policy; therefore, the letter was mailed by a local cotton growers' cooperative. It urged growers to voice their opinions on the pesticide ban, scheduled to go into effect on February 1, 1988: "There is considerable political support to get implementation delayed but we doubt that it will be effective unless individual growers and grower organizations put a lot of pressure on Congress to step in and prevent EPA from putting these rules into effect. If you share our concerns about these totally unworkable regulations, we ask that you immediately contact Congressmen Ortiz and de la Garza, and Senators Gramm and Bentsen and tell them what these rules will mean in your farming operation."

The proposed pesticide ban was scheduled to be implemented just before the 1988 cotton planting season. Growers conveyed a sense of urgency to their elected officials. The ban was rescinded for 1988, but there was a possibility of a revised regulation in the future. The growers were beginning to doubt they could influence FWS and EPA's joint decision processes by exercising political pressure through Texas congressmen.

The Cameron County Coexistence Committee was conceived during an informal lunch meeting. Present were a cotton grower, the county Extension agent, and two leaders of the local cotton cooperative. All four had experience with zero-sum interactions with environmental interest groups and regulators. They worried that if the proposed pesticide ban was implemented, there would be unacceptable consequences for the local agricultural economy. Also, Congressional support for environmentalists' programs to expand wildlife preserves could be diminished.

The committee's mission statement focused its goals narrowly: "to address problems and conflicts related to implementing the Endangered Species Act in Cameron County and to develop and offer functional solutions to the regulatory agencies that will promote compliance with the law and allow the coexistence of endangered species and the agricultural interests in Cameron County to the greatest possible extent."

The initiators were mindful of local protocol. Part of their initial vision was to request official sanction by the county commissioners. The county government already had an Environmental Review Board (ERB), which served as an advisory body to the county commissioners. The Coexistence Committee intended to complement rather than compete with the ERB by defining a particular role and focus: local implementation of the ESA. One member of the ERB was invited to be a member. The Coexistence Committee was officially appointed as a unit of county government in February 1988.

The committee met first in March 1988, and frequently through April and May. The meetings were chaired by a cotton grower. The county Extension agent kept a record of the committee's process. The core committee consisted of nine members: three growers; the county Extension agent; an agrochemical dealer; a representative of the Texas Department of Agriculture; an environmentalist representing the Cameron County Environmental Review Board; the manager of FSW's local wildlife refuge; and a local staff member from the Texas Parks and Wildlife Department. In April 1988, they presented official statements at a local public hearing and at a congressional hearing on the ESA in Austin, Texas. Their final recommendations were submitted to EPA on May 31, 1988.

The Coexistence Committee's starting point was that neither growers nor environmentalists could fully support the EPA proposal to ban 17 pesticides. Growers were concerned that they could not produce cotton economically without the pesticides on the EPA list; the environmentalists and agency representatives saw this proposed pesticide ban as yet another example of a federal regulation that had been inadequately tailored to local issues and circumstances. Four months later, they produced a consensus proposal that involved banning five pesticides completely, restricting three to in-soil application, and requiring notification of FWS before use of two others. All members agreed that it was unnecessary to ban the remaining seven of the 17 pesticides originally on the EPA list. Initially, the pesticide ban had affected the entire county. The Coexistence Committee instead recommended targeting only the portion of the county that ecologists considered the habitat of the aplomado falcon. Their plan represented a workable alternative.

To develop these recommendations, members of the Coexistence Committee had to pool their knowledge in three areas. First, they researched historical accounts of the aplomado falcon's habitat and behavior. There was anecdotal evidence of the falcon having nested in Cameron County in the 1940s, but none had been sighted recently, until a hatch-and-release program began in 1985. Because the county has significant patches of suitable habitat, efforts to reintroduce young falcons had been initiated by the Peregrine Foundation of Boise, Idaho, in cooperation with FWS's Laguna Atascosa Wildlife Refuge in Cameron County—with some successes and some disappointments.

Second, they studied when pesticide use was likely to adversely affect the falcon's habitat. They scrutinized the scientific basis for the proposed pesticide ban. Few studies had been conducted on the aplomado falcon, and much of the toxicological evidence being used was extrapolated from pesticide exposure studies involving other birds.

Finally, they identified the particular practices that might affect the bird's survival. The committee struggled with the difference between long-term pesticide exposure and a one-time exposure to a high dose. Mutual learning involving biologists and growers was crucial. For example, aplomado falcons prey on other birds that eat small seeds. Some granular pesticides, such as Furadan, resemble these small seeds. The same pesticides sprayed as a foliar compound are not dangerous to the birds.

A mutually acceptable solution was not guaranteed from the start, and some on both sides felt it was futile to seek one. In retrospect, the biology of the situation seems to have allowed a favorable solution. However, that solution became apparent only when committee members began to share information, discovering that pesticide application rates lower than the legal maximums were being used and that they were both sufficient for pest control and safe for the falcon. Together, the committee members developed more comprehensive conclusions and recommendations than either the growers or the ecologists could have developed separately.

Pursuing Implementation

Things were quiet for several months after the Coexistence Committee's recommendations were submitted to EPA. On July 3, 1989, EPA published in the *Federal Register* its revised proposal for pesticide bans in conjunction with endangered species protection. The announcement detailed a new approach to biological consultation, changes in pesticide labeling guidelines, a new policy for announcing pesticide bans, a new schedule for implementation, and an interim program for 1989 and 1990. EPA invited written public comments on the proposed revisions, due October 3, 1989. The Coexistence Committee remobilized. Because of changes in agency personnel and other adjustments, three members of the core committee were replaced. Time was inadequate to re-establish the group's collaborative process and develop a consensus; instead, members individually submitted their comments to EPA.

The resurrected EPA proposal alerted the Coexistence Committee to the possibility of renewed federal regulatory action in Cameron County and led them to realize that their proposal was not likely to result in policy changes without a proactive and collaborative initiative. Through a chance discussion with an EPA official, the representative of an environmental interest group learned that no action had been taken on the committee's 1988 recommendations (several months after they had been submitted). The environmental group expressed its discontent and exerted pressure for implementation of the locally based recommendations. The irony of an environmental interest group taking leadership to push for less stringent pesticide regulations made an impression on EPA officials and agricultural interest groups in Texas.

The Coexistence Committee worked as a team for several months to educate and advocate for coexistence, contacting various branches of the FWS and EPA bureaucracies responsible for implementation of the ESA and associated pesticide regulations. The focus of their efforts was to challenge the need for a ban of 17 pesticides that in 1987 had been named as "jeopardizing" the aplomado falcon and its habitat in Cameron County. There was no precedent for reversing an ESA "jeopardy ruling" on the basis of local evidence. However, through the efforts of the Coexistence Committee with support from bold leadership within FWS, the jeopardy decision was reversed. The Coexistence Committee considers this among its proudest achievements.

The Coexistence Committee Today

Today, members of the Coexistence Committee consider themselves an information-sharing network and an informal coalition. Rather than meeting regularly, they mobilize when asked to respond to a particular issue. For example, in 1995, committee members participated in discussions of a proposed revision to the county's boll weevil eradication program. In 1994, members assisted with the release of fledgling aplomado falcons from the Peregrine Foundation on the Laguna Atascosa refuge.

Several groups in other parts of Texas and elsewhere in the U.S. have tried to replicate the Coexistence Committee's process, and have had varying degrees of success. An attempt was made to expand the committee into a four-county group that would address a broad range of environmental issues. This group was to meet monthly, discussing a different issue each time. After several meetings they disbanded. One participant observed that because they tried to do everything, they accomplished nothing.

A Framework for Innovation

The Coexistence Committee produced innovative solutions to pesticide management in the interest of protecting endangered species, as shown by widespread acclaim it earned from the Cooperative Extension Service, the Fish and Wildlife Service, the state's Department of Agriculture, and the media (Lemieux, 1995; Precker, 1995; Santa Ana, 1995; Spears and Dale, 1995).

The significant innovations in this case were not in how the growers managed pests, but in how they chose their pest management methods, who else was involved, and what factors they considered. Farmers routinely choose application rates and formulations that maximize the benefits for their farms. They do so as individuals, with advice from chemical manufacturers, distributors, and extension agents, within the constraints of federal regulations. In Cameron County, in contrast, some cotton producers took account of impacts on endangered species and made their decisions in an open setting involving agency personnel and environmental interests. Their most significant innovation was to create a setting for solving problems (Sarason, 1972). The type of setting they created is increasingly known as collaborative community problem solving.

In Cameron County, each side apparently had sufficient power to implement an alternative to a negotiated agreement that would have been uncomfortable or unacceptable to the other side. The cotton growers' campaign of letter-writing and phone calls to Congressional representatives and federal agencies seems to have led to the withdrawal of the draft regulation, and thus demonstrated the farmers' political clout. It is likely that the farmers also had sufficient influence with federal legislators to disrupt acquisition of land for the Rio Grande Valley wildlife corridor, a high priority for environmentalists. Congressional funding to purchase easements for wildlife conservation is secured annually, and therefore is subject to political influence.

The environmentalists' influence was based in the federal Environmental Protection Act and Endangered Species Act. An unusual feature of the Cameron County situation was that several legislators were involved with federal policy on both conservation expenditures and pesticide regulation, and were sympathetic to both environmental and agricultural perspectives. This gave each side a strong "alternative to a negotiated agreement" (Fisher and Ury, 1981): either side might successfully disrupt the other's initiatives (respectively by blocking congressional funding to acquire land for the wildlife corridor or by pushing for pesticide regulations to protect endangered species). This prospect made collaboration attractive to both sides.

Several factors contributed to an outcome that almost all the members considered positive. Some were external and situational; others were the result of the initiative and judgment of the participants.

Diversity of membership. The committee, although small, was diversely representative of the agricultural community, environmental interests, and state and federal agencies. When a group is pursuing an internal consensus, a diversity of viewpoints can stimulate creative thinking. Each stakeholder is likely to espouse an internally consistent set of values, purposes, and preferred courses of action. To the extent that stakeholders are exposed to such frameworks and acknowledge their legitimacy, dissonances are introduced into their own conceptual frameworks. These dissonances stimulate a search for a new level of consistency. Later, as the group tries to reach consensus, diverse participation increases the prospect that the consensus they reach will hold up when it is exposed to a broader political debate.

One useful guideline about diversity of representation is to have all major stakeholders directly represented in the process. There is an inevitable tradeoff between comprehensive representation and size. The Coexistence Committee's small size contributed to the development of trust and an effective mode of operation. Meetings were open; other people were welcome to attend, and visitors participated regularly. An open meeting policy seemed to work well for the Coexistence Committee, allowing it to hear information and viewpoints from parties who might not otherwise have been heard.

Legitimation from external authorities. The committee sought and obtained official status as an ad hoc committee of county government. They were mandated by the County Commissioners' Court to pursue solutions to a situation that could affect the entire county, and they received support and encouragement from the county government. Among the members' interest groups and agencies, however, the collaborative process and the committee's pursuit of coexistence were more likely to receive ready acceptance and encouragement from distant officials (such as in Washington, D.C.) than from local or regional officials. Those at lower levels appeared duty-bound to implement policy; some at higher levels could see the costs imposed by rigid approaches.

A shared purpose. Especially with diverse representation, a group created for planning, problem solving, or decision making may be combative and adversarial. However, if participants acknowledge the possibility that their interests are not diametrically opposed and that mutually acceptable ("win-win") solutions may be possible, they may be able to establish a truly collaborative mode of exploration. In the Cameron County case, the chair frequently reminded the group that its goal was to seek "functional solutions" to the problem. Specifically, their agreed-upon goal was to identify solutions that would allow agriculture and wildlife to coexist. Reminders of the quest for "functional solutions" legitimized the committee's purpose and contributed to a climate of open-minded thinking, yet kept the group focused.

A flexible process, adapted to the purpose at hand. It was clear to the participants that no immediate solution was available for their dilemma, and that no expert could provide a ready-made answer. They were united in their disdain for rigid regulations designed at the federal level but fitting poorly at the local level. It seemed equally clear to them that they would need to invent not only the solution but also the process for getting to it. The committee developed a sequence of tasks that at one time or another included exchanging information about their understanding of the situation, identifying additional information needed, gathering that information, exploring alternative solutions, reaching consensus about a comprehensive solution, and taking steps to achieve wider acceptance of that solution.

Reframing the problem. A key to innovative solutions is the way a situation or problem is "framed" (Goffman, 1974). As discussed above, the Coexistence Committee was itself an innovation. It reframed the context for problem-solving by presuming that a federally imposed countywide ban on certain pesticides was not acceptable, and that instead, through local study a "coexistence" solution might be found that was acceptable to wildlife and agricultural interests and worthy of implementation. The innovative nature of these assumptions contributed to a tone of open inquiry and exploration of alternative solutions.

Establishing trust. Finding new solutions, and even the open sharing of information, were not automatic. Before farmers were willing to share detailed information about their practices, for example, they needed a basis of trust. Establishing that trust took time—six months according to some participants—and demanded renewed attention to trust each time a new member replaced an old member. Members spoke of respecting one another's expertise, but it was also clear that they achieved a respect for each other as human beings, even a fondness, and an understanding and perhaps an appreciation of each other's values and concerns.

Anticipating consequences. The committee members developed a way to assess their ideas for reducing risk to wildlife while controlling cotton pests. As their understanding of the situation developed, they explored indirect impacts, such as that smaller birds might ingest pesticide granules and then become prey to the falcon. Their understanding went beyond easily predictable consequences, expanding to a systems framework that considered multiple and interacting factors. They also acknowledged the importance of anticipating outsiders' concerns and reservations about their recommendations.

Establishing "learning loops." The committee's work was not done when it submitted formal comments to the agencies with recommendations for pest management and wildlife protection. One meaning of "learning" is to take action based on thoughtful consideration of a situation, then to gather information about the impact of the action and reflect on it (think-act-reflect). Reflection on the outcomes of action may, of course, lead to further thoughtful action, resulting in a "learning loop." Just as a feedback loop is required for a thermostat or other control device to produce the desired end-state, so, too, a course-correcting feedback is required to assure that an action successfully produces its desired result (Wiener, 1948).

As the committee moved into an implementation phase, it engaged in this type of learning loop. With some difficulty, the members learned where in the bureaucracies of several agencies their plan was foundering. They observed and reflected on the situation at some length, but eventually found ways to convince influential officials that the plan deserved a more open-minded consideration. The most important strategic choice was to pursue a collaborative approach to the problem. Working together allowed both sides to be more influential: they could present their proposed solution to agencies as one that both farmers and environmentalists could support. Through their experiences and successes, the Coexistence Committee members became convinced that a collaborative approach can be productive, and have pursued a similar approach to other problems.

Conclusions

When the Coexistence Committee members reflect on their coalescence as a collaborative team, a central issue that emerges is trust. Trust is an intangible. Committee members offer no recipe for trust-building except time, listening, and a common interest in the long-run well-being of the community. They emphasize the importance of agreeing on a principle that all can support—in this case, coexistence. The arguments over language and vocabulary were, for them, a trust-building activity. Those who worked together as a Coexistence Committee look back and say their participation paid big dividends, as much for themselves individually as for the community.

When they try to convey to others what worked, the committee members often mention their ground rules. The first was that they started by inventorying the facts, and agreed to emphasize facts in their deliberations, not emotions. Second, they always let participants be heard, completely. Finally, they tried to bring their discussions and recommendations back to "functional solutions." *Workability* was the decisive test.

A collaborative problem-solving approach was a bold experiment with uncertain outcomes. However, the participants considered it worth trying because other options seemed less likely to produce satisfactory, sustained results. In retrospect, participants came to believe, as the county Extension agent pointed out, that it was the "right way" to do business.

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Valley Care: Bringing Conservation and Agriculture Together in California's Central Valley

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Introduction: Loss of Wetlands of California

For the past 50 years the primary strategy for dealing with wetland losses and declining waterfowl populations has been to protect wetlands by having state and federal agencies acquire them. In recent years it has become obvious that this strategy can be effective only if it is complemented by strong efforts to maintain wetlands and other waterfowl habitats on private lands (Payne and Wentz, 1992). This is especially true in California, where more than 95% of the historical wetlands base has been lost or modified. Of the 285,000 acres of wetlands left in the Central Valley, two-thirds are privately owned and are managed for duck hunting (Heitmeyer et al., 1989).

The Central Valley of California is 400 miles long, lying between the Coast Range and the Sierra Nevada. It includes the Sacramento Valley, the Delta-Suisun Marsh complex, and the San Joaquin Valley. Historically, the Central Valley contained 4 million acres or more of natural wetlands and 6,000 miles of streams, rivers, and associated riparian habitats. Today, less than 300,000 acres of wetlands and 950 miles of riparian woodlands remain (Gilmer et al., 1982).

The remaining wetlands in the Central Valley, along with seasonally flooded and unflooded agricultural land, support up to 60% of all waterfowl in the Pacific Flyway (U.S. Fish and Wildlife Service, 1978). The original wetlands, riparian areas and associated habitats provided some of the continent's most important living space for Neotropical migrant birds (especially shorebirds and wading birds), unique plants and insects, and a diversity of other wildlife. Today, the remaining wetlands and associated habitats host several species listed by the federal or state government as threatened or endangered. These wetlands also support large populations of more common species, but in an overcrowded environment. If common species are to avoid decline and endangered species are to maintain viable populations, we must reverse the loss of natural wetland and riparian habitats on which they depend..

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With only a fraction of the original wetland and riparian habitat base of the Central Valley remaining, the diverse migratory birds and other wildlife depend on certain types of agricultural lands (mainly small grains) for part of their living requirements. Improved management of these lands to mimic wetlands could accommodate increased populations of threatened and endangered species, Neotropical migrants, and migratory waterfowl.

Today, even the farmlands of the Central Valley are under severe threat, compounding the problem of loss of natural habitat. The American Farmland Trust (1995) has identified the farmlands of the Central Valley as the most threatened agricultural region in the United States. Agriculture and conservation must work together if we are to maintain the agricultural land base, increase the value of private and public lands for wildlife, and enhance the diversity of wildlife found in the Central Valley.

In recognition of private lands' importance to waterfowl, starting in 1990 Ducks Unlimited (DU) increased its efforts with farmers, ranchers, and private duck clubs. These efforts are designed to assist the private landowner's objectives, whether agricultural or wildlife-related, besides enhancing and restoring waterfowl habitats. The program is delivered from DU's regional offices, such as the Western Regional Office in Sacramento, where a private effort known as Valley Care (Conservation of Agriculture, Resources, and the Environment) has been established.

Valley Care: Objectives and Purposes

With support from the National Fish and Wildlife Foundation, the Hofmann Foundation, the California Wildlife Conservation Board and others, DU is engaged in the second year of Valley Care to help solve many of the wetland conflicts in California's Central Valley. Valley Care is enhancing, protecting, and restoring wetlands on private land, adding to the public wetland base, enhancing agricultural lands for a diversity of wildlife, providing education for a broad range of the public, and establishing new partnerships among other conservation organizations, the agricultural community, businesses, and public agencies.

Valley Care focuses its efforts on the three geographically distinct areas of the Central Valley: the Sacramento Valley, the Sacramento-San Joaquin Delta, and the San Joaquin Valley. In each of these areas our primary efforts toward private landowners are enhancement, restoration, and communication and education. The following sections provide greater details on the work being done in these geographic areas. Because of the landscape scale of this effort, the methods used and benefits expected are discussed in each section.

Sacramento Valley Rice Lands

Enhancement

Rice lands offer a unique opportunity to provide supplemental wintering habitat for many species of waterbirds. DU's efforts to date have shown that winter flooding of rice lands has substantial benefits for a broad variety of wildlife. DU is involved in a wide effort with other conservation groups, rice growers, resource agencies and agricultural commodity groups to develop methods for proper winter flooding of harvested rice fields.

Working with rice farmers, DU pioneered the use of rolling, crushing, and flooding rice stubble and straw as an alternative to burning it. Initial tests and operational practices demonstrated that the new practice is accomplishing the grower's objective of decomposing waste straw, controlling weeds and diseases, and providing winter habitat and food for waterbirds. Rolling rice straw is proving economical in comparison with alternative agronomic methods that do not have the same wildlife benefits. The practice also eliminates air pollution caused by burning, which now is tightly regulated (Wrysinski et al., 1995).

During the 1993-94 winter season and the first year of the Valley Care program, rice growers in the Sacramento Valley winter-flooded about 90,000 acres. During 1994-95, winter flooding of rice increased to over 140,000 acres, with Valley Care staff providing direct technical assistance to growers on 76,876 acres (Ducks Unlimited, 1995). Many of these fields were developed as Valley Care demonstration sites. Staff from DU, cooperating agencies, and agricultural commodity organizations conducted field days and ranch tours for rice farmers, environmentalists, and others interested in this approach. These activities, together with landowner workshops, media releases and other educational and promotional events, helped contribute to the total of 140,000 acres of enhanced seasonal agricultural wetlands created on rice land during the year. Cooperating groups included several Resource Conservation Districts, county Farm Bureaus, the Natural Resources Conservation Service, the California Rice Industry Association, and others. DU provided funds, technical assistance, advice and equipment to help create this landscape-scale change. During the coming winter (1995-96), we hope to repeat or exceed this figure.

Other funds (primarily from the U.S. Bureau of Reclamation) are being used by the University of California at Davis, the National Biological Service, the California Waterfowl Association, and the Point Reyes Bird Observatory (all under contract to DU) to conduct basic research into the biological and agronomic values and problems associated with winter flooding. Approximately $2 million eventually will be invested in this research effort.

"More Than Ducks"

The agronomic value and economic benefits of winter flooding seem as high as expected, and the biological values are substantial (Ducks Unlimited, 1995). The results for migratory bird use are very revealing. The Valley Care motto, "More Than Ducks," is nowhere better demonstrated than in the enhanced agricultural fields of the Sacramento Valley. Winter-flooded rice fields are valuable not only for waterfowl, but also for Neotropical migrants. Wading birds, shorebirds and cranes are just a few of the nonwaterfowl species that are benefiting from the temporary wetlands promoted on agricultural areas.

Almost 30% of all waterbirds using rice fields are nonwaterfowl species, and half of these are shorebirds. Rice fields hold a substantial portion of all shorebirds surveyed in the Central Valley throughout the year. In winter, when cooperators were actively flooding rice lands, rice fields in the Sacramento Valley held 68% of all shorebirds surveyed. Among shorebirds, flooded rice fields held 85% of the dunlins *(Calidris alpina)*, 70% of the dowitchers *(Limnodromus scolopaceus)*, 70% of the killdeers *(Charadrius vociferus)*, 67% of the unidentified small sandpipers (*Calidris* spp.), 53% of the yellowlegs (*Tringa* spp.), and 31% of the least sandpipers *(Calidris minutilla)* (Page et al., 1994).

Northern pintails *(Anas acuta)*, American widgeons *(A. americana)*, and to a lesser extent mallards *(A. platyrhynchos)* and northern shovelers *(A. clypeata)* accounted for most of the ducks surveyed. Snow geese *(Chen caerulescens)* and Ross' geese *(C. rossii)* made up over 70% of the geese surveyed, with greater white-fronted geese *(Anser albifrons)* accounting for more than 23%. Canada geese *(Branta canadensis)*, mostly cackling Canada geese *(B. canadensis minima)*, which are in need of protection, were approximately 3.5%, with tundra swans *(Cygnus columbianus)* constituting less than 3% of the geese and swans surveyed (Miller et al., 1989).

These results reflect the substantial value of the Valley Care rice lands program for a broad diversity of wildlife. As winter flooding becomes more common and as we learn more about how wildlife benefit from it, we anticipate that its value will increase, benefiting the continent's wildlife, especially Neotropical migrant shorebirds and waterfowl.

Restoration

We anticipate that individual rice growers will show strong interest in converting some rice to natural, seasonal wetlands. One such project completed this year, which serves as an example of projects planned for the program's third year, was the restoration of 55 acres of previously farmed agricultural land on the Garbutt Ranch in the Colusa Basin. The restored wetlands and remaining agricultural lands will be managed to provide year-round wildlife habitat. This project also enhanced 104 acres of existing seasonal, semi-permanent, and permanent wetlands on the ranch. This and similar restorations mimic the original natural wetlands in the Central Valley and form a cornerstone effort of Valley Care.

Before the adoption of modern agricultural and land modification techniques, the Colusa Basin acted as a natural basin or sink for winter overflow from the Sacramento River and from the streams draining the eastern slope of the Coast Range. The mosaic of habitat types created on Garbutt Ranch supports a greater diversity of species than a strictly farming operation that floods seasonally for farming or hunting purposes. The completion of this project will improve the landowner's ability to control water through improved drainage, application, and recirculation. This restoration and the White Road Ranch restoration, which took place in the rice fields under the first year of Valley Care, is typical of restorations that are being accomplished in this program and that will continue in the coming years.

Delta and Suisun Marsh

Enhancement

The Sacramento-San Joaquin Delta (Delta) and Suisun Marsh also are focal areas for Valley Care. DU has worked with farmers in the Delta to winter-flood idle cropland for Neotropical birds (especially shorebirds), sandhill cranes, swans, ducks, and other waterbirds. Last year (1994-95), cooperating landowners contributed nearly 17,000 acres to over 30,000 acres that were flooded in the Delta (Ducks Unlimited, 1995). Our long-term goal in the Delta is to establish a growers' management group that will continue this practice over the long-term with limited outside involvement.

Winter flooding of Delta lands provides benefits both to substantial numbers of migratory birds and to private landowners. It provides winter water and food for waterbirds and assists the farmer by slowing or preventing erosion and land subsidence, preventing weed growth, and reducing soil salinity. Valley Care biologists provide guidance on timing, depth, and duration of flooding and other management techniques through formal planning with the landowner. Direct assistance also is provided through redesign of water delivery structures and other engineering services provided by DU engineers.

Restoration

DU also has expanded the Valley Care effort for the Delta and Suisun Marsh to establish a series of permanent wetland restorations and enhancements along with the agricultural system. We found an increasing interest among landowners in returning parts of their land to natural wetlands. This mosaic landscape approach is fundamental to the planning efforts for this region and is a cooperative effort with the Delta Protection Commission and the Suisun Resource Conservation District.

Five projects were completed this year in the Delta and twelve in the Suisun Marsh, representing over 12,000 acres of restored or enhanced wetlands. Although these areas are hunted a few times a year, these private lands along with public refuges are the only real wetlands remaining in this part of California. Many resident wetland species, including threatened and endangered species of both wildlife and plants, are entirely dependent on these lands. To qualify for restoration assistance through Valley Care, private land must be enrolled in an easement program and the landowner must sign a long-term site-specific agreement with DU that protects the Valley Care investment. The landowner also must agree to follow a management plan, written by Valley Care staff, that remains in effect for the length of the site-specific agreement.

Also, this year Valley Care initiated a marsh management program to manage privately owned wetlands directly. Five duck clubs, including two with pending projects, presently are cooperating with DU in the management program for the Delta. Most duck clubs cooperating with DU have absentee owners; therefore, with the owners' permission, the Valley Care biologist coordinates and implements drawdown schedules and moist soil irrigations and assists in the fall with flooding regimes. A weekly visit to the property allows much closer monitoring than the landowner could provide, and results in better habitat for many species. So far, 1,580 acres have been treated this way. These management activities are used as demonstrations so that these landowners and others can manage their wetlands better in the future. The management of these private lands provides a broad range of benefits to many species of plants and animals.

San Joaquin Valley

Enhancement

The San Joaquin Valley, the third focal area for the Valley Care Program, includes the Grasslands Ecological Area and the Tulare Basin. Historically, this area had more than one million acres of seasonal and permanent wetlands. Today, less than 5% of the original wetland base remains, more than 70% of which is privately owned. Resident and migrant waterbirds depend on these wetlands for survival. Their declining populations can be attributed to the lack of available wetland habitat (U.S. Fish and Wildlife Service, 1978).

Agriculturally based enhancement projects are at a premium in the San Joaquin Valley. Valley Care's initial effort in the San Joaquin Valley has focused on existing wetlands ecosystems, but future emphasis on the surrounding agricultural community should provide additional opportunities for agricultural enhancement. An increased presence in the region will lead to better understanding of the difficulties it faces. Inadequate water and "wildlife unfriendly" farming are the two most critical factors affecting enhancement and restoration activities. Future work will be on proper water use and on developing a working relationship with local farmers.

Restoration

The Valley Care Program stresses private land management and strives to provide wetland restoration opportunities as well as technical and financial assistance. Through these efforts, the San Joaquin Valley may again contain many wetlands for wetland-dependent species.

Many private wetlands in the Grasslands and Tulare Basin areas remain poorly managed by today's standards. In an effort to improve management of privately owned wetlands, DU is conducting landowner workshops, providing written management plans for individual duck clubs, and assisting with habitat development through water management.

Promoting these activities has helped DU biologists develop a positive rapport with private landowners. Seven duck clubs totalling 2,300 acres enrolled in Valley Care's new marsh management program for 1995. Continued development of these lands and the education of landowners are vital to DU's impact on the San Joaquin Valley.

Finally, Valley Care strongly advocates additional endeavors to secure critical public land currently threatened by urban encroachment. Current efforts include restoration of over 600 acres in the corridor between the North and South Grasslands. Additional land must be secured in these critical areas to maintain the traditional flight lines of wintering waterbirds. This corridor is under threat of development by expansion of the city of Los Banos. Of the 600 acres being restored in the corridor, 250 acres (Mud Slough) is being restored this year through Valley Care.

Communication and Education

An integral component of DU's Valley Care Program is our communication and education effort through which we inform, educate, and communicate to the public the importance of agriculture, wetlands, and wildlife conservation. This is a multi-faceted outreach effort designed to generate interest, promote awareness, and elicit support among targeted audiences and the public. This is accomplished through various methods, including a landowner newsletter, technical management documents, displays, news releases, an informational poster, brochures, workshops, personal contacts, and public appearances. Audiences specifically targeted include private landowners and managers, the agricultural community, youth, conservation groups, media, business and industry, and community decision makers.

Monitoring and Evaluation

As the Valley Care Program progresses, there will be an increasing need to evaluate the success of its agricultural and wetlands enhancement projects. The monitoring system will need to account for several complex cultural and physical landscape variables. The basis for recommendations is that many facets of evaluation have a direct link to maps. The location of each enhancement project in relation to wildlife refuges and waterfowl population densities will be an important evaluation criterion. Complex spatial relationships such as these are most efficiently handled using Geographic Information System (GIS) technology. GIS allows several management scenarios to be considered, revised, and reanalyzed in a timely manner. Two basic needs of Valley Care are project tracking and site evaluation and monitoring.

GIS and project tracking

Tracking the status of projects is important in every program for justifying expenditures. Typically, the first stage in tracking project status is inventory. Valley Care project locations and associated attributes will be converted into GIS format. Graphic information associated with enhancement projects will also be stored on-line as needed. For instance, 35 mm slides will be scanned into digital format and maintained as an item in the database of projects. This will allow the staff to document project status by maintaining ground photography before and after enhancement. Project design diagrams or engineering plans may be managed in the same fashion.

Remote sensing as a tool for evaluation and monitoring

Remotely sensed data will serve as a baseline for an inventory of Valley Care projects' physical characteristics. It also will provide the base for further GIS analysis, such as targeting additional sites for future wetlands restoration.

Image-differencing techniques are an economical automated method for analyzing change (Jensen, 1985; Hame, 1986; Yokota and Matsumoto, 1988). More recently, the use of multiple dates of Landsat Thematic Mapper data collected within a single year has proven useful for mapping wetlands and rice lands in the Central Valley of California (Spell et al., 1995). New satellite sensors such as cloud-penetrating radar and several new higher resolution optical earth resource satellites will be operational in the next few years, which will increase monitoring opportunities and reduce costs.

The Valley Care program will take advantage of the integration of satellite inventory and GIS technology to help guide wetland restoration programs in the Central Valley. California resource agencies, conservation organizations, local governments, and agricultural interests will benefit from accurate and up-to-date wetlands inventory information for use in planning land use actions and mitigating their attendant impacts on wildlife.

Ducks Unlimited, Inc., Pacific Meridian Resources, the Central Valley Habitat Joint Venture (CVHJV) of the North American Waterfowl Management Plan, and the U.S. Bureau of Reclamation are partners in a rice inventory project presently underway. Satellite images collected from 1988 to 1993 were processed to determine the changes in winter-flooded rice lands. Baseline satellite inventory along with other GIS data layers such as soils, water delivery, land ownership, and crop location ultimately will be integrated to target potential areas for wetlands restoration and to insure that reliable water sources are available for managed wetlands as mandated by the Central Valley Improvement Act of 1991.

Currently, a model is being developed that allows new wetland enhancement and restoration sites to be targeted. The model determines the value of a restoration site using variables such as the distances to wildlife refuges, to contiguous wetlands greater than 10 acres, and to water delivery systems. Other variables, such as waterfowl population densities, soils, and land ownership, will be added as funding allows. The model also allows monitoring of CVHJV goals for waterfowl habitat enhancement for each CVHJV basin. It uses the satellite landcover classification and assigns a habitat value based on waterfowl energetics or food production from the various types. These powerful and dynamic modeling tools will be used to monitor the success of the Valley Care program. Similar techniques are applicable to similarly dynamic areas nationwide, such as the Mississippi River Alluvial Plain, which recently experienced severe flooding and significant changes to riverine wetlands and surrounding agricultural land. Remote sensing and GIS technology will help ensure proper evaluation of Valley Care projects and other state and federal projects throughout a wildlife corridor or bioregion such as the Sacramento Valley.

Conclusion

The Valley Care program already has had substantial success. It is dramatically changing the landscape of California's Central Valley and leaving a legacy of improved agricultural practices, major increases of wetlands and riparian habitats, and benefits to the continent's major populations of Neotropical endangered species and other wildlife. The program's results demonstrate what can be accomplished when private conservation groups and agricultural organizations work with each other and with traditional state and federal wildlife agencies for the benefit of both agriculture and conservation.

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The Delta Farmland and Wildlife Trust

David Melnychuk[1]

Introduction: Farming and Wildlife in the Fraser Delta

Farming and wildlife can be compatible. A recent community-driven initiative in the southwestern part of British Columbia is providing everyday practical proof. The establishment of the Delta Farmland and Wildlife Trust (DF&WT) in 1993 marked the beginning of a cooperative approach by farmers and wildlife conservationists to resolve traditional conflicts between them.

Not only can farming and wildlife coexist compatibly in the same space; DF&WT is showing that reciprocal benefits are possible when there is mutual understanding and respect between farmers and wildlife conservationists. Under DF&WT, farming and wildlife share the Fraser River Delta in the southwestern tip of British Columbia, Canada, a special place for many British Columbians and other Canadians. This part of British Columbia is endowed with several exceptional qualities, including the mildest climate in Canada, extremely productive farmland, and waterfowl species and wildlife habitat of international significance.

Unfortunately, these highly valued qualities also have attracted an expanding urban population and created pressures that threaten the sustainability of both farming and wildlife. The Fraser River Delta is home to the fastest growing urban area in Canada (Greater Vancouver Regional District, 1994). The population of the Greater Vancouver Regional District was projected to increase from 1.6 million to 2.6 million in 30 years (1991 to 2021). Urbanization during the past 100 years and projected growth are seriously threatening the existence not only of valuable farmland but also critical of waterfowl habitat. This danger is the force behind an alliance between agricultural and wildlife interests.

Natural Resources of the Area

Winters in the Fraser River Delta characteristically are mild and wet, while summers are cool and dry. The nearby Vancouver International Airport has an annual mean

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rainfall of 1055 mm. The growing season usually begins in mid-March and continues for approximately 250 to 265 days.

The Delta contains some of the most productive farmland in Canada (Klohn Leonoff Ltd. et al., 1992). Much of the approximately 15,000 acres presently farmed in this region was reclaimed from the sea and estuary at the turn of the century by pioneer ancestors of many of today's farm families. The soils developed on the rich alluvial deposits of the Fraser River and typically are deep, fine textured, and exceptionally productive for a wide range of crops. The area is noted for its high yields, including the Canadian record of 205 bu/acre for winter wheat *(Triticum aestivum)*, and for its suitability for specialty berry and vegetable crops.

The Fraser River Delta is recognized as containing internationally significant waterfowl habitat. It is the largest estuary on Canada's Pacific Coast. Its moderate climate, abundant food supply and varied habitat support hundreds of thousands of migrating and overwintering birds with the highest species diversity in Canada. Butler (1992) identified over 300 species of migratory waterfowl, birds of prey, and songbirds. This region is a vital resting and feeding area on the Pacific Flyway for birds migrating from the Arctic to Central and South America. Every year, an estimated 1.4 million birds use it for their survival.

The Farmland-Wildlife Habitat Relationship

Although agricultural activities over the past 100 years have dramatically altered the natural environment and displaced many of the original plant species, the farmlands of today offer a variety of habitats essential for waterfowl, shorebirds, birds of prey, and songbirds. During the winter, waterfowl make extensive use of fall-planted cover crops such as winter wheat, barley *(Hordeum vulgare)* and fall rye *(Secale cereale)*. In addition, species such as the American widgeon *(Anas americana)*, mallard *(A. platyrhynchos)* and Northern pintail *(A. acuta)* feed on the leftovers in harvested fields of potatoes, corn and grain (Butler, 1992). Agricultural fields that have been left to grow into grasses for several years provide excellent habitat for the Townsend's vole *(Microtus townsendii)*, a main source of food for birds of prey, including hawks, eagles, owls and the great blue heron *(Ardea herodias)*. Hedgerows and woodlots bordering grass fields and ditches provide food, cover, water, perch sites, nest sites, and movement corridors for birds, mammals and insects. Maintaining a varied agricultural landscape is critical for the survival of many species in this region.

Formation of The Delta Farmland and Wildlife Trust

As the Fraser River Delta becomes increasingly urbanized, the remaining agricultural areas come under greater pressure for nonagricultural developments such as golf courses, residential subdivisions, industrial developments, and an expanding transportation network. More than 70% of the original wetlands of the Fraser River estuary have been converted to other uses in the past 100 years. The projected urban growth over the next 30 years can be just as destructive unless protective measures are implemented.

Recognizing that the futures of agriculture and wildlife in this region are at risk, several local citizens, conservation groups, and government agencies banded together in the belief that some sort of action was required. Under the leadership of the Municipal Government of Delta, 19 stakeholders were assembled who grappled with the challenge for several months. From the collective wisdom of this group was born the concept of establishing a trust that would be dedicated to preserving farmland and conserving wildlife habitat. The Delta Farmland and Wildlife Trust is community-based and non-profit, with no formal attachment to the government. Many of its founders are directors of DF&WT or members of its Advisory Committee.

DF&WT's most valuable asset is perhaps the make-up of the Board of Directors, which includes three long-term resident farmers, three community wildlife conservationists, and two respected business representatives. All decisions regarding Trust programs and initiatives reside with the affected community.

DF&WT firmly believes that conservation of wildlife resources in the Fraser River Delta is intimately linked with the preservation of farmland and the associated farming community. The central themes are: first, to bring together various organizations and individuals concerned with the preservation of farmland and the conservation of wildlife habitat and provide a forum for them to exchange views and research needs; and second, to offer sound educational and practical advice and incentives to farmers and landowners for farm stewardship and habitat enhancement techniques that integrate farming practices with wildlife needs.

Farm Stewardship Programs

In the past two years, DF&WT has implemented an extensive on-farm stewardship program aimed at enhancing wildlife habitat while providing a clear and identifiable benefit to the agricultural sector. The following is an outline and description of the specific initiatives (Temple et al., 1994).

1. *Grassland set-asides*. Encouraged by financial incentives of up to $300/acre, farmers take land out of commercial production of vegetables and plant it to perennial grass. The field remains in grass, largely unharvested, for up to three years. In this short time, excellent habitat is created for the Townsend's vole (an important food for several raptors, as mentioned). The agricultural benefits of a grassland set-aside include increased organic matter content, better soil tilth, and improved drainage.

2. *Winter cover crops*. Farmers are encouraged to plant winter cover crops (winter wheat, barley, fall rye) in the fall after the main crop is harvested. The resultant forage crop is a valuable source of food for waterfowl such as the American widgeon. The

benefits for the soil include an increase in organic matter and protection from the compacting force of heavy winter rains.

3. *Hedgerows.* Hedgerows associated with farmlands support a diverse and abundant bird population because of the diverse habitat they provide. More than half the bird species on farmland are associated with hedgerows, even though hedgerows constitute only a small fraction of the available habitat. The structure and species composition of hedgerows are important determinants of wildlife species abundance. Height, density, patchiness and plant species diversity contribute to wildlife use of hedgerows. DF&WT has an incentive program for establishing hedgerows on farmland. Native trees and shrubs are made available and installed at no cost to the farmer. Also, farmers who take land out of production and establish hedgerows are paid an annual fee but are responsible for maintaining the hedgerows.

4. *Grassed field margins.* Strips planted to grass along the edges of agricultural fields provide a transition between fields and hedgerows or drainage ditches. They are important to ground-nesting birds and to small mammals. The wider the strip, the greater its benefit to wildlife. In 1994, DF&WT established a series of trials to evaluate the suitability of several grass species for field margins, which were 3 meters wide along a major drainage channel. The farmer gains several benefits from establishing grassed margins. Native grassland plants choke out annual agricultural weeds that otherwise might infest the crop. They may be a nectar source for butterflies and beneficial insects like bees, and may provide habitat for predatory invertebrates such as beetles that help control aphid populations. Margins also can prevent pesticides and fertilizers from draining into ditches and polluting the local watercourses. Field margins, like grassland set-asides, may require farmland to be taken out of production. Therefore, annual incentives of $300/acre may be offered to farmers who wish to participate in this program.

5. *Other conservation programs.* A universal trend in agriculture has been the draining of wetlands and removal of woods to increase the amount of cropland. In the Fraser River Delta, over 70% of the original wetlands have disappeared, with a corresponding decrease in associated wildlife. Most farms have areas that are not used for crops and that can be enhanced to become valuable wildlife habitat.

The initial list of enhancements includes watercourses, wetlands and ponds, all of which can attract marsh-nesting birds such as the red-winged blackbird *(Agelaius phoeniceus)*, winter wren *(Troglodytes troglodytes)*, and a variety of waterbirds. The second category of enhancement activities involves farm trees, woodlands, and field corners. These can provide roosting and nesting habitat for hawks and owls, including the red-tailed hawk *(Buteo jamaicensis)*, Cooper's hawk *(Accipiter cooperii)* and the great horned owl *(Bubo virginianus)*. Incentives for these programs cover the full cost of establishment plus an allowance for future maintenance.

Research and Demonstration

DF&WT, in cooperation with the University of British Columbia's Faculty of Agricultural Sciences, has launched several research projects to address the many interactions between farming and wildlife, specifically in relation to the stewardship programs advanced by DF&WT:

- Of prime importance to vegetable growers is a three-year study of the effects of field boundaries (grass, shrubs, trees and ditches) on the occurrence of beneficial insects, insect pests, diseases, and weeds that can affect the main field crops in the Delta area.
- The second study will determine the effects of various common and useful agricultural grasses on the activity of small mammals, particularly the Townsend's vole.
- The final research effort involves screening a wide range of overwintering cover crops to assess how they are affected by grazing waterfowl and how well they protect the soil surface, provide a green manure to improve soil structure, and conserve residual nitrogen.

To maintain the support of the farming community, DF&WT must provide programs that generate balanced benefits to the farming and wildlife sectors. Research is needed on wildlife enhancement activities that are new to the area. Farmers must feel confident that stewardship and wildlife programs will not threaten their farming operations.

Public Awareness

DF&WT believes in maintaining a high community profile and involving the community in all activities and programs. It prepares a regular newsletter, supplies articles to local newspapers, and sends representatives to community events such as festivals, open houses, and forums. Every year, DF&WT organizes and hosts field days that are open to farmers and the public and that highlight field plots and demonstration sites.

A high point of 1994 was FARM TOUR 94. This bus tour was well attended by farmers and by people from all levels of government and from many interest groups. It provided an excellent opportunity for DF&WT to explain its mandate and to demonstrate various farm stewardship projects. The Honourable John Fraser (Canada's Ambassador for the Environment) attended the tour and subsequently gave a strong endorsement of DF&WT.

Financing

In 1993, DF&WT received a three-year grant from the Canada-British Columbia Green Plan to cover its initial start-up costs (project coordinator, administration, research). Since then, DF&WT has been active in raising funds from both public sources and private donations.

DF&WT took a giant step toward financial independence in early 1995, when it was awarded a substantial grant from Environment Canada to implement a farm stewardship program in the Fraser River Delta. This perpetual trust fund was set up through the Vancouver Foundation as part of the overall mitigation of the loss of habitat resulting from expansion of the Vancouver International Airport. DF&WT's long-term financial goal is to become independent of government grants and to rely solely on funds generated by the private sector plus the interest from the existing trust fund.

Conclusion

The establishment of the Delta Farmland and Wildlife Trust resulted directly from the sincere concerns of local farmers and residents of Delta, people who feel that farming and wildlife in the Fraser River Delta are in jeopardy and that existing jurisdictions are not meeting the challenge. The local community needs to have a direct influence on the future of these two critical resources.

Several factors will determine DF&WT's future success in making a positive contribution toward preserving the valuable farmland and wildlife of this region. Without ranking their relative priorities, the list includes: continued cooperation between farmers and conservationists; public support for maintaining farming and wildlife; financial support from the private sector; and appropriate government policy decisions. At present, all these ingredients exist at a level that makes the future look promising for this new and innovative organization.

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Establishment of On-Farm Native Plant Vegetation Areas to Enhance Biodiversity within Intensive Farming Systems of the Sacramento Valley

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Introduction: The Region

The Central Valley of California is the most productive and diverse agricultural region of the United States. The Sacramento Valley, like the rest of the Central Valley, is dominated by large-scale monocultural production of crops on an ever-decreasing amount of flat, productive agricultural land. Agriculture is the primary land use in much of the Sacramento Valley. Many of California's 250 agricultural crops are produced in this fertile alluvial basin.

The Sacramento Valley is bordered on the west by the Coast Range and on the east by the foothills of the Sierra Nevada. The Sacramento River is the primary drainage for the Sacramento Valley, supported by a web of sloughs and creeks originating in the foothill edges. Of the original natural ecosystems, less than 1% of the grasslands, 5% of the wetlands, and 12% of the riparian areas remain. These areas contain the last vestiges of the diverse native perennial grasses, shrubs, sedges, rushes, and trees that once were common in the valley.

Intensive farming systems, through tillage and cultivation practices, have removed most of the native perennial plant communities. Remnant strips along the riparian corridors and foothill regions are now isolated by large tracts of intervening agricultural land. The valley's intensive farming systems, driven by competitive, localized markets, seek to maximize yields of high-value crops through heavy use of off-farm inputs to supply plant nutrients and control weeds and insects.

Continuous efforts are made to eradicate weeds through herbicides and tillage. Unfarmed areas, such as roadsides, borders, corners, canal banks, and equipment yards, are generally kept free of all vegetation, a practice known as *clean farming*. Clean

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farming has resulted in soil erosion, a decrease in plant and animal biodiversity, and an increase in residual nutrients and pesticides in surface and groundwater. Although it is intended to eradicate weeds, clean farming produces a bare dirt environment that is perfect for invasive weeds to colonize rapidly.

The removal of all vegetation from unfarmed areas within the agricultural setting also removes food and shelter for wildlife. As a result, plant and animal biodiversity has decreased dramatically in the past thirty years. Wildlife populations have declined, and in many cases have been eliminated, as a result of diminishing habitat. Especially important for the farmer is the decrease in populations of game animals, such as quail, pheasant, dove, rabbits, deer and ducks, which once were common in the Sacramento Valley, providing abundant recreational opportunities. Desirable species of insects, reptiles, and amphibians also are absent because of clean farming practices.

Aware of the decline in wildlife, some growers in the Sacramento Valley recognized the potential for restoring unfarmed areas to biodiverse wildlife habitats. Since nearly every parcel of farmland contains access roadsides, irrigation canals, sloughs, or unfarmable sections, wildlife habitat could be created within the existing agricultural production framework. In particular, some farms on the west side of the Sacramento Valley began to develop and implement strategies to replicate the existing natural biodiversity of riparian corridors and remnant wetlands and prairies.

Hedgerow Farms

Since 1976, Hedgerow Farms has been integrating wildlife habitat and biodiversity into modern, intensive row-crop farming. Owned and operated by the family of John and Marsha Anderson, the farm has over 500 acres of valley floor and foothill terrain. Its soils are predominantly Class I and II, with some of lower quality. Row and field crops, including production of native grass seeds, continue to be the primary commercial enterprises.

Until the late 1970s and early 1980s, the land had been clean farmed. Revegetation practices along the roadsides and field borders were begun in response to the lack of pheasant, dove, and quail on the property. These areas initially were planted with non-native species. Although they were successful, it soon became apparent that native plant species could be just as beneficial for increasing biodiversity. Working closely with local farmers, specifically A.H. Rominger and Sons, who lease part of the farm, the Andersons began revegetating the unfarmed areas with native plants. Over time the emphasis changed from wildlife enhancement to the restoration of lost California prairie savannahs, riparian zones and wetlands on the unfarmed strips of land. This was done by incorporating over 50 locally adapted species of native perennial grasses, forbs, sedges, rushes, shrubs, and trees. All together, over 70 species have been used. The benefits of the revegetation practices have been numerous and the wildlife populations have exploded.

Revegetation practices

Native grasses. Currently, the farm has about 200 acres in native grass seed production and 165 acres in row crops. The remaining land is poor, and has been restored to either wetlands or prairie. Eighteen species of native perennial grasses are grown for seed. The species grown and their farmland uses are shown in Table 1. Having evolved in California, the grasses are drought tolerant and fire resistant. Most are long-lived perennials with extensive root systems, enabling them to outcompete weeds, enhance water infiltration, and control erosion. They also are easily managed with grazing, mowing, or burning. The physical differences among the species—in height, density, and biomass—allow different species to be selected for various functions (for example, short species along roadsides). These characteristics make them an ideal choice for revegetation work.

Roadside vegetation. The California perennial grasses have been incorporated into all recent wildlife enhancement projects on Hedgerow Farms. Roadside prairie corridors have been established on approximately four miles of adjacent county roadsides, originally using non-native perennials, but now incorporating eight to ten species of native perennials. Under this program the standard bare dirt management has been replaced by a sustainable vegetation system that excludes weeds while providing habitat and increasing biodiversity.

Canal bank vegetation. As with the roadsides, irrigation canals traditionally have been managed by clean farming techniques. Several miles of canals running through the property have been revegetated. Planting native brushes and sedges *(Eleoharis macrostachyis, Juncus xiphioides, J. balticus, Carex barberae)* at the water interface provides needed cover that controls erosion and allows young waterfowl to hide. Wetland-adapted native grasses do well above the waterline and are easily managed with mowing. They also are excellent for suppressing noxious weeds and preventing erosion.

Natural slough renovation. One mile of Union School Slough also runs through the property. The slough carries natural drainage from the Coast Range, immediately to the west. It also transports summer irrigation water, which makes it a permanent stream. In 1992, a large riparian restoration effort was initiated that widened the slough borders and provided an additional 6 to 10 acres of potential riparian habitat. Extensive planting of over 40 species of native plants has turned the area into a wildlife mecca. This project demonstrated the potential habitat and biodiversity value of natural sloughs, which are channelized and clean farmed in many agricultural environments.

Tailwater ponds. Six row crop tailwater ponds dot the property. These ponds fill from both winter runoff and summer irrigation. Their primary functions are sediment retention, nutrient and chemical biodegradation, groundwater recharge, and irrigation water return. However, when vegetated, these ponds act as small wetlands that are used extensively by waterfowl. Over 40 species of native plants have been incorporated into pond plantings.

Table 1. Native perennial grass species availability in the Sacramento Valley, San Joaquin Valley, Delta, and surrounding foothills.

Scientific Name	Common Name	Uses[1]
Nassella pulchra	Purple needlegrass	1-10
Nassella cernua	Nodding needlegrass	1,2,4,7,10
Nassella lepida	Foothill needlegrass	4,7,10
Melica californiaca	California oniongrass	1,2,4,7,9,10
Poa sucunda	Pine bluegrass	4,7,10
Hordeum californiacum	California barley	1,4,7,10
Hordeum brachyantherum	Meadow barley	1-5; 8-10
Leymus triticoides 'Rio'	Creeping wildrye	1-6; 8
Elymus trachycaulus majus	Yolo slender wheatgrass	1-6; 8-9
Elymus glaucus	Blue wildrye	1-6; 8-10
Sitanion jubatum	Squirrel tail	1,4,7
Bromus carinatus	California brome	1,2,7,9,10
Festuca idahoensis	Idaho fescue	1,4,7,10
Muhlenbergia rigens	Deer grass	1,4,5,8
Agrostis exarata	Bent grass	2,3,5
Deschampsia caespitosa	Tufted hairgrass	2,3,5,8
Deschampsia elongata	Slender hairgrass	2,3,5,6,8
Aristida hamulosa	Three awn	4,7

[1]Farmland Use Codes:
1. Hedgerows, berms, borders
2. Canal banks
3. Drainage ditches
4. Roadsides
5. Tailwater ponds
6. Riparian sloughs
7. Upland meadows
8. Flood plain meadows
9. Dryland pasture
10. Vineyard cover crops

Hedgerows. There are about 8 acres of hedgerows on the farm that are year-round habitat highways for many animals, including deer, fox, bear, and coyotes. They act as a web, connecting the tailwater ponds, roadside prairies, sloughs, wetlands, canals, and native grass fields. This system also supports many species of beneficial insects that are important in controlling pests in the adjacent row crops. The system consists of corridors 15 to 30 ft wide along the edges and between fields. The vegetation design varies among sites, but always includes complexes of perennial grasses, forbs, shrubs, and trees.

The result of taking several acres of land out of row crop production is that the farm now functions as a healthy ecosystem. Biodiversity is high, groundwater recharge has been enhanced, erosion has been curbed, and the farm is much more pleasing aesthetically. These unfarmed areas now are productive, and once established, require less maintenance than when they were cleaned farmed. They are contributing a sustainable element to the row crops by providing habitat and essential nectaries for beneficial insects. The negative effects have been negligible, and the concept is receiving increasing support from farm organizations and environmental agencies.

Pesticide use appears to be reduced. Actual data on pesticides will take several years to collect. Although pesticide use is expected to be lower in the long-run, additional broadleaf herbicides must be used during the first three years of establishment of the native grasses.

Associated research

Research, field trials, and monitoring are being performed on many of these practices. Researchers and collaborators from several agencies and organizations are participating in studies at Hedgerow Farms, including the following:

- Interaction between California native perennial grasses and other herbaceous species. (Cynthia Brown, University of California, Davis)
- Tolerance of native grasses to selective pre-emergent herbicides. (Tom Lanini and Rachael Long, University of California Cooperative Extension; John Anderson, Hedgerow Farms)
- Evaluation of establishment, persistence, performance, and management practices of 15 native and 4 non-native species of perennial grasses in a roadside vegetation environment. (Robert Bugg and Cynthia Brown, University of California, Davis; John Anderson, Hedgerow Farms)
- Establishment of a wood duck population on restored farm wetlands and riparian corridors. (Terri Jensen, University of California, Davis, and California Waterfowl Association; John Anderson, Hedgerow Farms)
- Small mammal populations in farmland borders; a comparison of constructed hedgerows and weedy corridors. (Student Chapter of the Wildlife Society, University of California, Davis)
- Evaluation of sheep grazing for weed control and management of native perennial grasses. (Brea and Robert McGrew; John Anderson, Hedgerow Farms)
- The contribution of insectary planting to the abundance of beneficial insects in field crops. (Rachael Long and Andrew Corbett, University of California Cooperative Extension)
- Monitoring the herbicide Diuron in an agricultural tailwater ponding system. (Blanca Rodriguez, Nan Singhasemanon, and John Troiano, California Department of Pesticide Regulation).

Future field trials and related studies will include:

- Native grassland restoration techniques and strategies
- Grazing and nutritional value of native grass species
- Economic impact of farmland habitat
- Monitoring wildlife populations on restored habitat on farmland
- Impacts of wildlife habitat on farm productivity
- Impact of insectary borders on controlling insect pests of field crops.

Yolo County Resource Conservation District Programs

Efforts to expand on the success of Hedgerow Farms and A.H. Rominger and Sons in increasing farmland biodiversity required the active participation of a larger network of growers. The Board of Directors of the Yolo County Resource Conservation District shared the goal of preserving natural resources for long-term sustainability of farm productivity. The five-member board also was committed to increasing the biodiversity on agricultural lands within its jurisdiction in the Sacramento Valley.

To accomplish these goals, the district required a full-time staff and supporting resources to conduct outreach projects on natural resource preservation and wildlife enhancement. With limited funds, the board hired a part-time executive director to search for funding sources and develop grant proposals for natural resources conservation and wildlife enhancement. Four proposals were accepted, providing the funding for ongoing research, outreach, and educational programs.

Water Quality and Irrigation Ecosystem Management Program

The Environmental Protection Agency, through the State Water Resources Control Board, has provided $142,500 to promote canal revegetation, streambank restoration, tailwater pond implementation, and roadside vegetation practices. The objective of this program is to establish working partnerships of growers with city, county, and state agencies to develop and implement wildlife-enhancing alternatives to traditional clean farming. Existing projects on Hedgerow Farms and A.H. Rominger and Sons provide examples of how biodiversity on agricultural lands can actually assist with insect and weed management practices while providing benefits to wildlife and enhancing the aesthetic value of the property.

U.S. Bureau of Reclamation Challenge Grant: Total Resource Management and Outreach Program

The Yolo County Resource Conservation District is one of five subcontractors on this $1.7 million project awarded to the California Association of Resource Conservation Districts. The goal is to increase understanding of the interconnections of soil, water, animal, plant, energy, and human resource use among growers, the public and agencies. This goal is met by establishing "model farms" for resource use efficiency, developing an evaluation model to determine the existing status of total resource management on farms, and conducting extensive public outreach.

A countywide recruitment effort was conducted to select the model farms for Yolo County. Seven growers were chosen who represent both the geographical and crop diversity of the region. Field crop, row crop, vineyard, orchard, and range settings are represented in the Total Resource Management and Outreach Program. Participating growers agreed to have interdisciplinary teams from several resource agencies evaluate soil, water, air, plant, animal, energy, and economic performance on their farms. Working with the interdisciplinary evaluation teams and growers, the project manager developed individual farm plans, and worked with the growers to implement practices to improve efficiencies.

The evaluation tool developed to analyze total resource management was an adaptation of the Natural Resources Conservation Service's SWAPA + H model. The model analyzes soil, water, air, plant, animal, and human factors to determine areas of potential improvement. By assigning practices to remedy resource or economic problems, the model can then predict the expected impacts of the proposed practices. Using this model, the project manager worked closely with participating growers to develop scenarios of practices for each model farm.

Once the participating growers implemented practices to improve efficiencies, their farms were used as outreach sites for neighboring growers, University of California Cooperative Extension, and other interested parties. Growers shared their experiences and described how the modified practices fit into their long-term goals. Water recovery or storage systems were the initial focus of field crop projects. The use of tailwater return systems and reservoirs not only allowed growers to reduce water costs, but also provided habitat for wildlife and waterfowl. The emphasis in vineyards and orchards was on promoting insectary habitats for beneficials. On rangeland, the focus was the control of noxious weeds. In all settings, the project emphasized improving water control in general.

After 18 months of this three-year project, farm evaluations have been completed, whole farm plans have been developed, and many proposed practices have been implemented. The remaining 18 months will focus on monitoring the practices to record changes in resource status, and on expanding the outreach program.

The Willow Slough Watershed Integrated Resource Management Plan

Current interest in watershed management rather than site-based management led to a partnership of the Yolo County Resource Conservation District, the County of Yolo, the California Wildlife Conservation Board, and the Yolo County Flood Control and Water Conservation District. This partnership has dedicated resources to developing a comprehensive plan for the watersheds on the west side of Yolo County, and will be the basis for all future resource management decisions.

The Willow Slough Watershed Integrated Management Plan entails a detailed analysis of the region's existing resources. This analysis will identify and set priorities for resource problems in the area. The overall plan will consider existing land uses and identify potential practices to enhance wildlife habitat, reduce flooding, and decrease erosion while maintaining a strong agricultural foundation.

Farmland habitat workshop

Since 1989, the Resource Conservation District has sponsored annual workshops that provide farmers with the latest information on restoring habitats on the farm. The two-day workshops include one day of lectures and vendor displays dealing with all aspects of farm-friendly wildlife practices. Subjects include site selection, management, planting designs, planting techniques, and technical and funding assistance. The second day is devoted to tours and demonstrations on all aspects of farmland restoration.

Results to Date

Quantitative data on the success in increasing biodiversity and enhancing wildlife habitat is being collected through the Westside Tributaries Project, the U.S. Bureau of Reclamation Total Resource Management and Outreach Program, and the Water Quality and Irrigation Ecosystem Management Projects. Ongoing evaluations of research being conducted on Hedgerow Farms also will provide quantitative data.

There are few economic differences between the Hedgerow Farms model and conventional clean farming. The Hedgerow Farms model imposes additional costs for seed and plant materials, special equipment, and increased transportation due to limited local markets for the native grass seeds. However, cost savings are achieved in the long term from reduced pesticide usage, labor, and tillage. No clear difference in yields has been noted. Implementing practices in unfarmed areas causes little or no reduction in the land available for crops.

Surveys and interviews at Hedgerow Farms and Resource Conservation District workshops have shown a marked change in the attitudes of resource agency professionals toward agricultural production practices. Through tours, lectures, and hands-on activities, agencies and growers are working closely on topics that once were controversial, such as the Endangered Species Act, water control systems, riparian corridor restoration, and weed and insect control strategies. Through both passive and active educational programs, the barriers that created clashes between government and agriculture in the past are giving way to cooperation and practice implementation.

Birds of Prey and Their Use of Agricultural Fields

Kerry J. Fitzpatrick[6]

Human Activity and Raptor Habitat

Agricultural fields potentially are an important habitat for birds of prey, and the right agricultural land management practices can attract them to farmland. This paper examines the literature for areas of compatibility between farming and raptors in the northeastern United States (bounded by the Mississippi River to the west and Kentucky and Virginia to the south). I discuss the following key aspects: 1) the predator-prey relationship being played out on agricultural land; 2) two basic strategies for enhancing farmland habitat for raptors; and 3) where these strategies might be applied.

Many human activities alter wildlife habitat. One species may benefit from a change while another may be harmed. Raptors are opportunists, able to adapt rapidly to favorable circumstances. As forests were cleared for agriculture during the 1700s and 1800s, the fields and pastures attracted barn owls *(Tyto alba)* to areas outside their preferred marsh habitat. Their range and population expanded as they moved into grassland habitat in search of their favored prey (Colvin, 1985). On the other hand, when local habitats no longer provide essentials such as adequate food or breeding space, populations decline (Newton, 1989).

The Midwest is a good example. In the middle of this century the region shifted from an agriculture that depended heavily on forages to one based on row crops. The once common barn owl declined with the loss of pastures, hay, and fallow fields (Colvin, 1985). Most habitat changes taken individually are small, involving only a portion of a field or farm. But however slight the separate changes, they may accumulate over time, particularly if the change is a trend among farmers in an area. Changes in land management can either improve or degrade the habitat's value for raptors; to maintain or increase raptor populations it therefore is necessary to identify and implement those changes that favor them.

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Raptors and Their Prey

Open fields are a significant habitat for birds of prey. Of the 25 raptor species common in the Northeast, 80% depend on fields for part or all of their diet (DeGraaf and Rudis, 1986; Mersmann and Fraser, 1990). Total cropland, including row crops, orchards, hay, pastures, cover crops and fallow land, account for 28% of the land area in the Northeast (U.S. Department of Commerce, 1995). This small portion attracts a large proportion of raptor species, so that its appropriate management could be very beneficial for the community of raptors.

Raptors prefer open areas, which presumably offer several benefits: an abundant supply of prey, an unobstructed view of prey, a minimum amount of escape cover for prey, and an open expanse for flight and maneuvering. Their primary use of unforested areas is for foraging, for which they often use agricultural land (DeGraaf et al., 1980). Raptors appear to concentrate on the small mammals living in the grassland portion of farms, particularly meadow voles *(Microtus pennsylvanicus).*

Of all the small mammals found in northeastern grasslands, the meadow vole is perhaps the most important dietary component for birds of prey, particularly during the fall and winter. In their landmark study of raptor predation, Craighead and Craighead (1956) found that meadow voles constituted 83% of the collective fall and winter diet for nine species of raptors in southern Michigan. Although voles in that study fell to 30% of the total raptor diet during the spring and summer, they were only slightly less important than the largest category, small and medium-sized birds (37%). Eleven species of raptors are known to consume a significant number of voles; six of these are specialists that depend on voles (Table 1). This one rodent is the "staple food" of many raptors and is directly responsible for behavior and population changes in these birds (Craighead and Craighead, 1956). Generalist feeders shift their diet according to the availability of voles, prospering when they are abundant. When the number of voles is low, the specialists either suffer reduced reproductive success and increased mortality, or they leave the area (Craighead and Craighead, 1956; Village, 1990; Taylor, 1994). An examination of the ecology of the meadow vole and its habitat requirements should suggest management strategies to benefit raptors.

Meadow Voles

These microtine rodents are often associated with crop and pastureland (Johnson and Johnson, 1982). Voles can eat both grasses and forbs in their entirety, but grasses are more important because they provide better cover and regenerate quickly when mowed or grazed (Ryder, 1980).

Raptors prefer the meadow vole for several reasons. First, it has the most extensive range of all North American voles and occurs in a wide variety of habitats (Burt and Grossenheider, 1976), including marshes, bogs, open woods, hay fields, pastures, grain

Table 1. Northeastern birds of prey that consume voles (*Microtus* spp.).

Species	Diet Type	References
Northern harrier *(Circus cyaneus)*	Specialist[1]	Weller et al., 1955; Craighead and Craighead, 1956; Hamerstrom, 1979
Red-shouldered hawk *(Buteo lineatus)*	Generalist[2]	Craighead and Craighead, 1956
Red-tailed hawk *(Buteo jamaicensis)*	Generalist	Craighead and Craighead, 1956; Baker, 1977
Rough-legged hawk *(Buteo lagopus)*	Specialist	Craighead and Craighead, 1956; Baker, 1977; Village, 1990
American kestrel *(Falco sparverius)*	Generalist	Craighead and Craighead, 1956; Smith et al., 1972
Common barn owl *(Tyto alba)*	Specialist	Craighead and Craighead, 1956; Colvin and McLean, 1986
Eastern screech owl *(Otus asio)*	Generalist	Craighead and Craighead, 1956
Great horned owl *(Bubo virginianus)*	Generalist	Craighead and Craighead, 1956
Snowy owl *(Nyctea scandiaca)*	Specialist	Chamberlin, 1980; Village, 1990
Long-eared owl *(Asio otus)*	Specialist	Craighead and Craighead, 1956; Marti, 1976; Village, 1990
Short-eared owl *(Asio flammeus)*	Specialist	Snyder and Hope, 1938; Craighead and Craighead, 1956; Clark, 1975

[1]Specialist: focuses hunting efforts on voles, which typically make up 50% or more of prey items.
[2]Generalist: consumes a variety of prey, but voles are first or second largest category, typically making up 25% or more of prey items.

crops, and orchards (Hamilton and Whitaker, 1979). The meadow vole is probably the most common mammal in the northeast. Craighead and Craighead (1956) estimated the population of meadow voles as three to ten times that of the next most populous prey species, white-footed mice (*Peromyscus* spp.). Its population density can be as high as 200 to 300 per acre (Hamilton, 1940) because of its very high reproductive rate (Hamilton and Whitaker, 1979). At 28 to 70 g, the adult meadow vole is two to three times larger than other common small mammals (Burt and Grossenheider, 1976). This results in a higher energy gain per unit of hunting effort than for other small mammals (Taylor, 1994). Finally, the meadow vole is an easy catch. It is active both day and night throughout the year, making it available to both diurnal and nocturnal predators. The territorial nature of voles causes noisy encounters between males, which increases their vulnerability to predation. Three species of raptors demonstrated a marked preference for voles when given a choice between voles and white-footed mice. The voles "freeze" when attacked, while the white-footed mice jump erratically to avoid capture (Derting and Cranford, 1989). All these factors combine to make the meadow vole a preferred food prey.

Two Strategies to Benefit Raptors

Recent literature suggests a close ecological relationship between raptors, meadow voles, and agricultural fields. Because raptors prey on voles, they prefer agricultural grasslands (Taylor, 1994), and therefore can benefit from proper management of this habitat. The literature reveals two strategies that enhance this predator-prey relationship by increasing the production and predation of meadow voles.

The presence of large numbers of voles requires a well-developed grass habitat. Steele (1977) showed that the population density of meadow voles is correlated with the amount of vegetation per unit area in their habitat. Grassland vegetation is the primary source of food and water for these rodents. Living grasses and litter create a protective cover that appears to define a vole's habitat (Birney et al., 1976). Voles are not found in open habitat unless forced there (Baker and Brooks, 1981). Their reproduction and survival is greater in taller, denser grasses.

The ability of a raptor to prey on a species depends on its ability to see, hear and ultimately capture its prey. Both the amount and structure of vegetation affect a prey's vulnerability and availability for predation. Tall or dense vegetation protects small mammals. The raptor's choice of habitat in which to forage depends more on vegetative cover than on the abundance of prey (Craighead and Craighead, 1956; Wakeley, 1978; Baker and Brooks, 1981); these birds selectively forage where there is the highest probability of capturing prey (Andersen, 1991). Even when prey are scarce, a raptor selects foraging sites with medium to low cover (Craighead and Craighead, 1956). A strategy for increasing the predation of voles would be to reduce the amount of cover that obscures potential prey.

Row and forage crops conceal prey, but birds of prey quickly exploit the removal of that cover during harvest (Young, 1989). Mowing fields or harvesting crops increases their foraging efficiency and ultimately increases their reproductive success. Raptors' preference for short vegetation suggests a compatibility with agriculture.

These two strategies work in opposite directions. Providing more grass to encourage an increase in vole population conflicts directly with reducing vegetation to favor predation. A fallow or old field with grasses and forbs three to four feet tall allows little avian predation, while the closely cropped pasture is unlikely to support any meadow voles. A compromise is needed. A moderate amount of grass would provide an intermediate habitat which, although not optimal in either respect, allows for both production and predation of meadow voles. This middle ground shows promise for management, because the grass height preferred by raptors falls within standard agricultural practices. It is conceivable that with the proper vegetative structure, an agricultural field could attain a sustainable yield, with vole production balancing predation.

Applications

Practical strategies to increase the production and predation of meadow voles can be used within current agricultural systems. A management plan designed to benefit raptors will not be implemented if it is expensive, requires a great deal of labor, or reduces productivity. Farmers and other land managers are most likely to participate in wildlife-oriented management programs whose costs to them are low.

The following practices benefit birds of prey by increasing the number of voles:

- Putting more land into grass provides more places for meadow voles to live. These could be hay fields, pastures, forage crops, fallow fields, or set-asides. Any livestock system based on forages rather than grains or concentrates benefits birds of prey. When highly erodible soils are taken out of tillage, more habitat is created. Therefore, water and soil conservation projects usually are beneficial.
- Cropping grass closely, whether by mowing or grazing, reduces its value for voles, which are likely to abandon grass that is less than four inches high. Mowing at even a slightly greater height or reducing grazing pressure by even a small amount will improve the vegetation's usefulness to voles. For grass kept short, increasing the interval between mowings would benefit voles. If a field is mowed infrequently, mowing during the growing season will allow rapid regeneration of the vegetation.
- Maintaining the noncrop portions of farmland in grass creates habitat. These often are narrow linear strips, such as the margins of crop fields, forest edges, road shoulders, equipment tracks, and erosion control strips. On some farms

this is the only usable habitat. A breeding pair of raptors can thrive if an adequate amount of this habitat exists within their home range (Taylor 1994).

- Providing refuges to which voles can migrate when crops or forages are harvested will allow for quick recolonization when the field regenerates. An unmowed or unharvested strip at the edge or even in the middle of the field will create such refuges. Contour strip cropping creates a similar interspersion of vegetated and open habitat.
- For areas where the timing of mowing is not critical, a mowing regime can be established by alternating mowed and unmowed strips. Only the unmowed strips are cut back at the next mowing. This creates a permanent mix of taller protective cover and shorter, more nutritious grasses (H.H. Obrecht, Refuge Biologist, Patuxent Wildlife Research Center, Laurel, Maryland, personal communication, 1995).
- Although almost any grass or forb can serve as food for meadow voles, the species does better with certain plants such as clover (*Trifolium* spp.) or bluegrass (*Poa* spp.) (Rosenburg, 1992). Succulent and young plants and plants grown under moist conditions support more voles (Taylor, 1994). Warm-season grasses provide a higher quality forage during the hot dry months, which also improves vole reproduction.
- Leaving crop residues on the field, such as with a no-till system, allows voles to move through the fields to better habitat after a crop has been harvested.

The second group of practices that benefit birds of prey make voles more available for predation by raptors:

- Reducing vegetative cover makes it easier for the birds to find and capture prey. This can be done both on large fields and in narrow linear habitats, and applies especially to vegetation more than one foot tall. It can be accomplished by mowing or grazing, but in either case the grass should not be left so short that it is unusable for voles. My empirical observations suggest that a good balance is obtained in the range 6 to 12 inches, but this needs to be tested.
- The selection of plant species also can improve a raptor's access to voles. Choosing either short species of grass to reduce the height of the cover or species that grow in clumps to reduce the density of cover both would benefit birds of prey.
- Although some raptors can hunt on the wing, all can benefit from having hunting perches. The absence of perches is not usually an issue in the linear edge habitats, where trees, fence posts, poles and utility lines can be found. These structures give the bird a vantage point from which to search the surrounding area for prey. Without perches, the area is less likely to be hunted. This is a common

habitat deficiency in large open fields (Reinert, 1984). A single post or pole eight to ten feet above the ground with a two- to three-foot cross "T" is ideal in the center of a medium-sized field (Kays and Dutky, 1995). For larger fields, several poles 100 yards apart will greatly improve the habitat.

Making even one of these management changes would improve raptor habitat. Including several in a farm's overall management plan would have a synergistic effect, greatly shifting the predator-prey relationship to the benefit of raptors.

Benefits and Conflicts

The farmer understandably is concerned about how the meadow vole affects the farm's operation and productivity. In general, meadow voles are compatible with livestock. Any improvement in forage quality or quantity will benefit both voles and livestock. The vole is not a pest of barns or residences. It prefers to have contact with the soil and is unlikely to enter farm buildings. Undoubtedly, the meadow vole competes with livestock for vegetation. The loss should be small, however. With a medium density of 50 voles per acre (Craighead and Craighead, 1956), the total mass of vegetation consumed daily by voles would be about 2.5 kg/acre. If a farmer values wildlife, this may be an acceptable loss of productivity.

The encouragement of raptors and voles may be inappropriate in certain circumstances. For example, raptors might attack free-roaming or unprotected poultry, particularly the young, so that attracting these birds seems unwise. On the other hand, an abundance of accessible meadow voles might offset this hazard, as raptors have shown a preference for these rodents. Meadow voles are incompatible with orchards, pine plantations, nursery operations and strawberry farms. They eat bark and girdle small shrubs and trees, particularly during the winter. Losses and damages to nursery stock can be extensive. In such a case, it would be beneficial to encourage raptor predation with perches and reduced cover, without enhancing vole production (Kays and Dutky, 1995). The problems created by one species in the predator-prey relationship can be minimized by encouraging the other species.

Conclusion

To manage land for the benefit of raptors it is important to understand the ecological relationship of the bird with its key prey species (Taylor, 1994). Much of this information is lacking for meadow voles and northeastern raptors. More study is needed if the strategies I have presented are to be applied effectively. The following questions should be considered:

- How do specific grass heights affect the production of meadow voles?
- How do specific grass heights affect a raptor's access to meadow voles?
- How much predation is possible while maintaining the vole population?

- How many voles are lost during plowing, mowing, or herbicide application?
- How much forage is lost to meadow voles?
- How do the size and spacing of refuges affect repopulation by voles?

The answers to these questions will allow refined management approaches to enhance raptor habitat on farm land.

The practices discussed here show promise for providing birds of prey with habitat. The management approach applies to eleven of twenty-five northeastern birds of prey. Therefore it is likely that a particular practice will benefit many raptor species. Because the practices attempt to improve grasslands, animals other than voles and raptors also will benefit. Grassland raptors already show a preference for agricultural land; management of this land needs only small changes to enhance it for raptor use. The techniques fit with existing farm practices and require little or no extra effort. Agricultural lands represent the largest portion of land area that is intensively managed. The equipment, land, and expertise in vegetation management all are found in one location. These factors suggest that the farmer's efforts will be rewarded.

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Value of Shade Coffee Plantations for Tropical Birds: Landscape and Vegetation Effects

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Introduction: Biodiversity in the Tropics

The plight of tropical forests has commanded worldwide attention, with scientists throughout the world directing their efforts toward it. While our conservation efforts have been consumed by the causes and processes of this forest loss and the resulting rise in species extinctions, the tropical landscape continues to be converted from natural habitats to an agricultural mosaic. In several Latin American countries, including El Salvador, Haiti, and the Dominican Republic, there is essentially no forest—what remains are cattle pastures and agricultural fields (Pimentel et al., 1992; Greenberg and Reaser, 1995). Although a focus on deforestation is imperative for slowing the rate of forest loss and understanding its implications, tropical conservation may benefit from a redirected effort toward alternatives offered by the agricultural ecosystems that remain after forests have disappeared (Pimentel et al., 1992). Finding means by which dominant agricultural ecosystems can harbor high levels of tropical biodiversity and slow the loss of forest species will clearly be essential as anthropogenic habitats continue to dominate the tropical landscape.

Coffee (*Coffea* spp.) is a tropical agricultural crop that may provide such an alternative. It is a dominant feature of the economy and landscape of developing tropical countries. In trade value, it is the second largest globally exchanged commodity for developing countries after petroleum (Wrigley, 1988; Rice, 1993). Moreover, coffee plantations make up 44% of the permanent arable cropland in Latin America (Rice, 1993). Yet compared with other agricultural products, coffee production not only has a surprisingly small impact on tropical biodiversity, but also can provide critical habitat

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for tropical forest organisms where no natural forest vegetation remains. When grown in the traditional manner under a shade canopy, coffee plantations can provide habitat for many organisms typical of forest communities, including insects (Benítez and Perfecto, 1989; Perfecto and Sediles, 1992), mammals (Estrada et al., 1993; 1994), and birds (Wunderle et al., 1990; Wunderle and Latta, 1995).

However, since the early 1980s coffee has been undergoing conversion from shade-managed production to cultivation under full sun, with removal of most or all of the shade canopy (Rice, 1993; Perfecto et al., in press). Coffee, like cacao *(Theobroma cacao)*, is a tropical plant that originally was cultivated under natural shade for sustained viability (Beer, 1987). When grown under sun conditions, however, its yield can be two to three times greater than with shade management, but only for a short time except with costly and intensive use of fertilizers, herbicides, and insecticides (Beer, 1987). There are several reasons that a farmer might convert from a traditional plantation to sun coffee: the demand (however shortsighted) for increased yields; additional revenue from harvesting lumber from the canopy; and the need to combat the coffee rust *roya*, which is thought to proliferate under shade conditions (Rice, 1990; Peck and Bishop, 1992; Perfecto et al., in press). As the large-scale coffee industry overshadows small traditional farmers, and as new strains of coffee are developed that thrive without canopy shade, complete replacement of traditional plantations by sun coffee throughout the tropics is becoming inevitable (Greenberg, 1994). Ultimately, this loss of canopy trees in a "technified" plantation represents a concomitant loss in biodiversity of forest organisms.

While current studies suggest that conservation of tropical biodiversity benefits from shade coffee management, traditional shade coffee plantations vary greatly in habitat characteristics, placement in the tropical agricultural landscape, and their resulting ability to harbor viable populations of many forest species. For example, their canopy may consist of natural forest trees, introduced or mid-successional leguminous vegetation, or alternative crop trees grown for supplemental income. These shade trees vary greatly in size, height, density, amount of shade, and the fruit and flower resources their canopies provide (Weaver and Birdsey, 1986). Moreover, the coffee plants themselves can be cultivated at a wide range of densities and heights.

These variations in habitat characteristics are accompanied by variations in landscape-level features such as plantation size, shape, and configuration. Plantations also differ in their distance from contiguous forests, which may serve as population sources for forest organisms using the coffee habitat, and from other agricultural crops, riparian forests, and other regionally available habitat types. The separate and combined effects of these landscape-level and habitat-level factors require further attention to understand and enhance the potential for coffee cultivation to conserve critical features of the environment.

Understanding how these habitat- and landscape-level variations affect shade coffee plantations' ability to harbor tropical biodiversity is an important step in developing alternative conservation strategies that incorporate agriculture. In this study, we evaluated how several habitat characteristics and landscape-level factors individually and together affect the species richness and abundance of tropical resident and migratory birds in a shade coffee landscape. In doing so, we hoped to understand better the ecological relationships that determine the structure of avian communities in coffee habitats and to suggest alternative management techniques on both habitat and landscape scales that would increase their conservation value.

Study Site and Methods

This study was conducted in shade coffee plantations near Santa Clara, in the western province of Chiriquí, Panamá. Fieldwork was done from 6 January to 3 March 1995, during the height of the dry season in southern Central America. Ten shade coffee plantation study sites were established at various distances from a large contiguous forest park, Parque Internacional La Amistad (PILA). Plantations located further from the park's border were generally at lower elevations (elevational range of plantations, 350 m) and in more fragmented habitats. Focal plantations were representative of the existing variation in shade coffee management in this region: they varied widely in distance from different habitats, connectivity with forest and with other plantations, density and size of the coffee plants, and canopy structure and composition. Panamanian shade coffee plantations in this region typically are managed traditionally, that is, with the principal canopy consisting of remnant forest trees left standing during clearing for coffee cultivation. Unlike other regions of Central America, where leguminous alternative crop trees such as *Inga* are commonly used as coffee canopy (Petit and Greenberg, 1994), only banana (*Musa* spp.) is regularly intercropped with coffee plants in this region.

To determine avian species richness (number of species), abundance (number of individuals) and community composition (which species were present) within the shade coffee plantations, we conducted point counts (Hutto et al., 1986) between 6:30 and 10:00 A.M. at ten points within each plantation. Each census point (100 in total) was visited four times during the two-month study period. All birds seen or heard during the 10-minute sampling period at each point were recorded. Besides noting the presence of individuals and species, we also recorded the height distribution of observed birds and whether the canopy birds were in trees that were fruiting or flowering.

An important conservation aspect of shade coffee plantations is that they can harbor many bird species that normally are forest-dwelling. We therefore established two forest census sites of ten census points each in the PILA forest to characterize the local forest bird communities and to determine how similar they were to those of the coffee plantations. One site was within the forest near the shade coffee border ("forest border" site);

the other was within PILA and represented more interior forest communities ("forest interior" site). The number of species shared with the forest border or forest interior were then used to express quantitatively the similarity of the bird communities in the coffee plantations and the local contiguous forest.

We measured habitat-level characteristics within each circular census plot and averaged across all ten points within each shade coffee plantation. Measurements included the density and size of all coffee plants within 10 m of the census plot's center and the mean height of ten sample plants (one each at 5 m and 10 m from the plot's center in each cardinal compass direction, one at the center, and one at a randomly selected plant). Because variations in how the understory is managed can affect ground-dwelling birds, we estimated to within 10% the fraction of the ground covered by herbaceous vegetation and by leaves. We measured the following canopy variables: mean canopy height; percentage canopy cover, averaged across the four compass directions; size at breast height of all canopy trees within the 25 m radius census circle; and the fruiting or flowering condition of the canopy trees. Vegetation profiles were recorded at ten points within the vegetation circles (one at the center of the circle, one each at 5 m and 10 m from the center in each cardinal compass direction, and one at a randomly selected point within the circular plot). In an effort to describe the overall vegetation structure and diversity of foliage height, we recorded these data as the presence or absence of vegetation at each 1-m height interval.

Shade coffee plantations in the agricultural landscape matrix may be viewed as forest-like habitat islands in an open-field agricultural sea. For example, the distance from contiguous forest or from possible habitat corridors such as riparian areas or fencerows may affect the ability of forest birds to disperse to suitable forest-like habitat provided by shade coffee plantations. Therefore, it may affect the composition of the avian community and the overall conservation value of a given plantation. We therefore measured several landscape-level factors for each of the ten shade coffee plots to determine their relationships with bird variables and to assess the relative importance of landscape factors versus habitat factors. Slope, aspect, and the shortest distance to surrounding habitats (e.g., riparian habitat/water, open field, second growth, and forest) were measured at each census point in each of the compass quadrants (NE, SE, SW, NW). These measures were then averaged across all ten census points to acquire an overall mean for each plantation. Distance to the nearest large contiguous forest (PILA) and the area:perimeter ratio (a measure of habitat configuration) were determined for each shade coffee plot from aerial photos digitized for computer analysis.

To illuminate better the relationship of landscape and vegetation variables to specific bird communities in need of attention, we determined bird abundance and species richness separately for several categories: residents (year-round tropical breeders); migrants (long-distance Neotropical migratory birds); forest birds (birds typically found in forested habitats, based on Rappole et al., 1983, and our own experience); forest migrants; and species shared between the forest interior and forest border. Abundance measures for each plantation were based on the number of individuals recorded inside and outside each 25 m radius census circle, averaged across all four visits and then across all ten census points within that plantation. Species richness for each plantation was the number of species averaged across all ten census points and all four visits to that plantation.

We used simple linear regression to assess bivariate relationships between bird variables and individual habitat or landscape factors. All proportional data first were arcsine transformed to meet parametric test assumptions. We used stepwise and multiple regression to assess the relative contribution of landscape and habitat variables in explaining avian abundance and species richness. Because of the large number of independent landscape and vegetation variables, we first used stepwise regression analysis to generate the significant model-building variables for each dependent bird variable. Once the relevant landscape and habitat level factors that survived the stepwise analysis were determined for each bird variable, we used multiple regression analysis to generate separate multiple regression models describing the relative influence of landscape and habitat level factors on coffee bird communities.

Results and Discussion

Habitat-level factors

Several variables related to the vegetation and habitat structure and composition of the shade coffee plantations were significantly related to avian abundance and species richness. For example, as the extent of canopy cover increased in a plantation, there was a concomitant increase in the abundance of forest-wintering migrants ($p=0.073$, $R^2=0.39$, Fig. 1) and in the number of migrant species that were found in a plantation ($p=0.018$, $R^2=0.58$, Fig. 1). This suggests that shadier sites more closely resemble a forest in vegetation structure or in available resources, and as a result can harbor a greater diversity and abundance of migratory birds. Managing plantations to maintain canopy trees and high levels of shade will increase the carrying capacity of this agricultural habitat for overwintering migratory birds. Growers should be encouraged to limit removal and pruning of these shade trees.

Canopy trees were important for avian communities, not only for vegetational structural diversity, but also for providing alternative food resources. Many bird species observed in the plantations, especially migrant songbirds such as the Northern oriole *(Icterus galbula)* and the Tennessee warbler *(Vermivora peregrina)*, were omnivorous during the dry season, feeding to a large extent on nectar and fruit offered by canopy trees in the shade coffee plantations. Migrant species tended to be more abundant in coffee plantations with higher densities of flowering canopy trees ($p=0.054$, $R^2=0.39$, Fig. 2). Further analysis showed that birds tended to be more abundant in flowering trees than was expected just from availability of those flowering trees (t-test, p=0.093, Fig. 2). Therefore, maintaining a high density of forest canopy trees in a shade coffee plantation may benefit tropical birds not only through additional structural diversity but also by providing important foraging resources. When trees must be removed from a plantation for additional income from lumber, those that do not provide alternative nectar or fruit for wildlife should be removed first, thereby maintaining bird diversity and providing continual forest regeneration through seed dispersal and flower pollination. Further investigations are needed into the potential role that intercropped agricultural trees such as *Inga* and *Musa* (banana) might play in providing alternative nectar resources for some avian species while providing additional income for coffee farmers.

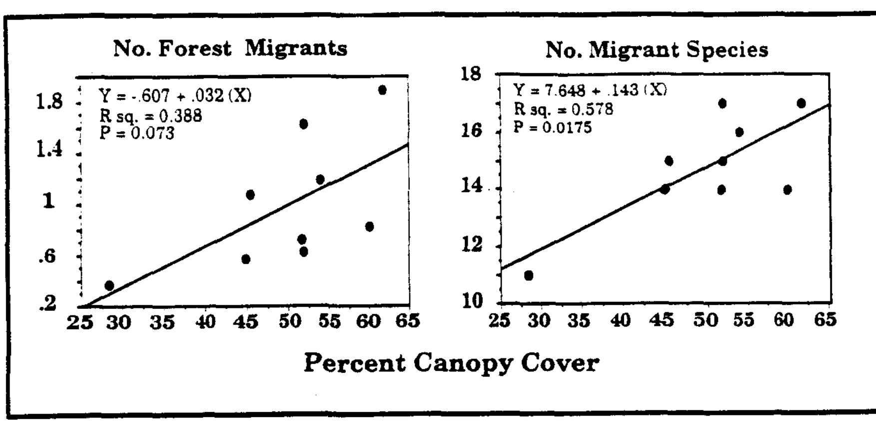

Fig. 1. Relationship between canopy cover and the abundance of forest migrants and richness of migrant species in ten shade coffee plantations in western Panamá.

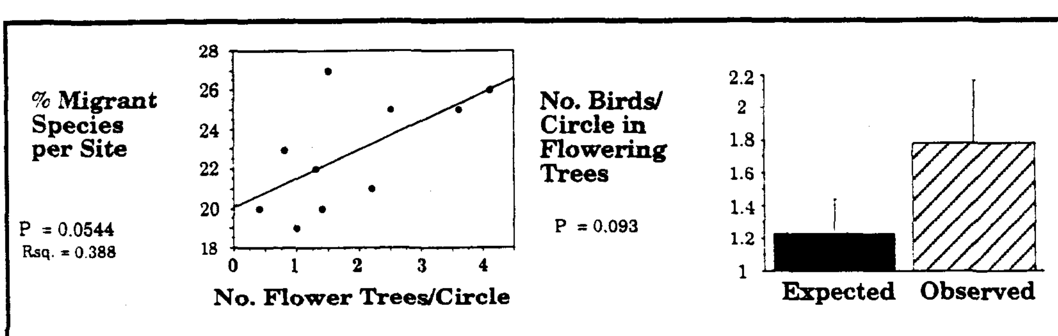

Fig. 2. Relationship of flowering canopy trees to bird communities and abundances in shade coffee plantations. A) The percentage of birds that were migrants in a plantation versus the number of flowering canopy trees. B) Number of birds observed in flowering trees versus the number expected based on availability of flowering trees alone.

Landscape-level factors

The landscape configuration of shade coffee plantations influenced the species richness and abundance of tropical resident and migratory birds. The further the plantation from the contiguous forest (PILA), the lower the number of forest species shared with the forest interior or the forest border plots within the park (forest interior species: $p<0.01$, $R^2=0.64$; forest border species: $p<0.01$, $R^2=0.66$; Fig. 3). These data strongly suggest that shade coffee has maximum conservation value as a multi-use, transitional buffer-zone habitat along the border of protected forest areas, where it can sustain large communities of forest species in an agricultural landscape. Moreover, shade coffee bird communities are more like those of the forest border than the forest interior ($t=7.20$, $p<0.0001$; Fig. 3). Thus, while shade coffee harbors large numbers of forest border species, it is not a full replacement for the forest interior, and enhances wildlife conservation best when integrated with large contiguous forest reserves. When shade coffee plantations in a region must yield to technification, the canopy trees closest to forest reserves should be removed last.

With increasing distance from the forest park, species composition of the study plots changed significantly: not only were forest species less likely to be found, but the fraction of the bird communities consisting of migrants increased ($p<0.01$, $R^2=0.67$; Fig. 4). This relationship probably resulted in part from the decline in tropical forest residents with distance from the forest source population, as well as from the propensity of many overwintering migrant species to occur in secondary and more open habitats in tropical latitudes (Keast and Morton, 1980; Hagan and Johnston, 1992).

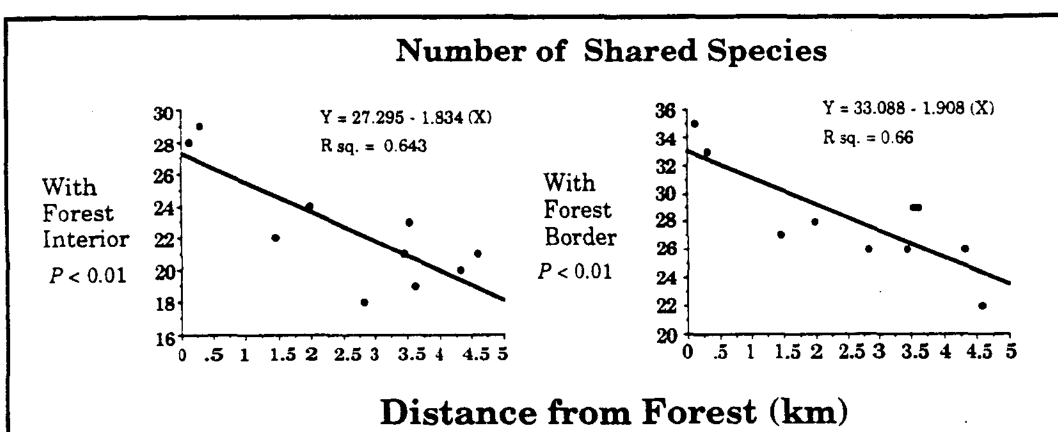

Fig. 3. Change in the number of species shared between the focal shade coffee plantations and the forest interior bird communities or forest border communities, with increasing distance from the contiguous forest, Parque Internacional La Amistad.

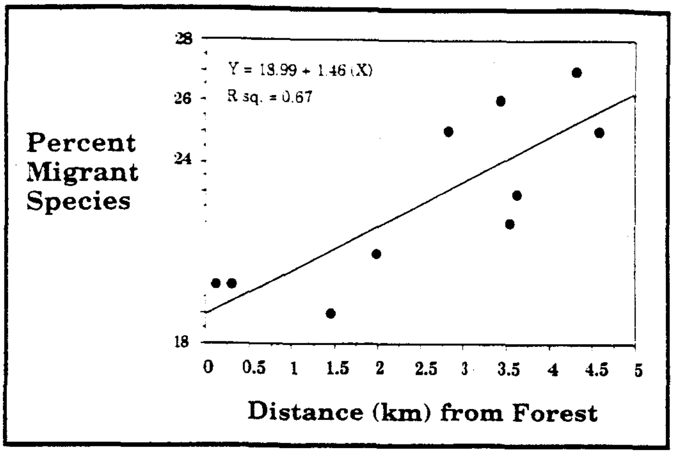

Fig. 4. Change in the percentage of migrant species composing the shade coffee communities as plantations were located further from contiguous forest.

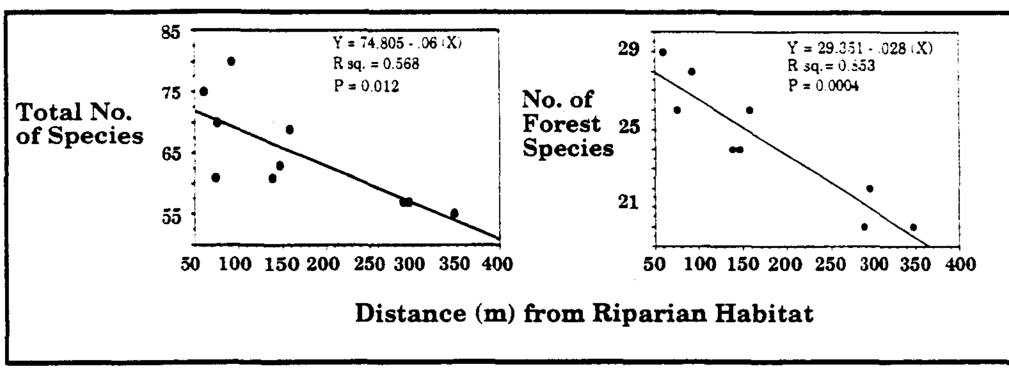

Fig. 5. Total species richness and forest species richness of avian communities in ten shade coffee plantations at varying distances from riparian habitats.

If contiguous forest is a source of forest birds for shade coffee plantations, as suggested by the decline in forest species richness with distance from forest (Fig. 3), we hypothesize that connectivity with forest habitat via dispersal corridors may be important for species richness within coffee plantations. In the coffee landscape of western Panamá, the most likely dispersal corridors are riparian habitats. The regression analysis revealed significant declines in total and forest species richness with increasing distance from riparian habitat (Fig. 5). This suggests the importance of maintaining buffer corridors of forest habitat along river courses to enhance avian dispersal (especially of forest birds) to the forest-like haven of shade coffee plantations. These landscape-level relationships are also evidence that contiguous forest habitat is serving as a source "mainland" for forest birds, for which shade coffee plantations are potential land-bridge islands. Whether these coffee plantations are viable "arks" for declining tropical forest birds or sinks for dispersing populations has yet to be determined.

Relative contribution of landscape and habitat-level factors

Because the enhancement of shade coffee's conservation value may be nullified if a plantation's landscape- and habitat-level factors are opposing each other, we sought to learn which combination of factors at these two levels best explained the individual bird variables. Multiple regression analysis was conducted for each bird parameter on variables selected by stepwise regression from the larger pool of independent measures.

The results of significant multiple regression models are presented in Table 1. In general, landscape and habitat factors both were important in explaining the variation in bird abundance and species richness. The value of shade coffee as a conservation tool to enhance tropical bird biodiversity did not depend solely on habitat-level factors that cause a plantation to approximate forest vegetation. Landscape factors, such as the area of a plantation and its distance from the contiguous forest park, from open habitats, and from riparian areas, all were influential in enhancing the capacity of a plantation to harbor Neotropical migrant species and tropical forest-dwelling birds. When managed with these habitat- and landscape-level factors in consort, shade coffee plantations can provide an important conservation tool in highly managed agricultural landscapes while meeting economic needs.

Conclusions

Coffee cultivation under shade management provides an important opportunity for a tropical crop to enhance the biodiversity of highly disturbed landscapes while simultaneously producing the largest legal export cash crop in the Neotropics. While habitat-level factors such as increased canopy cover and maintenance of flowering canopy trees may increase the number of migrant species and individuals, landscape factors must also be considered in developing and managing shade coffee regions.

Failure to acknowledge the dispersal needs of tropical forest birds from diminishing forest habitats and along riverine corridors means failing to achieve the full potential of shade coffee as a conservation tool. Development funding to coffee regions should encourage maintenance of traditional shade coffee techniques. Coffee cultivation by small farmers and small-farmer cooperatives also should be encouraged, as they are more likely to produce shade coffee than are large corporations that can afford the major chemical inputs typical of sun plantations. Aid from international development organizations also should encourage the reforestation of currently technified plantations with leguminous shade trees to provide farmers with more nutrient-rich soils, soil cover, and less expensive and more sustainable coffee harvests.

Table 1. Significant landscape and habitat variables from multiple regression models explaining bird parameters in shade coffee plantations.

Dependent Variable	Significant Habitat Variable	Habitat p	Significant Landscape Factor	Land-scape p	Overall Model R^2 (p)
Number of migrant species	Vegetation 15-20 m	0.0013	Distance to riparian habitat	0.0014	0.86 (0.001)
Percent migrant species	Number of flowering trees	0.106	Distance to contiguous forest	0.01	0.78 (0.005)
Number of species shared with forest interior			Distance to open habitat	0.043	0.42 (0.043).
Number of species shared with forest border	Vegetation 0-1 m Vegetation 7-8 m Vegetation 8-9 m Vegetation 15-20 m	0.036 0.002 0.011 0.0002	Distance to open habitat	0.076	0.99 (0.0003)
Number of resident species	Vegetation 2-3 m	0.083	Distance to riparian habitat	0.118	0.67 (0.02)
Number of forest species	Vegetation 0-1 m	0.09	Distance to riparian habitat	0.08	0.84 (0.002)
Number of forest migrant species	Vegetation 6-7 m Vegetation 15-20 m Vegetation >20 m	0.023 0.007 0.10			0.89 (0.003)
Total number of species	Vegetation 0-1 m	0.005	Area:perimeter ratio	0.009	0.83 (0.002)
Total number of species inside 25-m radius			Area:perimeter ratio Distance to riparian habitat	0.05 0.066	0.67 (0.02)
Number of migrant individuals	Large canopy trees Number of coffee plants	0.009 0.014			0.82 (0.006)
Number of forest individuals	Vegetation 15-20 m	0.03	Area:perimeter ratio Distance to riparian habitat	0.0005 0.005	0.95 (0.0003)
Number of forest migrant individuals	Vegetation 15-20 m	0.06	Area:perimeter ratio	0.02	0.71 (0.013)

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Environmental, Economic, and Social Benefits of Feeding Livestock on Well-Managed Pasture

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Introduction: Trends in Dairying

Encouraged by tax policies, low-interest loans, advertising, and professional advice, during the 1970s many farmers incurred large debts by investing heavily in machinery and facilities and by expanding tilled crops into previously uncultivated erodible land. They did so to take advantage of high crop and milk prices, but the promise of high profits and low labor demand did not hold true. From the late 1970s to the late 1980s, commodity prices (adjusted for increases in the prices farmers paid for production inputs) dropped by about one-fourth, and farm prosperity turned into economic recession (U.S. Department of Agriculture, 1990). As a result, farmers, especially dairy farmers, are caught in a cost-price squeeze, with their profit margins greatly reduced by both higher operating costs and lower prices for their products (Murphy et al., 1986). Dairy farmers currently receive about $0.27 per kg of milk, the same price they received in 1978. Besides the financial fiasco, farmers have realized that "labor-saving" machinery does not run by itself, and that it breaks down and rusts away.

The high debt load and low profit margin of confinement dairying illustrates a situation that damages our society, country, and Earth. It causes farmers to milk more cows to spread production costs, feed more supplements to produce more milk, and grow more corn and other tilled crops on erodible land to feed more cows. Feeding too many cows on too little land means that excessive amounts of phosphorus (P) and nitrogen (N) are brought onto the farm in feed and fertilizer, and leave it as manure runoff and nutrient leaching. Tilling erodible land results in soil erosion and the movement of nutrients, pesticides, and sediments to surface water, making conventional agriculture the largest single nonpoint source of water pollutants (National Research Council, 1989). Removing forests or perennial grassland covers to produce tilled crops with little return of crop residues puts CO_2 into the atmosphere, possibly contributing to global warming (Lal et al., 1995).

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The work, debt load and stress associated with high-input, high-capital, confined livestock production cause many people to quit farming, and make it less attractive to farm children, who look for other ways to make a living. Having fewer farmers on the land in turn causes serious social problems because of deteriorating rural communities and landscapes.

Vermont: An Example of Problems Resulting from Conventional Agriculture

Among the most serious concerns of Vermonters is the health of Lake Champlain, which is threatened by excessive P input (Lake Champlain Basin Program, 1994). The total annual P load to Lake Champlain is estimated at 650 t (metric tons). Of this, 450 t (71%), comes from nonpoint sources, including 300 t from agriculture. The 1,726 Vermont farms in the Lake Champlain Basin contribute 190 t of P per year to the lake. Total annual P inputs to Lake Champlain must be reduced by 200 t (30%) to reach the water quality goal agreed upon by New York (recently reneged), Vermont, and Quebec in 1993 (Lake Champlain Basin Program, 1994). Most Vermont dairy farmers unnecessarily feed year-round in confinement; to feed the confined cows, they produce tilled crops on unsuitable, erodible land. Clearly, these practices must change.

Another symptom of problems in conventional agriculture is that since 1947 the number of dairy farms in Vermont decreased 80.5%, from 11,206 to 2,187 in 1994. During 1984-1994, an average of 103 farms went out of business each year, a rate of decline 60% greater than in the previous decade (Vermont Department of Agriculture, 1994).

This alarming loss of farms is resulting in deterioration of rural communities. As small farmers sell out to increasingly larger farmers, town businesses have discovered that a large population of small farmers spends more in town businesses than do a few large farmers. Every time a farm goes out of business, the rural economy and landscape suffer. About 45,000 jobs in Vermont are directly linked to agriculture. Vermonters are learning that condominiums, abandoned scrub brush fields and dying towns are sorry replacements for cows, open pastures, and vibrant communities (Light and Morrissette, 1991)

The loss of Vermont dairy farms has occurred despite successful efforts by university researchers and Extension personnel to help farmers increase milk production per cow. Unfortunately, as production per cow increases, debt and labor demand per cow also increase, resulting in spiraling financial and emotional stress and degradation of rural communities and the environment.

Socioeconomic forces shaped current conventional agriculture in Vermont and elsewhere. In promoting highly mechanized practices as more profitable and labor-saving, effects on the soil and other biological consequences were ignored and land stewardship discouraged, resulting in farming practices that severely damage the environment. The current economic problems of conventional agriculture are inflicting more damage to farm families and the environment. The divorce and suicide rate among farmers is among the highest of any group, a symptom of their financial and work-related stresses (Davidson, 1990). As farm families struggle to stay together and survive financially, land stewardship suffers and environmental degradation increases (Lal et al., 1995)

A Solution

A sustainable rural culture requires not only that we fix what is wrong with conventional agriculture—soil erosion, environmental pollution, low farm profitability, and so forth—but also that we improve the farm family's quality of life. An integrated approach to these problems is needed, with improved quality of life a strong incentive for farmers to change to less polluting practices.

Dairying is a prime example of an agricultural enterprise where significant positive changes can be made easily, greatly benefiting farmers, society, and the environment. Feed is the area where the greatest savings are possible, because it accounts for up to 60% of total dairy production costs. One way to reduce both feeding costs and environmental pollution is to make better use of permanent pastureland, which currently is greatly undervalued and underutilized. It is an enormous resource that covers 236,000 ha in Vermont, and 3.6 million ha in the 12-state Northeast region (U.S. Department of Agriculture, 1974).

Management-intensive grazing (also known as rational, controlled, intensive rotational, prescribed, or short duration grazing) is an advanced method of controlling the frequency and intensity of grazing to improve livestock feeding on pasture. It was developed in France (Voisin, 1959) and later refined by farmers and researchers in New Zealand and elsewhere (Murphy, 1994). Although it has been a common practice in other countries for 35 years, it is an innovative alternative technology for American farmers.

Better use of the pasture resource helps solve the problems of low profitability and excessive work load, especially for dairy farmers. Feeding cows and other livestock on pasture can cost only one-sixth as much as feeding them in confinement (Semple, 1970). The benefits of pasture feeding compared with confinement include:

- decreased costs for grain and concentrate supplements, cropping, harvesting, storage, feeding, and manure handling
- lower machinery use and repairs, and saving in fuel (25 to 40%)
- lower hired labor requirements
- sale of surplus feed or lower purchases of feed
- lower veterinary and breeding costs because cows on pasture are healthier and have better reproductive performance than cows in year-round confinement
- longer productive life of the cows

- premium price for high-quality milk (low somatic cell count) from pastured cows (Semple, 1970; Murphy et al., 1986; Condon and Ashley, 1992; Rayburn, 1993; Smith, 1994; J. Brigham, J. Brown, M. Eastman, M. Hanson, J. Rutter [dairy farmers], personal communications, 1990-1994).

What Needs to Be Done?

Although we know how to manage pastures better than we did several years ago, in the U.S. we have just begun to learn about managing livestock on pasture. Compared with other countries, we have put only a small investment and effort into developing and using our huge pasture resource. The potential for low-input, highly profitable, sustained livestock production on permanent pasture is enormous.

To achieve that potential, we must increase our pasture and livestock management research and outreach efforts. These must be guided by farmers and must respond to them. Otherwise, researchers and Extension personnel can easily spend publicly supported time and resources to answer questions that no one is asking.

The shift to low capital, management-intensive, highly profitable pasture-based livestock production is already occurring in Vermont and elsewhere. However, the transition may not be rapid enough to save most remaining dairy farms. Discarding an old way and putting a new one into practice is emotionally and mentally painful, and most people hesitate to do it, even if the old way threatens their livelihood (Nation, 1992). At least they know the old way and its consequences; the new is unknown, and if it fails, they could be out of business. Compounding the difficulty is that when farmers attempt to change from confinement feeding to a pasture-based enterprise, they are discouraged from doing so by most people that they have contact with, including their neighbors, veterinarian, artificial inseminator, milk hauler, feed dealer, and machinery and supplies salesmen. Farmers making the change need support from like-minded people who know that it is possible and that it clearly is beneficial.

In addition, technical help is needed to enhance farmers' ability to productively use a more management-intensive pasture-based system. Unfortunately, just when we need more Extension agents who are highly trained to help farmers make this change, Extension funding for agriculture has been reduced.

Vermont's Response to the Problems

Responding to the need to spread management-intensive grazing among dairy and other livestock farmers, we developed a Pasture User Support Group Network, beginning with one Pasture Management Advisor and 25 farmers in 1992, in cooperation with Extension agents. This program is part of a larger project to revitalize rural communities, called Environmental Programs In Communities, funded by the W.K. Kellogg Foundation, with additional funding from the Kellogg Foundation and the USDA

Sustainable Agriculture Research and Education program, by 1994-95 we had expanded to four Pasture Management Advisors working closely with 80 farmers in seven Pasture User Support Groups located in nine counties. This year (1995-1996), because of decreased funding, our program involves only 2.5 (full-time equivalent) advisors, 45 farmers, four support groups, and seven counties.

Practical information about proper pasture management, supplementation of dairy cows on pasture, and the economics of incorporating well-managed pasture into farm feeding programs is being developed and shared by farmers through the Network. During the grazing season, Pasture Management Advisors visit each farm at least once every three weeks. They walk the pasture with the farmer, together learning about all aspects of grazing management with cows and other livestock.

Besides these frequent farm visits, once a month each group (including farmers, Extension agents, the advisor, personnel from the USDA Natural Resources Conservation Service and Farm Service Agency, and anyone else who is interested) meet for a pasture walk on a different group member's farm (42 walks on 42 different farms and 30 winter meetings during 1994-95). They discuss pasture feeding of dairy cows and other livestock and learn about pasture management from each other's shared experiences. During the off-season, monthly meetings are held at Extension offices. Other pasture management outreach activities include conferences, radio and television programs, videos, a monthly grazing management newsletter, and popular press articles.

A recent Kellogg Foundation evaluation of our Pasture User Support Group Network stated:

> Sustainable agriculture is a vital part of the future of rural Vermont. While sustainable agriculture has been endorsed by many organizations, including the University of Vermont, there has been little substance behind the endorsement. The Pasture User Support Group Network goes beyond talk, actually implementing an innovative program on real farms run by real farmers. When asked about the most important part of the pasture program, most participating farmers talked about quality-of-life improvements rather than herd health, grain bills, cash flow, or their bottom line. The program serves as a model of grassroots diffusion of technology rather than the more traditional top-down approach. (Brighton, 1994)

Environmental Benefits

Prevented or reduced nonpoint-source pollution

Prevention or reduction of nonpoint-source pollution (N, P, pesticides, and sediment) is an additional benefit of management-intensive grazing. Farmers feeding their cows on well-managed pastureland often grow less corn and other tilled crops (perhaps none), and purchase less pesticides, N and P fertilizer, and feed supplements. Substituting permanent pasture for tilled crops can decrease soil erosion, pollution of surface waters, and atmospheric CO_2 (Lal et al., 1995). From information we obtained from farmers, we estimate that for each dairy cow fed for 6 months on intensively managed pasture, about 6.8 kg less N, 16.5 kg less P, and 0.3 kg less herbicide is brought onto the farm because of reduced row cropping and feed supplementation.

Reduction of soil erosion and atmospheric carbon dioxide

A major goal of the nationwide Conservation Reserve Program (CRP) is to reduce water and wind erosion by establishing perennial grasses and legumes on 18 million ha of highly erodible and environmentally sensitive cropland that has been under cultivation. The benefits of perennial grassland are well known, especially the great reduction in soil erosion and the increase in soil organic matter (Cambardella and Elliot, 1992; Rayburn, 1993).

Pasture-based farms burn 25 to 40% less fuel than farms that feed confined animals using forage from tilled crops. They therefore release less CO_2 to the atmosphere, reducing agriculture's contribution to global warming. Grassland soils also can decrease atmospheric CO_2 by sequestering more C than tilled soils, even more than a temperate forest soil (Rayburn, 1993; Greenland, 1995; Lal et al., 1995).

Changing tilled cropland to permanent pastureland is a way of reducing atmospheric CO_2. Part of the CO_2 that perennial grasses and legumes capture through photosynthesis is stored as food reserves in roots and rhizomes. Some of these reserves are translocated to new shoots and leaves, but over time carbohydrate accumulates in the roots. The amount of root material may be three times greater than shoot production (Gebhart, 1993).

CRP grasslands are gaining soil C at an average annual rate of 1100 kg/ha. This suggests that the land enrolled in CRP is recovering about 45% of the 38 million t of C released annually from U.S. agricultural activities (Gebhart, 1993).

In intensively managed pastureland, the repeated cycle of root formation and carbohydrate translocation as plants are grazed and regrow (six or more cycles per growing season) can remove and sequester considerably more CO_2 from the atmosphere than in unused CRP grasslands, where plants regrow only once per growing season. For example, an intensively managed pasture that produces 9 t/ha of dry forage each year also produces about 27 t/ha of carbon-rich root and rhizome material in the soil.

This translates into a significant amount of CO_2 removed from the atmosphere. Permanent pastureland contains an average of 7.2% organic matter in the top 15 to 20 cm of soil, about twice the typical level in a tilled soil. In this layer, each 1% of soil organic matter content corresponds to 22 t/ha of organic matter. Thus, the 3.6% higher organic matter content of pasture soil compared with tilled soils translates into an additional 80 t/ha of organic matter, or 47 t/ha of C (the ratio of organic matter to C is about 1.7). This means that converting 1 ha of land from tilled crops to permanent pasture is equivalent to removing about 174 t of atmospheric CO_2 (Rayburn, 1993).

Incentives for Adoption of Alternative Practices

Just as socioeconomic forces encouraged farmers to use polluting agricultural practices, socioeconomic forces also can be harnessed to lead farmers to new practices that reduce or prevent damage to the environment. Grazing management techniques that have been proven to be highly profitable and labor-saving can be the incentive for farmers to change to livestock production based on permanent pasture as a way of improving the quality of life for their families.

Social benefits

The experiences of farmers in the Pasture User Support Groups show that society can benefit in several ways from widespread feeding of dairy cows and other livestock on well-managed pasture, and from the resulting improvement in the quality of life for the farm family. With more farms remaining in business because of the higher profitability and reduced workload, and with more farm children remaining in farming because it has become a desirable occupation again, the rural landscape will be maintained and rural communities and economies will be rejuvenated. As farm profitability increases because of reduced feed costs, farmers diversify their spending. Rather than spending most of their money on feed from large companies that usually remove their earnings from local communities and employ few local people, farmers instead spend more at local businesses such as retail stores, restaurants, travel agencies, vehicle dealerships, and recreational facilities.

One farm family's experience exemplifies what typically happens when a farmer changes from confinement to pasture-based dairying. For 17 years this family fed cows in confinement on corn and alfalfa produced on their farm in northern Vermont, which has 200 acres of nearly level land. Despite all the hard work by the farmer, his wife, and their son, and despite the wife's off-farm job, they were sliding into bankruptcy. Because of the hard work, financial problems and stress, the son decided not to continue farming, and in 1990 entered the University of Vermont to study psychology. In 1992, the family learned about the possibility of increasing profitability by feeding cows on well-managed pasture. In 1993 they joined a Pasture User Support Group and began receiving assistance from a Pasture Management Advisor. They stopped growing corn, sold all their corn production equipment, and seeded the entire farm to perennial grasses and legumes. By the end of 1994 their situation had improved so dramatically that the son decided to return to the farm; in spring 1995 he graduated, married, and bought a nearby house, and now farms with the parents. The farm's development rights were purchased in 1995 by the Vermont Land Trust, thereby conserving it forever as farmland.

When the family has paid off all the remaining debt that had accumulated, the farmer's wife plans to quit her off-farm job.

Economic benefits for farmers

Feeding livestock on well-managed pasture is more profitable because it is more efficient than confinement feeding in converting solar energy into a marketable product. Management-intensive grazing inexpensively produces large amounts of high-quality forage. This means that less grain supplement, silage, and hay must be grown or purchased. Since less of these are fed, less labor is needed. It takes two to three times more labor to feed the large amount of silage, hay, and grain supplements needed with confinement than to feed the smaller amounts needed with management-intensive grazing.

Other benefits include the reduction in labor for manure handling and the decrease in bedding expense, because animals are confined less when grazing. Similarly, less cropland must be planted, fertilized, protected from pests, harvested, and stored; this saves labor, fuel, seed, chemicals, machinery use and repair, and electricity. Decreased cropping also means less soil erosion and water pollution. However, our society still does not place a monetary value on these, so they are not included in economic analyses.

Additional benefits include improved herd management because the animals can be observed more closely when they are moving about freely as they go to pasture. Herd health generally improves. Both of these can save veterinary expenses and lead to higher conception rate, production, and longevity. On dairy farms, milk quality may improve because cows and their milk are cleaner when they graze on well-managed pasture, resulting in a premium price.

These factors all contribute to the dramatic increase in net farm income. The following are three examples of the more than 120 farms that increased their profitability since 1992 by participating in Pasture User Support Groups, mainly through lower feed costs. The gains are especially impressive when compared with the average profit of $44 per cow in the Northeast (AGRIFAX, 1993).

A farm with a 90-cow Holstein herd (Farm A, Table 1) showed an increase in net farm income per cow of 39%, from $495 in 1992, when the cows were being switched from year-round confinement to grazing on land that had been hay fields, to $690 in 1994, when cows were fed for more than 6 months on intensively managed, well-developed pasture. This herd has an average annual milk production of 9,534 kg per cow, which shows that high production and high profitability are achievable with cows fed on well-managed pasture. This farmer could reduce the herd while maintaining the same net farm income; his return on investment was 34.6% in 1994.

A farm with a small Jersey herd participating in our program (Farm B, Table 1) improved its pasture management to cut production costs, while increasing the land's capability to produce high-quality feed. This change increased net farm income more

Table 1. Financial analysis summaries of representative Vermont farms that switched to pasture-based dairying from year-round confinement.

	1990	1991	1992	1993	1994
Farm A					
Total milk cows			91	70	77
Milk sold per cow (kg)			8,777	10,085	9,039
Price received ($/kg)			0.29	0.28	0.30
Direct cost ($/kg)			0.23	0.24	0.23
Net margin[1] ($/kg)			0.06	0.04	0.07
Net farm income[1] ($)			45,084	47,977	53,131
Net farm income per cow ($)			495	685	690
Net farm income per worker ($)			12,881	13,708	15,180
Milk sold per worker (kg)			228,192	201,694	198,852
Net farm income/Cost of purchased feed			0.79	0.97	1.21
Feed cost/Milk income			0.25	0.25	0.21
Feed cost ($/kg milk)			0.07	0.07	0.06
Farm B					
Total milk cows		22	22	26	28
Milk sold per cow (kg)		5,944	6,455	6,114	6,556
Price received ($/kg)		0.32	0.33	0.32	0.33
Direct cost ($/kg)		0.27	0.26	0.26	0.22
Net margin ($/kg)		0.05	0.07	0.06	0.11
Net farm income ($)		6,832	11,406	10,514	22,095
Net farm income per cow ($)		311	518	404	789
Net farm income per worker ($)		3,416	5,703	5,257	12,548
Milk sold per worker (kg)		65,387	71,005	79,490	91,783
Net farm income/Cost of purchased feed		0.38	0.70	0.60	1.30
Feed cost/Milk income		0.43	0.35	0.35	0.28
Feed cost ($/kg milk)		0.14	0.11	0.11	0.09
Farm C					
Total milk cows	40	46	46	58	68
Milk sold per cow (kg)	6,894	7,436	9,131	6,498	5,283
Price received ($/kg)	0.34	0.29	0.27	0.27	0.29
Direct cost ($/kg)	0.33	0.27	0.25	0.25	0.27
Net margin $/kg)	0.01	0.02	0.02	0.02	0.02
Net farm income ($)	-491	2,203	7,881	10,841	23,906
Net farm income per cow ($)	-12	48	171	187	352
Net farm income per worker ($)	-246	1,102	2,627	3,614	7,969
Milk sold per worker (kg)	137,888	171,030	140,013	125,620	119,784
Net farm income/Cost of purchased feed	-0.01	0.04	0.13	0.25	0.80
Feed cost/Milk income	0.60	0.58	0.53	0.41	0.28
Feed cost ($/kg milk)	0.20	0.17	0.14	0.11	0.08

[1]Net margin = cash margin before depreciation; net farm income includes depreciation.

than threefold, from $6,832 in 1991, when cows grazed under poor management and were fed large amounts of forage and supplements in the barn during the grazing season, to $22,095 in 1994, with no tillage, pesticides, or chemical fertilizer.

Another farm (Farm C, Table 1) went from a net loss of $12 per cow when the cows were fed year-round in confinement in 1990, to a net profit of $352 per cow in 1994, when they were fed on intensively managed pasture for more than 6 months per year. The farmer received $0.34 per kg of milk sold in 1990, but feed costs that year were $0.20 per kg of milk, contributing to the net loss of $12 per cow. In 1994, the farmer received only $0.29 per kg of milk, but feed costs, including the 6 months of well-managed pasturing, were only $0.08/kg. This resulted in the dramatic increase in net farm income per cow.

Conclusion

Management-intensive grazing has proved to be a simple way for farmers to take existing pastures that now are largely wasted, and use them for feeding livestock to cut production costs and reduce labor needs. These benefits can enhance the quality of farm family life and provide an important incentive for farmers to use permanent pasture-based livestock production, with all its environmental, economic, and social benefits.

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Enhancement of Communities with Pasture-Based Dairy Production Systems

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Introduction: Problems in Animal Agriculture

Animal agriculture in the United States is facing several challenges as we approach the end of the century. Movement toward a global economy with fewer trade barriers will continue to affect the basic structure of agriculture. In one sense, efficient production systems will be needed to keep animal products competitive and available to a growing world population. However, growing public concerns about the environment have resulted in tighter regulations on the use of pesticides and the handling of nutrients of both organic and inorganic origin. Besides global concerns about converting various types of natural areas to agricultural production, society's concerns about noise, flies, odor, and water quality have begun to limit some farming enterprises even in traditional agricultural areas.

In North Carolina, the Environmental Management Commission adopted a water quality nondischarge rule for livestock and poultry farms above specified sizes (for example, 100 head of cattle; Barker et al., 1994). This rule means that farms above the threshold must provide certification of an animal waste management plan to the Division of Environmental Management by December 31, 1997. Certification poses tough choices for many producers. Although some are in a reasonably good position to comply, others will have to invest sizable amounts to meet the requirements or will be forced out of business. Preliminary surveys among dairy producers suggest that up to one-third will elect to explore other opportunities, given the pressures of age, proximity to expanding communities, low profits, and so forth. Such exits are likely despite the increased support for improving waste management facilities through state cost-sharing.

Because of high densities of livestock in many counties in North Carolina, particularly in areas of concentrated swine and poultry production, animal wastes already

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exceed the county's total crop needs for nitrogen (N) in 3 counties, phosphorus (P) in 18, zinc in 28, and copper in 20 (Barker and Zublena, 1995). In some areas, potentially toxic concentrations of minor nutrients are a concern. The challenges facing animal industries will require creative alternatives that can maintain economic viability and still meet society's demands for environmental sustainability.

The number of dairy farms in North Carolina has declined by 40% in the past decade. External pressures are expected to reduce the number further, threatening the stability of local production of fresh milk. The purpose of this paper is to challenge conventional dairy production by proposing alternative strategies that offer competitive production costs, favorable environmental consequences, and a positive impact on the community at large.

The Concept

A collective vision is being developed of new seasonal, pasture-based dairy farms in eastern North Carolina. Agriculture in this area historically has depended on tobacco, field crops, and recently, swine. All these enterprises are under pressure for various reasons: more restrictions on the use and advertising of tobacco; soil loss and petrochemical use in conventional cropping systems; and nutrient management and odor concerns with further expansion of swine enterprises.

For rural communities to remain attractive for a variety of local businesses, appropriate alternative agricultural enterprises are needed. North Carolina has a long forage growing season, and its eastern counties have productive land available under less pressure from urban expansion than other areas of the state. Therefore, the use of a productive ruminant species such as the dairy cow in a pasture-based system seems worthy of investigation.

The Case for Pasture-Based, Seasonal Dairies

Economic and production considerations

Milk prices are determined at the national level; little can be done to raise the price received by local farmers. Therefore, increased profitability and competitiveness depend on reducing the cost of production. Cash costs for feed consume from 23 to 52% of gross income in conventional dairies (U.S. Department of Agriculture, 1995). Even this figure understates the economic importance of the feeding program, because it also crucially affects reproductive performance and milk yield.

In controlled studies, well-managed pasture provided high quality, highly digestible forage that competed well with conserved forage in dairy cattle rations (Conrad et al., 1981; Rakes et al., 1992). Butler and Cohn (1993) summarized case studies from several states showing that rotational grazing management reduced average annual feed costs per cow by 5 to 40%. Many of the farms studied used pasture primarily as a supplemental forage or only for short periods in the year.

Objective evaluations have not been done of extensive use of pasture in our region. In a long-term study in progress in North Carolina, costs and returns for spring- and fall-calving grazing herds will be compared with those of similar groups fed total mixed rations in confinement (Washburn et al., 1994). Key questions remain regarding appropriate stored forage and grain supplementation to optimize farm productivity and profitability with grazing. Also, the proportions of various pasture species and the choice of calving season will affect optimal production. Principles of well-managed intensive grazing as practiced in other countries and other areas of this country hold great potential for reducing feed costs, but the savings should not be assumed to be automatic until these principles are properly integrated into systems adapted to the local environment.

Restricting calving to a short season can provide special opportunities for family and part-time farmers. With year-round calving, most chores must be done every day. In contrast, seasonal calving allows the whole herd to be dry for a few weeks, which reduces the daily workload. The combination of seasonal production and the reduced time required for planting, harvesting, and feeding makes a grazing system more attractive from the viewpoint of family labor. Whether seasonal production will be successful depends on several factors, especially reproductive efficiency (Washburn, 1991).

A five-year demonstration in Ohio with rotational grazing and spring calving showed that culling for reasons other than low production (mostly reproductive failure) was 40% in the first year, but decreased to 23, 22, 3, and 12% in subsequent years (Zartman and Shoemaker, 1994). In the current study in North Carolina, preliminary data from the first breeding season (April-June) also show high culling for both grazing (48%) and confined cows (32%) (Benson et al., 1995). Reproductive failure was the major reason for culling in both groups, with mastitis also a factor with confinement (8%). Obviously, continued high culling rates would be undesirable and would make it difficult for producers to maintain productive herds. Summer heat stress in North Carolina also will limit the opportunity for rebreeding. Additional questions about seasonal production include effects on milk marketing and cash-flow patterns.

Environmental considerations

In discussing dairy farming styles in the Netherlands, van der Ploeg (1994) pointed out that "economical farmers" who use low levels of external inputs and have comparatively high input-output efficiency are more sustainable than others, and have lower losses of minerals and less environmental pressure. The "economical" farming style depends more on on-farm production of cattle feeds, a principle consistent with effective rotational grazing systems.

Knook (1995) used estimates of Van Horn (1995) for confinement dairies and a grassland management model of Van de Ven (1992) to project N and P cycles for the grazing and confinement systems being studied in North Carolina. Each system had about 72 cows and 76 acres. The analysis accounted only for the lactating portion of the year (305 days for each seasonal group). The analysis of the confinement systems included calculations of losses during solids separation, lagoon storage, and field application. For pastured cows, an estimated 29% of the manure and urine (from milking, holding, and feeding areas) would need to be stored before application to pasture, while 71% would be distributed on pastures directly by cows. Under these assumptions, the predicted total loss of N would be 22% lower for pastured cows than for confined cows, with negligible surface runoff, 34% less leaching, and 46% less volatilization and losses of ammonia from the lagoon. In the pasture system, about 30% of N loss was predicted to occur via the environmentally benign process of denitrification, with N_2 the primary product.

The pasture-based dairy also was expected to lose less P, with the P pool in equilibrium, while P would probably accumulate on cropland in the confinement system (Knook, 1995). Accumulation of P in some areas in North Carolina is viewed as a threat to the long-term sustainability of animal agriculture. Use of a pasture-based feeding system, with supplemental feeding adjusted to minimize the excretion of sensitive nutrients (Tamminga, 1992), should effectively address this issue.

A major potential advantage of pasture-based dairies includes their acceptance by neighbors. Although people often complain vociferously about odors associated with animal waste applications from storage lagoons, pesticide applications to adjacent crop fields, or noise from farm equipment operating early in the morning or late at night, the same people are likely to welcome the pastoral scene of dairy cows grazing in pastures across their back fences.

Community considerations

There are several reasons to expect pasture-based dairy farms to contribute to agricultural and community stability. Local small businesses are more likely to survive when independent farms are functioning effectively in the community. The farms would benefit farm-related businesses directly and benefit general and service-oriented businesses indirectly by contributing to a stable local economy.

Pasture-based dairies also can vary in size. Some can be part-time enterprises where some family members work off the farm or have other farm enterprises to provide income. These would keep the character of the traditional "family farm." Others could be much larger, with up to several hundred cows, depending on available land. Several families could manage larger herds cooperatively or hire additional workers from the local community.

Pasture-based dairies near both small and large communities can foster an understanding of how human society is connected with plant and animal systems. In recent years, fewer and fewer people have access to or understanding of agriculture in general, and of animal agriculture in particular. Teachers in North Carolina are excited about recent programs such as *Ag in the Classroom*, *Farm Animal Days* and *Scientist-Teacher Partnerships*, which bring animal agriculture to students through classroom activities and field trips. Pasture-based dairies would be attractive and effective field laboratories for our schools. Dairy producers also could host tours for local civic clubs, providing insights on agricultural production.

Many areas of North Carolina have a rich local history and a growing tourism industry. These will be enhanced by the aesthetic value of dairy cows grazing in lush green paddocks. Bed-and-breakfasts and dairy farm vacations can be planned and promoted along with other tourism activities, thereby adding to both farm and community income. With millions of people in this country removed from agriculture by a generation or more, such ventures could be very popular. Folks who spent part of their early years on farms may have an urge to reclaim a farm connection or to provide such an experience for their children. Others with little or no farm recollection may find the contrast to conventional vacation options very attractive.

Local governing bodies might consider special arrangements to encourage pasture-based dairies to locate in their communities. These could include particular zoned areas to allow environmentally favorable agriculture to compete successfully even where land prices and taxes otherwise would be too high. Further, larger incorporated communities could provide long-term leases of public land to dairy producers as a novel way to maintain viable green space and allow the community to understand better the interrelationships between human society and animal agriculture. With a dairy located within city limits, hiking trails and border areas for picnic shelters and wildlife could be incorporated while allowing freedom of movement of cows to and from grazing paddocks and milking facilities. Such an innovative park system should make those communities attractive for many types of businesses and industries, because people would want to live in or near them.

Challenges and Limitations

Conceptually, establishment of pasture-based dairy farms is an exciting alternative to other agricultural and nonagricultural uses of land in many areas. This does not imply that answers are available for every possible problem with such systems. Data are needed to help define optimal systems. What equipment is appropriate for larger and smaller dairy units? What other enterprises are good complements to pasture-based dairies? How do supplementary feeding needs, milk production, and reproductive efficiency vary with environmental and economic conditions?

We can get approximate answers to some of these questions by using existing data in computer simulations, but for developing functional farm units it also is important to have observations from private farms and from whole-farm systems such as at North Carolina's Center for Environmental Farming Systems (Mueller et al., 1995). Such data will be critical for establishing the credibility of a pasture-based dairy enterprise among farmers, agricultural lenders, and community leaders in areas that traditionally have not had dairying. As van der Ploeg (1994) has observed: "In the search for sustainable animal production, *the empirical study of promising styles and practices* is becoming crucial" (emphasis in original).

In many areas, escalating land costs around expanding communities will require innovative policies to allow pasture-based dairies and other agricultural enterprises to compete. This will require public recognition of the importance of the community's connections to agriculture. It also will require that producers allow their farms to serve the public beyond production of food per se.

Summary

A collective vision of seasonal, pasture-based dairy farms is being developed in North Carolina. These can be economical, environmentally sound, and aesthetically pleasing businesses that benefit both rural and urban areas. Pasture-based dairy farms can help kindle a sense of community and provide opportunities for people who do not have agricultural backgrounds to appreciate and understand better the contributions of animal agriculture to society. Observational and controlled data are needed to provide a sound basis for developing such enterprises in North Carolina and elsewhere.

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The Potential of Dairy Grazing to Protect Agricultural Land Uses and Environmental Quality in Rural and Urban Settings

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Introduction

Since the mid 1980s there has been considerable interest in alternative farming systems that are both economically profitable and environmentally sound. Farmers and researchers throughout the country have been working together to develop and evaluate such systems. The concept of agricultural sustainability is becoming increasingly accepted, with both state and federal governments providing support to universities, groups and individuals for sustainable agriculture research.

Of the new production systems that have emerged and are currently being tested, grass-based livestock systems may have the greatest potential to address the integrated environmental and social goals promoted by advocates of sustainable agriculture. However, the main benefit of grazing and the main reason that so many producers have already converted to grass-based systems is the potential for profit.

With this combination of environmental and economic benefits, grass-based livestock enterprises could be the answer to some of the most pressing economic and resource concerns facing rural America today, particularly in dairying. Dairy grazing may be the way for small and medium-size producers to remain competitive and profitable in the twenty-first century, especially on farms at the urban edge, where conflicts with nonfarm residents over environmental concerns are likely. Win-win situations for both farmers and rural nonfarm residents can be created in communities willing to cooperate with dairy graziers.

The Need for Dairy Grazing

The dairy industry is in a major transition. Dairy producers have been told they must become more efficient if they are to compete with other low-cost producers in the U.S. and abroad. For dairymen in the northern milk-producing states (Minnesota, Wisconsin, Michigan, Pennsylvania, New York and Vermont), this means milking more

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cows and making a significant capital investment to modernize their facilities. If current trends continue, we can expect to see fewer dairies, larger herds, and the relocation of the industry to states with warmer climates and lower animal housing costs, especially Florida, Texas, New Mexico and California.

Traditional information sources are telling dairy producers that there is only one way to farm: Get big or get out. But dairy graziers across the U.S. are proving that there is an alternative. Grazing allows a producer to manage a reasonable number of cows with limited facilities, labor, and capital investment.

There is growing evidence to support the economic attractiveness of dairy grazing. In a recent analysis of six hypothetical dairy management scenarios for Vermont, we looked at dairy budgets and collected data from grass-based and conventional operations (Winsten and Petrucci, 1996). We also worked with a group of Vermont dairy producers who helped us select representative values for each management scenario.

We found that small- to medium-size operations can significantly reduce their feed costs and improve their profitability simply by making better use of pasture-grown, animal-harvested forages. In addition, if a seasonal dairy grazier is willing to make a modest investment in new infrastructure improvements and herd expansion, grass-based management systems can be extremely profitable.

Dairying in Urbanizing Areas

The American Farmland Trust recently did a national study of trends in farmland development and loss (American Farmland Trust, 1994). Not surprisingly, we found that farmland near or adjacent to metropolitan or urban counties faced the greatest development threats. However, we also found that these "edge" farms produce a disproportionately large share of our domestic agricultural products (over 56% of all food grown and consumed in the U.S.), and that certain sectors of the agricultural economy are particularly vulnerable to farmland conversion: 86% of all fruit, 87% of all vegetables, and 76% of all milk is produced on farms on the edge of urban areas.

Dairies are particularly vulnerable to development pressures. Both the settings in which they commonly are found and their physical characteristics often make them desirable for residential use. Dairies traditionally were established on rolling land that is less suitable for intensive row-crop production. The landscapes in dairy regions are more diverse, with a mix of crops, grass and woodlands that appeals to people seeking open space. Barns, silos and quaint old farm houses are highly desirable and are more likely to be found in good condition on dairy farms. People are attracted to these rural characteristics and seek them out for farmettes and new home sites.

The current economic state of the dairy industry also makes these edge farms vulnerable. Dairy producers are well known for taking in a large amount of money but keeping very little of it as profit. Low milk prices and high operating costs have led to very high debt-to-asset ratios for many dairy farmers, who often must struggle to service their debts. Most believe they will be required to make significant capital investments if they are going to stay in business. Many will opt instead to leave.

Environmental regulations also are a factor for edge farms. More states are implementing laws requiring better handling and storage of manure. Although more stringent regulations eventually will affect all farms, problems in urbanizing areas often are very visible and therefore are the first to be corrected through regulatory action.

An increase in development often leads to conflicts between farmers and rural nonfarm residents. People without a farm background often do not understand the sights and smells of agriculture, and are offended by the smell of manure. They have little patience for slow moving vehicles or animals crossing the road. Understandably, they may not appreciate it when animals foul a stream with manure or when pesticides drift onto their property.

Although the rural character of community can be maintained after development has started, it is difficult for agricultural enterprises to remain viable. Rising land prices and competition with developers make it less likely that land sales will be to other farmers. Current producers cannot enlarge their operations and young farmers cannot get started. As the conflicts continue and the pressures increase, agriculture is slowly squeezed out. Eventually, development density increases beyond a desirable level, driving out the nonfarm residents who first came in search of a rural setting. In the end, we have fewer farms, sprawling development, and the waste of a valuable resource. No one wins.

Grass Dairies: A Preferred Land Use in Rural Communities on the Edge

There have been many discussions in recent years about the potential of sustainable agricultural practices to reduce conflicts between agriculture and nonfarm rural residents. In theory, sustainable agriculture should minimize off-site impacts and enhance the environment. In reality, there are few sustainable farming options that work within the economic constraints imposed on farmers today. There are exceptions, especially for innovative producers who can work outside conventional markets, but overall, sustainable agriculture has not provided easy solutions.

Dairy grazing may be the exception with the most potential. Almost any dairy farmer can do it. Producers sell to conventional processors at market prices, and the pollution problems commonly associated with agriculture are largely eliminated. Dairy grazing is highly profitable because the cost of production is low. Most small and medium-size producers operating today could make more money simply by adopting some aspects of a grass-based system. This makes dairy grazing different. With the right techniques, grass-based dairying could be established as a permanent, sustainable land use in urbanizing areas.

Given what people who live in rural areas value, an identifiable niche arises that dairy graziers are uniquely qualified to fill. First, everyone wants a healthy environment. No one wants their surroundings to be contaminated by dirty water or potentially hazardous chemicals. Dairy graziers use hardly any pesticides, they do not need much fertilizer, and except for pasture renovation, they do not do much tillage. Manure storage and disposal are not big problems either, since in a well-managed system the animals never stay in one place for long. Also, land in grass suffers almost no erosion and holds nutrients very effectively.

Second, people want to be surrounded by well-tended working landscapes. The American psyche still has strong ties to our agricultural heritage. Because of this, we want to see people and livestock on the land, and we want to be reassured that the land resource is in good hands.

Finally, people want to live in friendly, economically stable communities. A tragedy in America today is that oversupply and low prices have made farming a dubious economic activity. Most people believe that the fate of American agricultural producers is to keep farming until they go broke. Many experts believe that there are too many farmers in America and that we still need to get rid of quite a few.

Dairy graziers have the chance to reclaim some of the respect that farmers have lost in recent years. The potential profit is sufficient for their operations to be economically sustainable. The management strategies work, and will prevent conflicts arising from resource concerns. From a social standpoint, if farmers keep their farms in order and are respected as good neighbors, communities will move away from the current view of agriculture as an unprofitable, transitional land use and instead see it as a highly desirable activity that contributes to overall economic development.

Dairy graziers have the potential to be integrated into new communities that are based on mixed land use and that value agricultural open space and farmer neighbors. One can even imagine communities that have farmland protection plans beginning to recruit grass-based dairy farms to maintain protected agricultural open space zones and to buffer residential developments.

Actions to Encourage Grass-Based Dairying in Urbanizing Areas

Several public/private initiatives can promote dairy grazing as a viable economic land use in urbanizing environments:

1. *Urbanizing communities should enact zoning ordinances with large minimum lot sizes in designated agricultural protection zones, but allow higher densities for developments that cluster homesites and permanently restrict large parcels of agricultural land for dairy grazing.*

Regardless of the strategies employed to protect farmland, an effective program must be based on good planning and zoning. In rapidly developing areas, a large minimum lot size is essential in an area zoned exclusively for agricultural use. Forty acres should be the minimum; 160 acres is not too large.

But planning alone will not stop land conversion when the economy is good and the demand for land is strong. One option is to allow developers to cluster or build at slightly higher densities in exchange for permanent restrictions on agricultural lands. This lets communities protect significant tracts of land while allowing land owners some flexibility.

For example, a 200-acre parcel in a 40-acre exclusive agricultural use zone could be planned to allow a minimum of five 5-acre home sites on parts of the property that would not significantly interfere with farming activities. Alternatively, a cluster development of five or more homes might be allowed on one 5-acre portion of the property. Either way, from 175 to 195 acres remains open and is available as pasture for dairy grazing. The open land could then be restricted with a conservation easement and sold to the producer at its agriculture use value.

2. *Local governments in urbanizing areas should encourage investors and preservation groups to plan and carry out limited developments on threatened dairy farms.*

In urbanizing areas, dairy farms often are among the largest contiguous parcels of land to go on the market. With the right promotion and planning, these tracts could be marketed to motivated investor groups or land trusts as high-value, limited-development sites.

Communities could promote these sites in the same way as industrial parks or retail sites, offering tax breaks, attractive financing, and other economic incentives. Limited-development sites also could be offered as part of a comprehensive economic development package, along with properties for industrial and retail uses. For some prospective buyers, having attractive rural sites available for residential development might even be a benefit offered to company officers.

As an alternative, communities could acquire these farms themselves and market them to individuals as limited partnerships, offering rural residential and long-term investment opportunities. A prospectus would show the cash returns expected through the appreciation of property values and through long-term leases and share-milking agreements with dairy graziers. In this way, open space would be held in common, the landscape would be maintained to the satisfaction of the owners, and farming could continue.

3. *Urbanizing communities should purchase development rights in designated agriculture/open space zones.*

Purchase of development rights is the surest way to protect agricultural land in rapidly urbanizing areas. Although many states and counties have PDR programs, township and municipal governments also should consider implementing PDR programs of their own. As a rule, the more local a PDR program is, the better it works.

Purchase of development rights is the final word in protecting agricultural land. PDR programs buy development rights at a mutually acceptable price from willing sellers, and thereby keep the land permanently open. Removing development rights also lowers the price of a farm so that it can be sold again to another farmer. Affordable land is the basic requirement of any farm, and stabilizing land prices is critical to the profits of any dairy, whether grass-based or conventional.

4. *Farming communities "on the edge" should consider recruiting dairy graziers by offering technical assistance and relocation services.*

Communities in urbanizing areas often turn their backs on agriculture and work instead to attract other revenue sources. Although it makes sense for communities to try to diversify their tax base, they should not give up on farming as a viable economic activity. Instead, they should help farmers by providing programs and services to overcome economic and environmental obstacles.

A good model for this is Lafayette County, Wisconsin. Although it is not under heavy development pressure, Lafayette County is a strong dairy area with many grass-based operations. The county promotes itself in the national press as having a fully integrated dairy industry, available and inexpensive land, and a strong support network of dairy graziers and others willing to share their experience and expertise.

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In summary, by building on the positive aspects of dairy grazing, any community—urban or rural—can support agriculture and find common ground for constructive interaction between farmers and nonfarmers. Where we do not plan for the future of agriculture, agriculture often does not have a future. Dairy grazing can fill a special niche, helping agriculture remain a vital part of urbanizing communities and maintaining the tradition of well-tended working landscapes as part of our rural heritage.

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Environmental and Economic Benefits of Organic Dairy Farming in Ontario

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Introduction

The demand for food, particularly livestock commodities, has increased as both the human population and its standard of living have increased. Particularly in developed market economy countries, food production increases have been achieved by adopting capital- and resource-intensive approaches such as mechanization, enterprise specialization, monoculture and simplified crop rotations, and agrochemical products, including biocides and inorganic fertilizers (Frey et al., 1984; Carey, 1991; Carnevale et al., 1991).

Alternatives to the conventional agriculture paradigm have been sought because of problems that have surfaced in recent decades. Soil degradation and erosion dominated the concerns about agriculture as recently as 1989, but current emphasis is on nonpoint-source pollution, wetland protection, biodiversity, and agrochemical pollution (Zinn and Blodgett, 1994). Concerns about long-term societal and environmental costs of agrochemical use have been documented with increasing rigor (Molder et al., 1991; Pimentel et al., 1993). Crews et al. (1991) argued that adopting more sustainable agricultural practices would reduce agriculture's damage to the environment. Organic farming is perceived by some as a way of alleviating the environmental degradation associated with conventional farming systems. It also is a way to cut input costs and maintain or recover the farm's financial health (MacRae et al., 1990). The defining feature of organic farming is not simply avoidance of agrochemicals, but the intentional integration of natural processes to achieve various goals, including a productive agriculture.

Objectives and Research Methods

In this paper we report a study designed with the following objectives: to identify key practices on organic dairy farms; to assess their robustness over time and across farms; and to compare the agronomic practices and economic performance of conventional and organic dairy farms in Ontario. Information on conventional dairies was

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obtained from the Ontario Dairy Farm Accounting Project (ODFAP), for which 120 farms (1.5% of the provincial total) are canvassed and reviewed annually (Ontario Ministry of Agriculture and Food, 1993). We designed a questionnaire intended to produce data directly comparable to that of the ODFAP, and administered it to 8 organic dairy farms (representing between one-fourth and one-third of the provincial total). Production data were from 1988 to 1992, while profitability and productivity comparisons were based on 1992 data only.

Results and Discussion

The sampled organic dairy farmers grew a variety of crops, with emphasis on forages (about 67% of their land) and spring and winter small grains (30%). They also grew minor amounts of soybean *(Glycine max)* and corn *(Zea mays)* (2.5% combined).

In contrast, conventional dairy farms predominantly grew grains such as winter wheat *(Triticum aestivum)* or corn (34% of total land), soybeans (33%), and pasture or hay (33%). Thus, organic and conventional dairies differed in cropping pattern, with resource-intensive row crops like corn occupying a much larger share of the land on conventional farms, and forages dominating on organic farms. Most crops grown on organic dairy farms were used as livestock feeds, supplemented by purchased minerals (salt, kelp, dairy premix) and vitamins. The mix of feedstuffs fed to the dairy herd differed among farms, with rations tailored to productivity. None of the organic farmers fed additives or growth stimulants.

Perennial forages

On organic farms, crop rotation is a key management tool for controlling weeds and insects and for maintaining good soil fertility and structure. Four of the dairy farmers completely integrated perennial hay or pasture into their crop rotations. The other four devoted 10, 23, 34 and 75% of their land to permanent hay or pasture. Inclusion of short-term meadows in a grain crop rotation underscores the beneficial integrating role of perennial forages on a livestock farm. They are not simply livestock feeds, but also serve for weed and insect control and for soil enhancement and conservation, all of which sustain production of annual grain crops in the rotation.

Permanent sod cover allows soil organic matter to accumulate, as has been shown in several long-term studies reviewed by Stevenson (1982) and Briggs and Courtney (1989). Deforestation and fossil fuel combustion are the most commonly mentioned causes of rising atmospheric CO_2 levels and global warming, but the CO_2 released by the cultivation-induced decline in soil organic matter also is a major contributor. Reversal of this trend may be contingent on the systematic reintroduction of perennial forages into today's agriculture. Conservation tillage, which is widely considered a soil-conserving alternative to conventional plowing, slows the rate of decline of soil organic matter but does not increase soil organic matter below the topmost layer (P. Voroney, Professor of Land Resources, University of Guelph, Ontario, personal communication, 1995).

Thus, the organic livestock industry's dependence on perennial forage crops can be seen not simply as an agronomic and economic issue, but specifically as a positive contribution to solving the global warming crisis. Alfalfa *(Medicago sativa)* and red clover *(Trifolium pratense)* were the most common crops undersown in grain crops, presumably because of the combination of high nutritional value for livestock and the nitrogen contribution to the succeeding crop in the rotation.

Small grain crops

Mixtures of small grains such as oats *(Avena sativa)* and barley *(Hordeum vulgare)* were the dominant carbohydrate source in organic dairy rations, while conventional producers placed greater emphasis on corn. Small grains are preferred by organic producers because rapid seedling growth and the narrowness of the rows reduce the time in which weeds can establish and compete. The availability of both winter and spring small grains not only provides winter cover to protect and enhance the soil, but also allows more complex rotations that can avoid the build-up of adapted weeds.

In addition, small grain crops have lower nutrient requirements than corn, consistent with the "everything in moderation" approach of organic producers. However, small grains also have less than half the grain yield of corn. As a result, organic dairy farms would be expected to require more land to grow the same amount of carbohydrates, which is consistent with their larger tillable area (Table 1).

Cover crops

Organic producers emphasize year-round soil cover when choosing their crop rotations. Year-round cover helps immobilize plant nutrients and reduces losses through

Table 1. Characteristics of Organic and ODFAP Dairy Farms (Average, 1992).

	ORG Farms (N=8)	ODFAP Farms (N=120)	ORG/ ODFAP
Tillable land (ha)	121	99	1.22
Herd size	48	45	1.07
Total milk shipped (liters)	282,338	263,906	1.07
Milk shipped per cow (liters)	5,882	5,865	1.00
Labor (total person-equivalents)	2.03	2.07	0.98

leaching or denitrification, as well as reducing wind and water erosion and increasing soil organic matter content. The organic farmers in this study achieved winter soil cover from 60 to 100% of the time (average of 85%), using winter small grains, perennial forages, and annual catch crops. To maintain more continuous cover, crops commonly were undersown into an existing maturing crop rather than sown after the crop was harvested. The crops used for cover included nitrogen-fixing legumes.

Weed control and soil fertility management

Weeds were not a serious problem, according to the respondents. However, quackgrass *(Elytrigia repens)* was the predominant weed on four farms. Prevention of weed and insect problems receives greater emphasis than control on organic farms. The particular crop sequence is selected to discourage the build-up of management-adapted weeds. For example, the same small grain was not grown consecutively, and winter and spring small grains usually alternated when both were grown in the same field. Varying the type and timing of cultivation to suit the different crops helped prevent build-up of particular weeds. Another preventive measure was the use of closely grown rather than row crops to achieve full cover more quickly and shorten the period for weed encroachment. The preference for cool-season rather than warm-season crops (for example, small grains and forages rather than corn and soybeans) also may allow full cover to be attained sooner in the spring, when the challenge from annual weeds is greatest.

Soil nutrients are valued on organic dairy farms, so that nutrients found in manure, bedding materials, and other organic by-products are recycled to replace those withdrawn by the harvested crops. Composted solid manure was used on all eight organic dairy farms, and liquid manure also was applied on four. On one farm, a specially constructed composting shed was used to protect against leaching losses.

Technical comparison of organic and conventional dairy farms

Tillable area (rented and owned) and herd size (milking and dry cows) on the eight organic (ORG) farms were 22% and 7% higher, respectively, than on the ODFAP farms (Table 1). Similarly, total milk shipped from ORG farms was 7% higher on the ORG farms. However, milk shipped per cow was equal on the two groups. Labor requirement, as measured by the total person-equivalents, was almost identical for the two farm types: 2.03 for ORG versus 2.07 for ODFAP. The similarities in herd size, productivity per cow, and milk shipped per farm occurred despite the substantial difference in the two groups' management.

Economic comparison of organic and conventional dairy farms

On average, total cash revenue of the ORG farms was about 7% lower than on the ODFAP farms (Table 2), although the ORG farms shipped a larger volume of milk

Table 2. Economic Performance of Organic and ODFAP Farms, 1992 (Can$).

	ORG Farms	ODFAP Farms	ORG/ODFAP
Total cash revenue	179,888	194,028	0.93
Total expenses	120,170	156,471	0.77
Net income	59,718	36,351	1.64
Net income per cow	1,244	831	5.01
Net income per tillable hectare	494	381	0.30

(Table 1). Besides sales of milk, cash revenue included subsidies, livestock sales, crop sales and other farm income, excluding value of inventory change. The difference in cash revenue was about equal to the income generated from other (non-dairy) farm income on ODFAP farms. On average, the organic farms' expenses were 23% lower than on the ODFAP farms (Table 2). Farm expenses are the sum of all costs on the farm, including overhead and depreciation. They were lower on ORG farms because of lower purchases of livestock and commercial feed. Expenditures also were lower for milk and livestock marketing, seeds, wages and salaries, synthetic fertilizers and pesticides, machinery repairs, and fuel. These savings accounted for about 89% of the difference in farm expenses for the two farm types. Total farm expenses per liter of milk shipped were Can$0.11 lower for the ORG farms.

The average net income of ORG farms was 59% higher than that of ODFAP farms (Table 2). Net income per cow was 50% higher on ORG farms ($1,244 versus $831), and net income per tillable hectare was 30% higher ($494 versus $381). Net income is the residual return to unpaid family labor, operator's labor, management, risk-taking, and land and equity capital.

Environmental comparison of organic and conventional dairy farms

The current study did not formally compare the environmental impacts of the two types of dairying in Ontario. Nonetheless, the conclusion that organic farming causes less environmental damage can be inferred on several grounds. First, the absence of synthetic pesticides and fertilizers on organic farms removes the potential for environmental damage from these sources. Second, the absence of purchased synthetic fertilizers encourages a strong conservation ethic to retain and recycle nutrients within the farm, further reducing the risk of off-site pollution. Third, the greater emphasis on winter cover with perennial forages, small grains, and cover crops improves soil structure and tilth while reducing the risk of erosion, degradation, and compaction.

In summary, the initial results from this ongoing research program suggest that organic dairy farming in Ontario is economically competitive with conventional dairying while reducing the risks of environmental damage.

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Integrated Resource Management at Work: A Case Study

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Introduction: Integrated Resource Management

The long-term competitiveness and profitability of American agriculture is a significant concern across all food production systems. New and innovative techniques for information and technology transfer must focus on management strategies that are economically profitable, environmentally sound and socially acceptable, and that fit within business, personal, family and community goals. Fundamental changes must occur in how we identify and analyze problems and in how we facilitate, measure and evaluate change (Barao, 1992). Factors that affect sustainability, beyond competitiveness and profitability, must become part of the total equation when farm management strategies are implemented.

Integrated Resource Management (IRM) provides the framework for an interdisciplinary approach to whole farm assessment, planning, and management. It recognizes and accounts for the interrelationships among subsystems, products, and internal and external forces that affect achievement of the farm's goals (Lippke, 1988). IRM recognizes both that the many subsystems of any food production system are connected, and that addressing concerns or making changes within a subsystem does not guarantee that the overall system will improve. Its focus is on the whole, and it fosters the interdisciplinary efforts required to implement management practices that will achieve the farm's goals.

IRM is a powerful tool for many purposes: demonstrating the economic and social advantages of technology adoption and change; evaluating the compatibility of a proposed technology or change within the existing farm system; assessing the complexity or ease of adopting the change; and measuring the impacts and results of the management strategies across the whole farm system.

IRM provides a measurable, stepwise process for identifying and analyzing problems, initiating and organizing programs, coordinating teams, and assessing impacts. It requires close coordination among team members with different disciplinary training, expertise, values, and perspectives. An understanding of the change process, including

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the human and social aspects of technology adoption, is critical to the effectiveness of the team as a whole and its success in achieving farm system goals. An agricultural producers who wishes to operate an efficient, profitable and sustainable enterprise in today's competitive environment will benefit significantly by enlisting an integrated, whole system approach to farm and family resource management.

Once the principles of IRM are understood, the challenge is to put them into practice; a whole system approach may appear overwhelming at first. The key to initiating a program and sustaining participation is to demonstrate quickly the interconnectedness of farm subsystems. As the cooperating producer begins to understand and experience the interactions among subsystems and their ultimate impact on farm system goals, a whole system approach will be embraced.

It is essential that the project leader and team members start with solvable problems where positive results are demonstrated quickly. The results will be the foundation and justification for addressing more complex, longer-term challenges.

Project Description and Results

A four-year participatory on-farm project was initiated to demonstrate and apply the principles of IRM within an existing beef cow-calf enterprise. The overall goal of the project was to design and implement management practices that improve animal and farm system performance and profitability while protecting and enhancing the surrounding environment. General farm goals were set assuming that management practices that increase and enhance the grazable land base also would contribute positively to environmental stewardship and farm system sustainability.

The producer-owned demonstration farm that was chosen consisted of a purebred Angus (seedstock) operation located within the piedmont region of northeastern Maryland. The terrain is rolling, and includes a significant fraction of highly erodible, loam-based soils. It is within the Deer Creek Watershed, a tributary of the Susquehanna River leading into the Chesapeake Bay. The farm encompasses 217 acres, including 20 acres of mixed hardwood forest. Several spring-fed streams cross the farm along with one major creek. Annual rainfall totals approximately 45 inches.

Six farm goals were established at the onset:

- Increased carrying capacity of the farmland base
- Increased animal-harvested (grazable) forage base
- Reduced reliance on mechanically harvested and stored feeds
- Reduced inputs of fertilizer, insecticides and herbicides
- Reduced animal impact on the environment
- Improved total farm profitability.

A whole farm-management plan was established to achieve these goals. Over the duration of the project, 65 acres of existing crop land (tilled) was converted to permanent pasture consisting of mixed stands of grass and legumes, and existing pastures (117 acres) were renovated and improved through the no-till addition of up to 30% legumes. A year-round grazing plan was established to utilize the grazable base fully. Pasture establishment and renovation resulted in the following whole-farm pasture profile:

65% of available area
- orchardgrass/red clover mix
- orchardgrass/alfalfa mix

30% of available area
- tall fescue/red clover mix
- tall fescue/alfalfa mix

5% of available area
- native Kentucky bluegrass/fescue mix with added red and Ladino clover.

In addition, innovative animal watering systems were developed to allow full utilization of grazing land while minimizing the animals' impact on existing streams. These water systems included spring development, gravity flow waterers, and hydraulic (energy-free) ram pumps to move water to stock tanks far from existing natural water sources. Reinforced and controlled stream crossings were constructed to allow the animals to move between pastures while minimizing stream and stream bed impacts and soil erosion.

As a result of the transition to 100% improved pasture with year-round grazing and forage stockpiling, during the four years of the project the farm's carrying capacity increased by 53% (based on the number of females of breeding age), total forage yield increased by 59%, and grazing days increased by 34% (Table 1). In addition, the overall nutritional status of the cow herd improved because of the higher quality forages, both grazed and harvested (Table 2).

Pasture soil tests were conducted on a rotating basis, with each field tested once every two years to monitor soil fertility levels and help pinpoint the need for supplemental potassium, phosphorus, and calcium. The addition of legumes to all permanent pastures and hay fields has reduced total nitrogen and phosphorus application by 80%. Currently, the use of external nitrogen is restricted to the fescue pastures (30% of grazable base) to facilitate stockpiling and winter grazing. High animal stocking rates (densities), which are part of the short-duration intensive rotational grazing plan, have eliminated the need for herbicides and resulted in more complete and uniform distribution of animal waste into the soil.

Table 1. Carrying capacity and forage yield characteristics.

	1991	1992	1993	1994
Pasture yield (tons, dry matter)	210	301	386	378
Total farm forage yield (tons, dry matter)	347	449	561	552
Mature cows	87	87	110	134
Grazing days	218	285	318	310

Table 2. Nutrient composition of harvested forage (%).

	1991	1992	1993	1994
Dry matter	84.4	53.2	58.3	48.6
Crude protein	10.1	14.7	15.6	17.3
Acid detergent fiber	40.6	38.7	37.7	36.5
Total digestible nutrients	56.2	58.4	59.4	59.9

To improve animal waste management further and reduce environmental impact, primarily during the winter months, when confined feeding may be necessary, a concrete feeding pad and manure collection and holding facility was constructed. This facility provides covered hay storage, a managed feeding pad and significant waste storage. A grass filterway was constructed next to the manure storage unit to facilitate the removal of liquids from the storage unit.

To determine total farm profitability, several economic indicators were tracked using the Standardized Performance Analysis developed by Texas A&M University (McGrann et al., 1992); they are summarized in Table 3. Feed costs represent a significant proportion of total cash costs in the cow-calf operation. These costs were significantly reduced by improved pasture/grazing management and the extended grazing season. Additional costs associated with a purebred seedstock operation, such as promotion, advertising, marketing, and reproductive management, also add significantly to total direct cash cost. In turn, calf value and hence net income per cow reflect the operational returns expected with purebred cattle.

Table 3. Farm financial performance.

	1991	1992	1993	1994
Raised/purchased feed ($/cow)	351.15	283.80	215.14	180.47
Cost of weaned calf production ($/calf)	N/A	470.79	306.52	262.65
Net income ($/cow)	N/A	209.40	336.85	372.05

Finally, an indirect but significant benefit of the best management and stewardship practices integrated into the agricultural production enterprise has been an improvement in wildlife habitat. The improved pastures and level of nutrition have benefitted deer, fox and other wildlife on the farm, as has the increased availability of fresh, clean, ice-free water sites. Wildlife observations were recorded in diary fashion over the period of the demonstration project. These observations indicated the following increases in observed wildlife: deer: 65%; fox: 27%; waterfowl: 30%; and turkeys: 70%.

Summary

These results point clearly to the benefits of an integrated or systems approach to total farm management. Over the duration of the demonstration project, the cooperators received the following significant recognition:

- National Land Stewardship Award from the American Angus Association
- Environmental Stewardship Award from the National Cattlemen's Association
- Chesapeake Bay Conservation Award from the Chesapeake Bay Foundation
- Governor's Certificate for Protecting and Enhancing the Chesapeake Bay Watershed, from the Governor of Maryland
- Soil Conservation Award from the District Soil Conservation Services.

The concept of integrated resource management, coupled with individual commitment to land and resource conservation and environmental stewardship, will result in long-term agricultural system profitability, environmental integrity, and sustainability. Further, when approached from an integrated or whole system perspective, the strategic implementation of best agricultural management practices can and will achieve both agricultural and environmental goals.

Targeted changes within an existing farm system as demonstrated in this project can improve the profitability and sustainability of the farming operation while benefiting the surrounding environment. The question remains whether the environment is absolutely better off as a result of the new farming practices, that is, not just compared with the previous agricultural system but compared also with how it would be used in the absence of agriculture.

Alternative nonagricultural uses will vary by region, state and area, and will be influenced by such factors as population growth, housing demand, the economy, and land values. In a highly urbanized state such as Maryland, especially within the northeast corridor, the nonagricultural alternative use of agricultural land is residential and commercial development. Therefore, the appropriate contrast is between well-managed existing agricultural production and commercial/residential development (high density housing, paved roads, storm drains, etc.). When viewed in this manner, the environmental benefits of a well-managed agricultural production system, as demonstrated in this project, are clear.

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Riparian Zones Then and Now: An Enhanced Environment Created by Agriculture

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Introduction: Livestock and Riparian Zones

Riparian zones with distinctive vegetation exist because water is available to plants during their entire growing season and promotes the establishment of species that require this water. If the water supply near the root zone of water-loving plants is removed, the plants are replaced by species capable of occupying drier areas that have no permanent water supply during an entire growing season.

Water supply in the semi-arid western United States is limited in quantity because of the seasonal and spatial distribution of the precipitation. Riparian wetland area therefore is limited compared with other, more common, upland vegetation types. Consequently, the condition of riparian zones has become a focus for discussion regarding how rangeland watersheds are being managed. Overuse of riparian zones by livestock is the reason most often cited in demands for changes in how these zones are used. A report by the General Accounting Office (1988), which emphasizes how livestock alter western riparian zones, has been used to justify the National Rangeland Reform '94 proposal (U.S. Department of the Interior, 1993). Controversy over this proposal is causing extensive debate in the U.S. Congress: the question is how best to provide for the needs of the livestock industry using public lands of the West while maintaining desired landscape conditions and satisfying the needs of other natural resource users. Beyond argument, grazing on public lands by livestock and wildlife is important to the economy and the well-being of the livestock industry and the public. In this paper we present evidence that because of agriculture, the quality and extent of riparian wetlands are far higher than before settlement. For reasons we will explain, careful consideration must be given to developing land management policies that continue to provide several important benefits: developed water sources for plant and animal use; unique riparian habitat for multiple uses; the health of the plant community that developed because of grazing patterns of large animals; and vast open rangeland for future use by wildlife.

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For convenience in reviewing the region's management history, we divide it into six periods:

- 1804-1840: exploration
- 1840-1870: migration
- 1870-1930: settlement
- 1930-1960: after creation of reservoir storage (dams)
- 1960-1975: multiple use management
- 1975-1995: riparian zone management

As we will explain, the changes in riparian zones from pre- to post-settlement resulted from native and introduced large grazing animals, alteration of flow caused by diversion of water for irrigation and reservoir storage, and multiple use of watersheds.

1804-1840: Exploration of the West

Stream channels adjust to changes in the characteristic flow regimes of individual watersheds. In turn, flow regimes are controlled by the surface condition of an entire drainage basin, as influenced by climate and grazing. A representative annual flow regime in the central semi-arid Rocky Mountain regions, where streams flow year-round, is the following: base flow occurs during late fall and winter; high flow occurs in spring when the snow pack melts; spring runoff declines in summer and drops to base flow again during late fall and winter. All stream channels and associated riparian zones adjusted to this flow regime.

Each year, most runoff occurs during approximately forty days in the spring. Historically, this heavy and powerful runoff (produced by a characteristic climate and watershed rangeland grazed by wildlife) shaped channels over many years by moving and depositing channel bed material and sediment in a downstream direction. Low-flow channel conditions then existed during the remainder of the year. Historical photographs and literature attest to the large, low-gradient streams, wide and braided with islands, flowing from mountain ranges through basins and across the plains. This pattern occurred because late-summer stream flow was limited to the small amount of water produced from remaining melt of snowbanks and from the frequent summer rains falling in the high mountains but not in basin regions. Shallow stream flow in summer would have been confined to a few small channels isolated in wide stream beds. Today, on rivers whose flow is unregulated, this type of channel shows that little water is available during summer to support riparian vegetation. Summer flow that supports riparian vegetation in unregulated rivers was, and still is, limited to specific situations: where the stream flows through islands, along margins of channel banks protected by enough vegetation to withstand high flow in spring, through the inside curve of river bends, and perhaps where two streams join and their summer flow is connected.

Only some perennial streams in the West could, and still can, support riparian zones in the plains. The large areas between these streams support only upland grass and shrub-type vegetation. Historically, this grew to the edge of the wide stream channels formed by spring runoff from mountain ranges. Wildlife would have been forced to use the water in these channels because there was no permanent supply during droughts except in the Sand Hills of Nebraska and the plains to the east, where rainfall in summer is adequate to support summer flow. What little riparian vegetation existed was subjected to this confined pattern of use by wildlife and the rampages of large grassland fires during summer.

The Platte River, with its headwaters in Wyoming and Colorado, was the first major river encountered by the Lewis and Clark expedition that had the characteristic spring flow from melting of the central Rocky Mountain snowpack. From their description of this and other rivers that entered the Missouri downstream from Three Forks, Montana, it is evident that these main tributaries were wide and filled with deposited sediment (sand) that formed many islands and small channels resembling braided channels. During high flow, the water spread out over these wide sand beds, but receded into the smaller channels during low flow conditions. Lewis and Clark did not consider these streams deep enough to be navigated by their boats. On June 27, 1843, Captain John C. Fremont spoke with John Lee, who had tried to float the Platte from Fort Laramie during high flow in a boat filled with cargo that drew only 9 inches of water; he could travel only 140 miles downstream (Nevins, 1956). Fremont also described timber along the Platte (Nevins, 1956, p. 100) that consisted primarily of cottonwoods (*Populus* spp.), extending from Grand Island to the south fork of the Platte, and up the south fork to the Rocky Mountains. Large islands were thoroughly wooded, although the banks themselves often had no timber or only fringes or clumps on meander bars. At the junction of the Yellowstone and Missouri on April 26, 1805, Lewis recorded the following: "There is more timber in the neighbor of this place, and on the Missouri, as far below as the Whiteearth [Little Muddy] River than on any part of the Missouri on this side of the Chayenne. . . . It is always understood that the upland is perfectly naked and that we consider the low ground well-timbered if even one fifth be covered with woods" (Coues, 1893, p. 282).

The smaller streams Lewis and Clark described that leave the Rocky Mountains and reach the Missouri are not very different from the Platte: "There is, however, no timber except on the Missouri, all the wood of the Whitestone River not being sufficient to cover thickly one hundred acres" (Allen, 1903, p. 97). On September 4, 1804, Lewis reported that the Rapid River at its confluence with the Missouri was 152 yards wide and four feet deep. He found that the river "widened above its mouth, and [was] much divided by sands and islands, which, joined to the great rapidity of the current, makes the navigation very difficult, even for small boats" (Coues, 1893, p. 117). The next week, Lewis and Clark reached the Niobrara River: "This river has a bed of about three hundred yards though the water is confined to one hundred and fifty." Two weeks later, on October 1, 1804, Lewis described the Cheyenne River as being "400 yards wide . . . [its] current gentle, discharging not much water and very little sand" (Coues, 1893, p. 146).

The Moreau, Grand, Cannonball, and Little Missouri are four other major rivers that are smaller than the Platte but that drain the western rangelands to the Missouri. Lewis describes them this way: "[October 7, 1804] we came to the mouth of a river . . . Sawawkawna River [Moreau] . . . and though it is now only water twenty yards width, yet when full it occupies ninety. . . . [October 8, 1804] at the Wetawhoo [Grand] its bed is one hundred and twenty yards, but water is now confined within twenty yards" (Coues, 1893, pp. 156-157). On October 18, 1804, they came upon the Cannonball River, whose "channel is about one hundred and forty yards wide, though the water is now confined within forty." On April 12, 1805, he reports that the Little Missouri, where it enters the Missouri, is "one hundred and thirty four yards wide, but its greatest depth is two feet and a half" (Coues, 1893, p. 268).

Lewis and Clark did not mention seeing evidence of actual flooding over the banks of the Missouri or its large tributaries during the spring of 1804, 1805, or 1806, except at the junction of the Yellowstone and Missouri, and near the Missouri headwaters, where beaver could maintain dams from year to year. This implies that water during high flow spread out over wide channels and became deeper, but seldom over-flooded the banks. Consequently, recharge of water to the banks of the larger rivers would only occur during spring and only through the banks themselves, but these would then drain during summer. Thus, riparian vegetation was limited to specific situations: the very edge of channels in straighter reaches; meander point bars where groundwater interflow could occur from the upstream reach of the meander to the downstream reach; stream junctions where surface and groundwater moved from one stream to the next; and islands where channel water would be available during low stream flow.

The presence of woody riparian vegetation was at best limited to one-fifth of the larger streams exiting the Rocky Mountains. Both buffalo *(Bison bison)* and Native Americans were confined to these zones because of their need for water and shelter. Captain Lewis recorded extraordinary examples of the number of buffalo using riparian zones. On July 11, 1806, they "had seen elk; but in this neighborhood the buffalo are in such numbers that on a moderate computation there could not have been fewer than ten thousand within a circuit of two miles" (Coues, 1893, p. 1081). Washington Irving (1863, p. 60) described the abundance of buffalo, based on Captain B.L.E. Bonneville's 1832 trip between the south and north forks of the Platte River: the Captain "command[ed] an extensive view of the surrounding plains. As far as his eye could reach, the country seemed absolutely blackened by innumerable herds. No language, he says, could convey an adequate idea of the vast living mass thus presented to his eyes." Similarly, when Captain Fremont was on the south fork of the Platte River on July 4, 1842, he encountered "column after column of buffalo . . . galloping down directly to the river. By the time the seading [*sic*] herds had reached the water, the prairie was darkened with the masses. . . . From hill to hill, the prairie bottom was certainly not less than two miles wide and allowing the animals to be ten feet apart and only ten in a line, there were already eleven thousand in view" (Nevins, 1956, p. 108).

Many accounts report on how many buffalo actually grazed the western plains. A reliable estimate is about 60 million. However, we do not need an exact count to visualize the impact the buffalo must have had on the riparian zones during the presettlement era. Their trampling of banks and the effects of their grazing must have been very great compared with what we observe today.

Evidence of their impact on riparian vegetation is supplied by trapper Osborne Russell, who wrote one Christmas in the 1830s: "The bottoms along the rivers are heavily timbered with sweet cottonwood and our horses and mules are very fond of the bark which we strip from the limbs and give them every night as the buffalo have entirely destroyed the grass throughout this part of the country" (Haines, 1963, p. 81). Captain Fremont, on the North Platte River near Casper, Wyoming, on July 23, 1842, gave this report: "We found no grass today at noon; and, in the course of our search on the Platte, came to a grove of cottonwoods where some Indian village had recently encamped. Boughs of the cottonwoods, yet green, covered the ground, which the Indians had cut down to feed their horses upon. It is only in the winter that recourse is had to this means of sustaining them; and their resort to it at this time was a striking evidence of the state of the country" (Nevins, 1956, 146).

1840-1870: Western Migration

The principal immigrant routes through the Rocky Mountains to the west coast were the Platte and Sweetwater rivers. Dorn (1986, p. 1) states that "an estimated 350,000 people crossed Wyoming between 1841 and 1866 primarily heading for California gold fields or to settle in Oregon or California." Other major routes to Colorado and Montana also used river corridors for roadways, a logical choice since "one should keep in mind that the primary needs of all these travelers were grass for the animals, water for the people and animals, and fuel for the campfires" (Dorn, 1986, p. 1). However, these travelers would not have caused much change in stream channel conditions because they would not have altered spring flows from mountain snowpacks.

1870-1930: Settlement

Traffic through the Rocky Mountains diminished as ranches, farms, towns, and industry became established. First the Pony Express, then stage lines, and finally the railroad (1869) connected East and West. These modes of travel also used river corridors and thus riparian zones. The railroad became the first human attempt to channelize stream flow, and consequently would have changed the natural flow regimes of basin streams. Railbeds next to channelized streams must have increased stream flow velocity because of the narrower stream bed. This caused movement of channel bed material and lowered the historical bed level of basin streams. This would have caused downcutting of tributaries as they eroded to meet the gradient where rail bed channelization occurred. Highways built to meet the needs of the automobile must have had similar effects. The consequence of railroad and highway encroachment on stream channels was to diminish riparian zone habitat that was limited already.

During this period, ranchers and farmers placed their base operations along streams for obvious reasons and replaced buffalo with cattle and sheep. Although livestock have historically been blamed for accelerated erosion, buffalo must have been responsible for much of the damage. Agriculture only replaced buffalo with livestock (in large numbers at first, but decreasing by the mid-1930s). By developing off-stream water supplies, ranchers expanded livestock's ability to graze beyond stream corridors. This probably increased grazing pressure on uplands and decreased it along streams, unlike when buffalo grazed these rangelands. The impact of farming on sod-covered uplands during this period was evident from the Dust Bowl days of the late 1930s. Assuredly, the alteration of native vegetation to produce crops and graze livestock in rangeland between streams has increased surface runoff and increased erosion of headwater areas.

The practice of diverting water to sustain pastures for winter forage at base ranching operations and to provide water for municipalities began as mainstem basin and low-gradient mountain stream systems were settled. Diversion of water during high flow reduced the streams' ability to cause erosion because it took away water during these periods in the spring and used it elsewhere. Flood irrigation provided groundwater that was, and often still is, stored under the developed land mass that borders our present perennial streams. This water returned slowly to mainstem surface aquifers in summer, the time of low flow (both historically and today). This supply, called *return flow*, generally represents surplus water not needed to grow pasture plants.

A reduction in stream flow during the spring runoff caused sediment to be deposited along the stream banks and filled in the less-developed braided channels. Where vegetation was allowed to become established, stream flow was consolidated into one or a few channels capable of transporting the new regime of reduced spring runoff below stream diversions. Flood-irrigated pastures would have provided vegetation cover and root mass, which would further hold the banks and channel fill in place. Sediment deposits on building banks, controlled grazing of livestock, and groundwater return flow during the dry summer period would have increased the survival of cottonwoods and willows (*Salix* spp.). The rate of encroachment of channel banks would have been regulated by three factors: the amount and timing of flow left in channels after diversion; the area contributing to the watershed between diversions; and the surface condition of the contributing areas. As streams were fully developed for diverting spring runoff, the result was that historical stream channels lost their braided appearance and narrowed to a single channel. Wide historical channels became riparian zone floodplains supported by irrigation return flow into a much smaller stream. Because this new configuration does not have as much conveyance capacity as in the past, over-bank flooding often occurs during spring runoff. This action further supports the floodplain riparian zones of today.

1930-1960: After Creation of Reservoir Storage

We have seen the importance of water development for the settlement of the central Rocky Mountain region and discussed how diversions of water could augment riparian zones both by channel bank encroachment of braided streams and return flow of groundwater from flood irrigation. Dam building and reservoir storage to regulate stream flow minimized overbank floods, increased available water during time of need, and improved the delivery systems for irrigating crops and pastures. Riparian zones thrived because more area below dams had water longer during the growing season and because irrigation water was available to replenish groundwater supplies to support return flow. Certainly, riparian zones above dams were flooded and lost, but this loss eventually will be recovered as the reservoirs are filled with upstream sediment. We now see many dams that support vast areas of riparian plants where streams enter the reservoir system and have deposited sediment above the low water level. These wetland areas differ from those that formerly existed as narrow corridors along the rivers before dams were built, because riparian plants now occupy broad, flat areas of deposited sediment. "Hungry" water (water without sediment) released from dams can erode riparian zones until the sediment supply is replaced by runoff water from tributaries draining below-dam watersheds. However, regulated release from dams to control downstream flooding of municipalities has generally allowed stream banks to stabilize at a given width and depth even if hungry water is released. Riparian zone wetlands along regulated river systems now support corridor forests from the Missouri River to the Rocky Mountains in areas where they did not exist before settlement. These riparian zones, therefore, are supported by a river that has decreased substantially in width and whose flow is consolidated into a few channels that are deeper than they were in the past.

Small reservoir storage, too, has without a doubt expanded riparian zones, even if the storage was designed for livestock water, distribution of animals, and erosion control. Because of water development for agriculture, riparian zones now exist where none existed before.

Unlike the lowlands, mountain riparian zones very likely changed little during this period of reservoir development. High spring flow would have been altered by road development for timber, by fire control, and by a reduction in grazing by livestock, but beaver populations either rose naturally or were managed to help sustain appropriate streamside vegetation. Little dam building and diversion occurred at high elevations.

Even where it did, mountain and canyon stream gradients were maintained by the presence of bedrock. Scouring of canyons by reservoir release would do little to change these riparian zone habitats.

1960-1975: Multiple Use Management

Several new issues in riparian zone management surfaced during the 1960s and early 1970s. Recreational fishing grew, and people interested in fishing insisted on action to mitigate the impact of water storage dams, which stopped the up- and downstream migration of fish. After making substantial progress on this issue, fisherman began to evaluate fish habitat needs and learned that poor habitat was tied to deteriorated riparian zones. This research was applauded because the public had more leisure time and was using more of it for recreation. Recreation is normally perceived as more enjoyable when experienced near water.

Improved access to more remote areas of drainage basins allowed entry by four-wheel drive vehicles for recreational purposes. After World War II, four-wheel drive vehicles were available from military surplus; public land agencies, ranchers, and some members of the public found them useful replacements for horses, wagons, and two-wheel drive vehicles in work and play. It was not long before the automobile industry capitalized on this market. Abuse of traveling on historic wagon trails and across native rangeland where there were no roads was on the rise. This was especially true on public lands, where access could not be curtailed. Heavy road construction also rose because of oil and gas development in basin and mountain areas.

More facilities were developed on stream reaches in response to the public's cry for more recreational opportunities. These facilities put larger numbers of people on small areas. Mountain home developments, more and bigger ski areas, and associated industries occupied substantial areas of mountain valleys. Hunting and fishing in the mountains via horseback also became popular, as did backpacking. Livestock grazing pressure declined.

This greater access and increased human activity in remote areas of drainage basins has resulted in more spring stream flow from channelization of headwater areas by roads and trails. Activities in these areas remove vegetation, reduce infiltration of water into the soil, and increase overland flow to streams. Riparian zones created by geological, beaver, and man-made dams have diminished where these impacts occur.

1975-1995: Riparian Zone Management

Many national conferences have been held in the United States since 1975 specifically to address riparian zone issues. A better knowledge of fish habitat needs, greater demand for recreational opportunity, more emphasis on habitat for birds and other wildlife, and less emphasis on water development all have made streamside zones an emotional issue.

Agriculture and livestock grazing have taken their share of criticism for reducing riparian zones. However, this paper helps support Dorn's (1986, p. 87) conclusion about Wyoming: "Riparian vegetation may be as extensive now, if not more so, than prior to settlement." In *The Case of the Shrinking Channels*, Williams (1978, p. 1) clearly shows that the North Platte River in Nebraska has substantially increased its riparian zone area: "The decreases in channel width are related to decreases in water discharge. Such flow reductions have resulted primarily from the regulating effects of major upstream dams and the greater use of river water by man. Much of the former river channel is now overgrown with vegetation. . . . The changes are most pronounced in the upstream 365 km of the study reach (Minatare to Overton). Within this reach, the channel in 1969 (and 1977) was only about 10-20 percent as wide as the 1865 channel. A significant part of this reduction in width has occurred since 1940."

In summary, agriculture, livestock grazing, and water development must be given their fair share of credit for building and maintaining riparian zone resources. The historical accounts we presented illustrate that agriculture has generally stabilized streams on private lands through water development. These streams now are being used to promote further change in riparian zones and aquatic habitat to enhance other activities, such as camping, fishing, and hunting. In fact, in the western U.S., well-managed private lands and riparian zones represent a large fraction of the critical winter habitat needed to maintain the increased wildlife populations the public desires. Equally important is that the off-stream water developed by agriculture is the reason that the distribution of all grazing livestock can be managed today.

Agriculture and the way water development has occurred in the West provide the solution to the future management of riparian zones for multiple use on public lands. A first step in reaching these goals is to diversify the options for managing grazing of both livestock and wildlife by further developing off-stream water supplies. A second step is to regulate wildlife populations to achieve the riparian zone attributes listed as desirable by federal and state agencies. Agriculture has demonstrated the value of these steps on private lands through wise development and use of water that allows it to maximize control over animal populations, manipulate their distribution, and control how long animals graze forage resources.

For Wyoming, Dorn (1986, p. 87) concluded that: "Today grass is more abundant than it was prior to white man's influence in the area; the prevalence today of cactus, sagebrush and other shrubs was *not* caused by livestock overgrazing." This statement implies that the vegetation that is growing now also grew before livestock were introduced into Wyoming and that erosion now must be about the same as then, because vegetation composition and cover have not changed to any large degree. In view of this, agriculture in Wyoming appears to have accomplished much since the 1930s, when it was common knowledge that livestock grazing was too heavy to maintain desired rangeland conditions. What the public perceives as natural wetland habitat in Wyoming and in the West, along the larger streams in the basin and foothill regions, is not really natural at all. Therefore, if people truly believe in promoting multiple use on public lands, they must accept that a good way to accomplish this is to become partners with the livestock industry that controls water rights and critical riparian habitat on adjacent private lands. The public also must evaluate the relative severity of agriculture's impacts on riparian zones compared with the impacts of other users of western watersheds. Other users can alter riparian zones far more severely than herbivory and hoof action by livestock and wildlife.

The watershed and the condition of its surface as a whole represent how riparian zones appear to the public. It therefore is important that this audience understands fully how historical use of water by agriculture has altered the landscape and riparian zones of the western U.S. We have shown the positive effect that agriculture has had in modifying these important habitats, and strongly encourage people to be aware that the distribution and extent of the riparian zone will change as water use changes. Therefore, we suggest that future planning be conducted on a watershed basis that incorporates historical documentation and use. This will help predict how riparian zones will look following reallocation of water supplies to uses other than agriculture.

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Can Sustainable Agriculture Landscapes Accommodate Corporate Agriculture?

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The Industrialization of Agriculture

The industrialization of U.S. agriculture is recognized as a fundamental change. It is associated with technological advancements and with the shift from food commodities to food products and more integrated marketing channels (Urban, 1991; Drabenstott, 1994). Thomas Urban, former president of Pioneer Hi-Bred, described industrialization as "the process whereby the production of goods is restructured under the pressure of increasing levels of capital and technology in a manner which allows for a management system to integrate each step in the economic process to achieve increasing efficiencies in the use of capital, labor and technology" (Urban, 1991). However, many are questioning whether applying the industrial model is in the long-term public interest (see the comprehensive review by Hamilton, 1994). The primary objection voiced is the separation of ownership from operation (Hamilton terms this "agriculture without farmers"). To the detractors, industrialization threatens the very existence of the family farm, which has been regarded as a powerful and effective economic, political and social structure and a major force in the nation's development (Lobao and Lasley, 1995). Others, such as Urban, see the trend as inevitable, because of new, highly demanding consumers and new producers able to use new technologies to move food from the farm to the dinner table (Drabenstott, 1994). The industrial producers have at their disposal high-powered biotechnology, the latest information technology, and marketing advantages that are less accessible to the independent producer. Perhaps more important, they have access to the large amounts of capital needed for the new technologies.

The industrialization trend in agriculture is not new. Processed vegetables and broilers have long been marketed through contracts and vertical integration. Market eggs and turkeys are largely industrialized, while fresh vegetables and hogs are moving toward vertical integration. Feed grains have resisted this trend (Drabenstott, 1994).

As can be seen in the sustainable agriculture literature, the trend toward industrialization has become highly politicized. Hamilton (1994) expresses the concern that sustainable agriculture must deal with far more than production (soil, water, inputs, prices,

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income), and consider the people on the land. This is a specific charge of the Leopold Center for Sustainable Agriculture at Iowa State University (Benbrook, 1991; Keeney, 1993). The question of the day might be expressed this way: "Is industrialized agriculture compatible with a sustainable agriculture?" The question is troublesome, and the answer might not satisfy everyone. However, it is time to heed Orr's (1994) admonition and put "twine in the baler," that is, to get serious about the threats to agricultural sustainability. To Orr, this means "raising difficult and unpolitic questions about the domination of the economy by large corporations and their present immunity from effective public control, . . . enforcing limits on the scale of economic enterprises . . . [and] a radical reconsideration of the present laissez-faire direction of technology." The "horse is out of the barn"; agriculture must deal pragmatically with industrialization.

Iowa and Swine Industrialization

Pork production is a major Iowa industry (Lawrence et al., 1994). It represents on average over $12 billion of economic activity yearly, or more than 5% of the state total. About $2.7 billion is sales by hog producers, $5.5 billion is packing and processing, and $3.8 billion is additional production activity. The swine industry in Iowa accounts for over 93,000 jobs, or 1 of every 16. Because it is widely dispersed throughout the state, pork production is an important economic activity in every county and represents a key value-added activity for Iowa agriculture, primarily by converting corn grain into higher value products. Kliebenstein (1995) estimates that each hog adds $72 to the value above homegrown feed, or $2.9 million for a typical community, assuming a density of 400 pigs per square mile and a trade area of 100 square miles. Table 1 presents data by Duffy (1992) on the return to management provided by a sow herd on a typical Iowa farm. Returns to labor are much lower on a cash grain farm than a farm that also has livestock.

Iowa could profit in several ways from more hog production. About 20 million hogs are currently marketed per year in the state. That volume is marginal for retaining the meat packing and processing industry (Lawrence et al., 1994). Iowa corn receives on average about 125 lb of fertilizer nitrogen per acre. Manure from swine can provide about 28 lb of that nitrogen if it is spread evenly throughout the state, resulting in significant cost and energy savings. Most important, Iowa needs value-added production, ways for owner-operators to continue making a living, and profitable start-up enterprises for entering farmers.

Several trends are forcing industrialization of the swine industry. Iowa's farm population is aging, and livestock farming is less popular with older farmers. The next generation often lacks the capital to invest in new technologies needed to maintain competitive production. And grain farming, at least before the 1995 Farm Bill, provided sufficient returns for large-scale owner-operators in the regions of the state with high grain productivity.

Table 1. Return to management ($) for various crop and livestock scenarios (Duffy, 1992).

System	Yield Level		
	Low	**Medium**	**High**
400 acres - corn/soybeans	-1,616	6,711	11,844
1,000 acres - corn/soybeans	-1,410	16,777	29,609
400 acres - continuous corn; 120 sows	24,035	31,532	35,885
400 acres - corn/soybeans; 120 sows	29,283	39,320	44,668

The U.S. hog industry has restructured in ways parallel to the overall change in farm structure: a decline in the number of farmers and an increase in the number of hogs per farm (Hurt, 1994; Benjamin, 1995). This trend has been apparent since 1965; in 1994, fewer than 210,000 farms had hogs sometime during the year, down 80% from 1965. The decline in the number of farms that have hogs has been faster than the decline in all farms. Over 55% of all hogs are on farms with more than 1,000 head in inventory. During the last three decades, the total number of hogs in the U.S. has not changed, but productivity has increased about 75% when expressed as pounds of pork produced per head of breeding stock (Benjamin, 1995).

The southeastern U.S., particularly North Carolina, has had the greatest restructuring of the swine industry during the past decade. The number of hogs has increased over 22% per year from 1988 to 1993, largely in very large operations (average of 7,350 head in inventory) (Benjamin, 1995; Wallace's Farmer, 1995). This trend has created a controversy in North Carolina. It is now being repeated in Iowa and other Midwestern states. Iowa has long been the nation's leading hog producing state, with over 25% of the total. Recently, its share has slipped even though its production has not declined in absolute numbers. In just two years (1992-1994), Iowa lost over 20% of its small-scale hog producers (<500 head), although over 75% of its hog producers are still in the small farmer category, the largest proportion in the nation (Wallace's Farmer, 1995). Iowa is seen as competing directly with North Carolina, Missouri and other states that are rapidly moving toward industrialized swine production.

The landscape, geology, climate, culture and farm structure of North Carolina and Iowa are vastly different, and there are many reasons that the two states should not be directly compared. Therefore, I will focus on Iowa, where the structural change is underway. This discussion attempts to provide a framework for coexistence of owner-operated hog farms and truly industrialized farms that use external capital, hired workers and vertical integration, or alternatively, that contract to deliver a specified number of hogs on schedule. I will not go into the social aspects, such as displacement of family farmers and quality of life issues, not because they are not important—they may be the key issues in the controversy—but only to limit the scope and complexity of the paper.

Basis for Evaluation

Society is attempting to evaluate the claim that there are significant differences in the social consequences of large confinement systems versus the smaller, more open systems of the past. Putting the question this way places the burden of proof on the critics of livestock confinement. These critics tend to be from populist movements and are normally not well financed compared with the owners and lobbyists associated with large systems. The alternative claim is that there are no significant differences in the consequences of the two kinds of systems. Putting the question this way places the burden of proof on proponents of the emerging large-scale systems, who must prove these systems do not cause problems.

Unfortunately, it is difficult to establish a basis of comparison. To what should we compare large systems? To well-run small- and moderate-size systems? To the average moderate-size system, which may have environmental and odor problems approaching those of large systems? Or to innovative small-scale systems that will minimize pollution problems while remaining competitive?

Environmental Issues

The storage and treatment of manure (more correctly *excreta*, which contains manure and urine), and the odors associated with it give rise to critical environmental problems in swine production. Manure handling often provokes media coverage, and "flowing rivers of manure" even were part of a recent syndicated column about Iowa. Beneath these environmental issues, which in themselves are very real, lie significant social issues. Even if large systems could magically be made pristine, they still would be perceived as environmentally threatening. The issue becomes one of size: Is bigger really more environmentally threatening, more odiferous, and more a source of pathogenic microorganisms (a very real concern as pathogens such as cryptosporidium become a public health threat in drinking water)? If not, can the larger units be accommodated in a diverse landscape that also permits smaller owner-operated systems to be competitive? And throughout the debate, can we maintain a landscape that is attractive to the urbanite and that conserves natural resources?

This accommodation must be harmonious. Rural friction is increasingly becoming the media's delight. Public fights over these issues are classic lose-lose propositions. A recent column in the *Des Moines Register* (Yepsen, 1995) noted that big hog lots are the hottest issue in Iowa politics in a generation.

Insufficient data are available to assess the environmental impacts of current large hog systems, and even less is known about the smaller systems. A recent scientific workshop on the issue (Jackson et al., in press) found it difficult to assess whether large and small lots differ in environmental impacts and odors, largely because of the lack of data. Issues that are considered unique to large systems include the large concentration of waste in a small area, technical and human failure in managing the lagoons used in large systems, inability of the land around the system to assimilate the waste without creating an overload of nitrogen, phosphorus or biological oxygen demand, and cultural and educational issues associated with proper utilization of the wastes. Individual units differ in their design, their maintenance and day-to-day operations, and their soils, geology, local groundwater regime and climate. This makes sweeping comparisons almost impossible.

Fitting Animals and Grain Production into a Sustainable Landscape

Industrial swine production has separated the rearing of the animal from the production of the feed. This is the crux of the environmental sustainability issue. When feed production is integrated with the feeding operation, manure recycling is easier, less energy is used to transport the feed, the "middle person" (the grain handler) is bypassed (except for supplying specialty products), and labor can be used more productively in the down times of the cropping season. Yet there are many valid reasons for the current trend. It usually is better for the operator to do one activity well than to manage several enterprises less well. But specialization increases risks of market downturns and weather problems. The grain farmer has been helped out of the dilemma by federal subsidies and crop insurance. Is it any wonder that the hog producer would seek to do the same through high technology and marketing agreements?

Another reason that has been put forth for the industrialization trend is that we lack competitive alternatives in swine feeding that require little capital and use appropriate technology. Housing and manure handling are two major needs. Although this might be too sweeping a statement, much of the blame for the lack of appropriate technologies lies with the institutions charged with developing them, in this case the land-grant agricultural colleges. Smith (1992) argues that if the U.S. wants to maintain farming as we know it, publicly funded research must develop technologies that enhance the farmer's ability to provide value-added products. However, there are questions regarding future sources of funds for agricultural research. Frisvold (1991) believes that in the future, major breakthroughs in agricultural technologies will more likely come from the private sector. This raises many questions regarding information availability, appropriate technology, and the interaction of the private and public sector in R&D. Alternatively, Lockeretz (1995) suggests that the academic world may no longer be a satisfactory setting for applied research. He proposes that applied research be done in a service mode that complements the university's traditional academic function.

All is not lost. The vacuum left by the recent shift in attention toward industrial technologies is being filled in alternative ways, including USDA's Sustainable Agriculture Research and Education Program and farmer-organized groups, such as the Practical Farmers of Iowa.

Honeyman (1991) summarized appropriate technologies for sustainable swine production in the Midwest involving the interrelated areas of feeding, manure utilization, animal behavior, genetics, and health. Gestating swine perform well on fibrous feeds such as forages and milling by-products. Substitute feeds for finishing swine include kitchen and food processing wastes and fibrous materials. Alfalfa is an excellent protein source and forage. Changing swine diets would help fit them into a sustainable landscape. Dietary changes also can alter the nutrient composition of the excreta (Honeyman, 1993). When diets are matched to age, with crystalline amino acids used to balance proteins and phytase used to increase phosphorus availability, both the cost of feeds and the nitrogen and phosphorus levels of the excreta can be lowered. The operation would be more efficient, use less feed, and require less land for manure. An Iowa State University team (lead by Dr. Mark Honeyman, Dept. of Animal Sciences, with partial support from the Leopold Center), demonstrated a highly effective feeding machine that automatically computes a diet from the sow's weight (Honeyman and Hoff, 1996). This allows producers to manage diets individually while maintaining the group lifestyle. Lower-cost open housing systems can be used, and a more animal-friendly environment is possible.

Manure from swine is variable in composition, difficult to apply accurately, and costly to recover. In larger systems, manure normally is not valued as a nutrient source. It is treated as a by-product that must be disposed of at low cost and in an environmentally acceptable manner. The move to lagoon storage in large systems increases efficiency of handling but also leads to ammonia volatilization, odor, and the potential for large spills if the system fails. We need low-input systems that use bedding or in some other way make it easy to handle manure.

Housing is the largest capital outlay for a hog farmer. The high cost of housing has accelerated the trend to large systems with corporate backing, including financing for housing. Inexpensive open housing systems are an attractive alternative to swine confinement units. They also offer much better indoor air quality and probably are safer for the workers. Research indicates no great difference in the performance of open and confined systems (Honeyman, 1991). Alternatives include pasture farrowing, with the housing moved around to different sites, and low-cost open air structures. Honeyman (1995a) recently demonstrated the feasibility of a low-cost hooped structure for farrowing and feeding based on successful designs used in Canada. He also recently described a Swedish swine production system that is management-intensive and relies on natural bedding, animal behavior and group housing (Honeyman, 1995b). It would be economically advantageous for medium-size farms, but is not well suited to large farms.

The Answer to the Question

The question "Can various sizes of swine systems survive in a sustainable landscape?" probably must be answered right now with a guarded "maybe" and "it depends." This coexistence should be the goal of the industry and its associated institutions, including the universities. A mix of producers is possible, and would add great diversity to the landscape. To develop this mix we need:

- Policies and educational programs that encourage development of cooperatives that would market manure as a resource (see Younos, 1990)
- A new look at the way grain is handled in intensive livestock producing areas
- Concerted efforts to support appropriate technologies for small swine producers In all cases these should be directed at minimizing environmental impact
- Leadership that can bring the various producers together to provide a common vision.

The next logical step is to move to watershed management. Some of the concepts presented here are close to a watershed or ecosystem approach. Watershed management concepts are catching on in areas such as the New York City catchments (Coombe, 1996). The Raccoon River Watershed, which flows through much of Iowa's most productive land, is now being evaluated as a volunteer demonstration project.[2]

These activities are largely citizen-driven. They represent a coalition of users of a resource—water in these cases—and users of the landscape, working toward a common goal. I see an exciting future in these coalitions, with government as a partner but not as the driver. China has gone much further in applying highly advanced ecological engineering concepts (Mitsch et al., 1993). Their approach integrates animal and fish production, marsh restoration and wetland management. Integrated nutrient management systems also have been discussed in the U.S. (Younos, 1990; Alessi et al., 1994; Karlen et al., 1994).

With dramatic changes coming in intervention in agriculture by the federal government, in global competition, in diet, and even in climate, the future of industrialization in agriculture is anything but clear. Working together, agriculturalists, environmentalists and government can build sustainable rural landscapes; working apart, they will insure the continuation of today's haphazard and divisive times. The latter will hurt people and the environment, but the former can lead to a more sustainable future for Midwest agriculture.

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[2]Information on this effort can be obtained from Roger Wolf, Project Director, Raccoon River Watershed Project, 5400 University Avenue, West Des Moines, IA 50226.

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On-Farm Composting of Food and Farm Wastes: Economic and Environmental Considerations

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The Role of Composting in Solid Waste Management

The United States generates about 180 million tons of solid waste per year, or about 500,000 tons per day (U.S. Environmental Protection Agency, 1990). The four major options for managing municipal solid waste (MSW), in declining order of priority, according to the U.S. Environmental Protection Agency (1988), are source reduction, recycling, incineration, and landfilling. Although landfilling is the least desirable, it is still the primary method of trash disposal in the U.S. Waste disposal costs have increased sharply over the past several decades, for several reasons: the decline in available space (the number of landfills declined by more than 50% just from 1988 to 1995, according to Steuteville, 1995); additional environmental protection regulations; and increased demand for MSW disposal. To divert material from landfilling and incineration, many states have set a recycling target of 40% or higher by the end of the decade.

Most recycling programs target newspapers, aluminum and metal cans, glass containers and, more recently, plastic bottles. Despite the expanded programs, the U.S. currently recycles less than 25% of its solid waste stream (Steuteville, 1995), and achieving a target of 40% or even 30% in the immediate future will be difficult.

A major factor in increasing the recycling rate will be wider use of composting, the aerobic decomposition of organic materials by microorganisms under controlled conditions. Composting can be done on a large or small scale. Like any other production process, the quality of the finished product is directly related to the quality of the inputs and the management practices that are used.

Since yard wastes and food wastes together make up on average about 25% of our waste stream (U.S. Environmental Protection Agency, 1988), composting them could

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easily double the recycling rate in many towns. Also, composting may soon become a necessity rather than an option, since many states no longer accept yard wastes in their landfills. Thus, [illegible]uld be prudent for local and state officials to develop and implement additional p[illegible]s for local or regional composting facilities.

Many towns already use composting to divert much of their yard waste. As of 1992, 78 (33%) of New Hampshire's 234 towns had composting operations (Office of State Planning, 1992); nationally, there were over 3,200 facilities composting yard trimmings in 1994 (Steuteville, 1995). Another recent survey (Kunzler and Roe, 1995) identified 58 facilities that compost food trimmings.

Several pilot projects have demonstrated that source-separated organic wastes collected from grocery stores, produce markets, and municipal institutions (for example, correctional facilities and school cafeterias) can be mixed with other wastes and composted on-farm (Vallini and Pera, 1989; Riggle, 1990; Bye, 1991; Jones, 1992). Furthermore, the grocery industry's Grocery Composting Task Force is supporting industry involvement by setting goals for waste reduction through composting. However, we do not have definitive data on the cost of on-farm composting of source-separated food wastes.

Objectives and Study Areas

The main objectives of this study were to determine whether on-farm composting could be a profitable enterprise for farmers and to assess whether low-to-moderate technology was adequate for on-farm composting. We examined three New Hampshire sites: Parsell Farm in Rochester; Gray Mist Farm in Groveton; and the composting facility at the University of New Hampshire's Kingman Experimental Farm in Madbury. At each site, data on all aspects of the composting operation were recorded.

Parsell Farm, a vegetable farm, composted food wastes from a Dover, N.H., supermarket and the Strafford County Complex, mixed with leaves supplied by the city of Dover. The supermarket food waste consisted of damaged and spoiled fruits and vegetables, salad bar leftovers, unsold prepared food from the delicatessen, and past-date bakery goods. Wastes from the County Complex were food preparation wastes and unserved prepared food.

A grant from the N.H. Governor's Recycling Program was used to purchase a Sittler windrow turner for Parsell Farm. This turner was powered by a tractor that the farm already owned. Parsell Farm received a hauling and tipping fee of $5 per 55-gallon barrel—about $40/ton, based on similar operations (Bye, 1991)—from those food waste generators who wished to dispose their wastes through the project. They deposited their wastes into closed plastic barrels, which were collected every two to three days by an employee of Parsell Farm and replaced with clean, empty barrels.

Gray Mist Farm, a dairy farm, uses Groveton's recycled newsprint as chopped paper bedding for its cows. Every two to three days, an employee of Gray Mist Farm collected food waste from a supermarket in Lancaster, N.H. (12 miles away) in 30-gallon containers provided by the project. This farm took a low-tech approach to composting: a bucket loader that it already owned was used to turn windrows of food waste, yard waste, manure/bedding mixture, and contaminated cardboard. The project purchased a tub grinder for the farm to reduce the particle size of certain wastes and to allow incorporation of food waste and shredded cardboard into the mixture. The farm did not receive a hauling or tipping fee.

The Compost Technology Center at the University of New Hampshire's Kingman Research Farm uses only farm and yard wastes from the University campus. The 4-acre field site receives materials from a concrete storage/mixing pad, where materials are prepared for composting. The material is composted in windrows using an FX 700 Wildcat windrow turner and a hydrostatic drive tractor. Some material is put directly into windrows from dump trucks.

Results of the Pilot Projects

Time spent on composting activities

The following results cover four composting activities: collection; emptying and cleaning the barrels; mixing the materials; and building and turning the windrows. Table 1 shows the fraction of time spent on each activity at Parsell and Gray Mist Farms. The estimated total time devoted to these four activities in a year is 342 hours at Parsell Farm and 234 hours at Gray Mist Farm.

Collection. We collected data at the Parsell Farm from August 3 to October 26, 1992. On average, each barrel collected by Parsell farm required 11.5 minutes of hauling time and about 2.1 truck miles. About five full barrels were collected per trip. Collection time per barrel could be greatly reduced by collecting food wastes from other sources near the supermarket, since the truck was rarely full. At Gray Mist Farm, each barrel required an average of 28 minutes for collection and hauling and 11.4 truck miles. Gray Mist Farm averaged about 2.4 barrels per trip.

Barrel emptying and cleaning. At Parsell Farm, the food waste was added directly to the windrows. At Gray Mist Farm, barrels were lined with paper leaf collection bags and emptied by placing them in the bucket of a payloader and inverting them over a tub grinder. No difficulty was reported with this procedure; because of the paper liner, the barrels required little cleaning.

Material mixing. As noted, at Parsell Farm the materials did not have to be mixed before the windrows were turned. At Gray Mist Farm, the food waste, newspaper bedding and cardboard were shredded in a tub grinder. The soiled newspaper/manure mix

Table 1. Distribution of time used for each composting activity (%).

Activity	Parsell Farm	Gray Mist Farm
Collection	35.2	46.0
Barrel emptying and cleaning	26.8	12.0
Material mixing	N/A	30.5
Windrow building/turning	38.0	11.5
Total estimated hours (for 9 months of composting)	342	234

Table 2. Composting costs and revenues ($/ton).

Activity	Parsell Farm	Gray Mist Farm[1]
Labor	34.60	42.25
Machinery	32.00	17.22
Land	4.00	3.13
Total	70.60	62.60
Tipping fee charged	40.00	0

[1]Estimated, assuming the material processed included the right amount of manure for the amount of food waste (see text).

was combined with the shredded food waste and cardboard in a manure spreader before windrowing.

Windrow building and turning. At Parsell Farm, the item for windrow building and turning mainly reflects turning time. This number should be compared to the total at Gray Mist Farm for windrow building and turning plus material mixing, because these together accomplish the same goal as the one-step process at Parsell Farm.

Costs

We considered all fixed and variable costs in determining the processing cost per ton of food waste tipped. Included with the fixed costs were capital recovery (depreciation), interest, taxes, insurance, and housing. The variable costs are the costs that vary directly with the amount of machinery use: repairs, fuel and lubrication, and labor.

Parsell Farm. During this project, Parsell Farm collected and processed a total of 28 tons of food waste. The average total cost of composting was estimated at $70.60 per ton of waste processed, including collection and transportation. The breakdown by cost component is provided in Table 2. Although this cost is competitive with other waste disposal fees when collection, hauling and tipping are included, it could be reduced further through modifications to the system.

Leaves were chosen to provide the necessary bulking, and the appropriate volume was used to maintain an acceptable carbon:nitrogen (C:N) ratio. The 28 tons of food waste were combined with 400 yd^3 of leaves that were supplied by the city of Dover and delivered directly to Parsell Farm. Five windrows were constructed during the project; three contained food waste mixed with leaves, and two contained only leaves. Only the former are included in the estimates of composting time and cost.

The leaves were contaminated with various materials and needed to be sorted before being formed into windrows. The cost estimates do not include the time used to sort through the leaves because we assumed that under actual operating conditions, the farmer would have rejected the contaminated leaves as unacceptable. There was no charge for delivering or accepting the leaves in this pilot project.

As noted, Parsell Farm charged $5.00 per barrel or approximately $40/ton for collection, hauling and disposal. Since the operation cost $70.60/ton, it incurred a loss of over $30/ton. This loss could be avoided in several ways: increasing the charge per barrel to $8.80; charging a tipping fee for leaves; lowering costs by following some of the recommendations given later; or by selling the compost. However, even at a rate of over $70/ton, composting compared very favorably to alternative disposal options from society's standpoint.

Gray Mist Farm. Because of the high ratio of manure to food waste in the Gray Mist compost, it was impractical to compute the cost per ton. Such an estimate would be unrealistically high if only the food waste (10.65 tons) was included in the calculations, and inordinately low if the total weight was considered (334 tons). Therefore, we estimated the amount of manure needed as a bulking agent and nitrogen source for the actual volume of food waste collected at this site. We did this following the assumption of Rynk et al. (1992) that the ideal C:N ratio would be 30:1 (see Cook et al., 1993, for details). According to this estimate, for every 32 tons of food waste (the estimated amount of food waste collected annually by this farmer), 150 tons of manure should be added to the compost. Under these assumptions, the total cost for composting food waste at Gray Mist Farm is $62.60/ton, which again is competitive with area tipping fees. This cost includes a fair return on the farmer's labor and investment.

Another important consideration is that Gray Mist Farm could not charge a tipping fee for the food waste that it collects because the supermarket's waste hauler charges on a volume basis. Therefore there is no saving when the weight of the waste is decreased, because the volume was unchanged. Prospective participants in composting operations should carefully examine the local waste disposal fee system.

Kingman Farm. Project expenses at Kingman Farm included the initial investment to prepare the site for composting. This cost is incurred regardless of whether any compost is ever produced. Included are land clearing, construction of the materials storage pad, and installation of the septic system at the materials storage pad. These costs totalled $28,262. Machinery and equipment investment were $41,750, including $12,800 in new machinery and equipment.

Costs incurred during compost production include collection of materials for composting, such as manure, wood ash, yard waste, etc., and transportation to the materials storage pad. A total of 7,200 yd^3 of material is required per year (32 rows × 225 yd^3 per row). Also included were material mixing, hauling to the windrow site, and loading of the compost for delivery. Each windrow yields 200 to 250 yd^3 of compost every nine months, for an annual production rate of 3,200 to 4,000 yd^3 for 12 windrows. All costs of machinery maintenance, materials, insurance, taxes, and labor were included. Total estimated cost per year was $37,488. This is equivalent to a cost of $10.44 per yd^3 of compost produced, exclusive of marketing and handling (see Halstead et al., 1993, for further details).

In all three case studies, changes in the assumptions used to derive cost estimates can alter the final price substantially. For example, whether the site is fully used, whether the other equipment is being fully used, and the next best use of the land (that is, its opportunity cost) all will affect final cost estimates.

Discussion of Results

Compost costs

Thorough cost analysis of the three pilot composting projects showed that on-farm composting of source-separated food waste is an economically feasible method to dispose of this portion of the waste stream. The net costs for collection, hauling, processing and tipping are competitive with other methods of solid waste disposal in New Hampshire. Paid at this rate through a combination of tipping fees and compost sales, farmers would receive a fair return on their labor and capital investment.

The process can be changed to become more efficient and less costly. The tipping fee of $5.00 for 250 lb of food waste at Parsell Farm was too low. For this farm to recover the true costs under current production conditions, it would need either to raise the tipping fee to $8.80 for 250 lb or to obtain some value from use or sale of the compost.

Process changes

Experiences at Parsell Farm illustrate the importance of composting efficiently. Arranging a route with enough stops to fill the collection vehicle with food waste, selecting waste generators who are near each other, using straight-sided barrels, lining barrels with compostable paper bags, and installing a pressure washer all would increase the efficiency of the operation and in turn decrease its costs.

If the supermarket in Groveton could renegotiate its contract with its waste hauler to reflect the weight of its waste rather than the volume, it could save on waste disposal costs. It then could compensate Gray Mist Farm for tipping the produce waste.

Kingman Farm uses equipment and techniques that may not be necessary at all composting sites. For example, the septic system used for leachate collection and sampling at the storage pad would probably not be required in all instances, depending on local and state ordinances and the physical nature of the site. In addition, it is possible to produce a satisfactory compost using only a tractor and a bucket loader for turning. Although this results in less aesthetically pleasing windrows and possibly a coarser compost, it might be cheaper than using the Wildcat turner pulled by a hydrostatic drive tractor, depending on the changes in labor that it would require.

Compost quality

Although neither commercial farm in this pilot study could recover all its costs through tipping fees, the possibility remains for the farmers to sell the finished compost product. Both commercial farms produced high quality compost, as did Kingman Farm (see Table 3). Laboratory results showed that the Parsell Farm compost was of high enough quality to be used as a potting medium, with a pH of 6.2 and an electrical conductivity (an indicator of soluble salt concentration) of 2.28 mmho/cm. The Gray Mist Farm compost was high in both pH (9.2) and soluble salt concentration (electrical conductivity 4.15 to 4.93 mmho/cm), which would prohibit its use as a potting medium. However, it could be used as a soil amendment or topdressing compost.

Siting considerations

Rural areas lend themselves to on-farm composting, not only because they have land available, but also because it is likely that neighbors are accustomed to farming's potential for undesirable side effects, such as flies and odors. Rural areas also have more technical experience in managing organic wastes, since they produce livestock manures and other wastes. This expertise make rural areas prime choices for large-scale composting activities.

Table 3. Representative analyses of composts and topsoil (dry weight basis).

	Parsell Farm Compost	Farm/Yard Waste Compost[1]	Gray Mist Farm Compost	Topsoil[1]
Chemical analysis				
pH	6.2	6.7	9.2	6.5
Organic C (%)	13.9	30.4	10.4	3.1
Total N (%)	0.78	1.3	0.76	0.3
C:N	17.8	24.2	13.7	10.7
Total P (%)	0.1	1.0	0.5	0.1
Total K (%)	0.9	1.2	1.5	0.1
Total Ca (%)	2.0	2.2	0.5	0.1
Total Mg (%)	0.3	0.5	0.3	0.2
Electrical conductivity (mmho/cm)	2.3	2.5	4.5	0.1
Nutrient/fertilizer value (lb/dry ton)				
N	16	26	15	6
P_2O_5	5	46	24	5
K_2O	21	29	35	2

[1]Fertilizer-grade compost and topsoil from the Compost Technology Center, Kingman Farm, Madbury, NH.

Water quality

A consideration in composting food and yard wastes is the environmental effect of consolidating the wastes in a small area. An N-transport and mass-balance study performed at the Kingman Farm site found high levels of NO_3-N concentrations (>100 mg/L) directly beneath the windrows. Major factors determining N loss during composting appear to be the form of organic C and the fraction of inorganic N contained in the waste, and the bulk density and moisture content of the waste. N losses during composting were 10 times higher for farm waste than for yard waste (Douglas and Ballestero, 1995). Although these losses appear high, elevated losses directly under windrows do not necessarily degrade groundwater quality significantly. As always, prudent consideration is required of issues such as surrounding property uses, setbacks, and monitoring.

Conclusions

In general, the processing cost per ton of waste disposed makes on-farm composting an economically efficient method for managing food, farm, and yard wastes using low-investment, low-technology composting. When judging the cost estimates from the case studies, other farmers and food waste generators should carefully consider the assumptions used and adjust the cost figures according to their specific situations.

A remaining question is whether composting should be conducted as an auxiliary farming activity, as it was at the two pilot project farms, or whether it should be a primary on-farm enterprise. If composting is to be a principal farming activity, the changes in machinery costs need to be considered to determine whether composting will remain competitive with other methods of waste disposal. Also, the consequences of diverting management time to composting or other farm enterprises may be highly important in the decision to compost.

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Recycling Municipal Organic Wastes through Compost Application to Agricultural Land

Thomas A. Obreza[1]

Composting: A Waste Management Alternative for Municipalities

Florida's municipal solid waste (MSW) management has become more complex and expensive because of difficulties in siting new landfills as older ones approach capacity. Current landfill tip fees are above $40 per t (metric ton), almost double the U.S. average. Also, strict new environmental standards have reduced the capacity of some landfills and caused others to close (Glenn, 1992).

The 1988 Florida Solid Waste Management Act mandated that counties relieve the strain on landfills by recycling 30% of their MSW. In 1993, the goal was modified to include a reduction in wastes at the source, such as by returning grass clippings to lawns. However, the volume of yard trimmings and the organic fraction of MSW will continue to rise with increasing population, so methods of disposal other than landfilling need to be explored. Alternatives include incineration, which is considered environmentally unacceptable by some, and composting.

Composting involves natural degradation of labile organic compounds by fungi, bacteria, and actinomycetes, which in turn synthesize new compounds that are resistant to further decomposition. This process occurs wherever organic materials accumulate naturally. Most decomposition is aerobic, in which the decomposing organisms use oxygen. Some breakdown is anaerobic (without oxygen), such as that which occurs beneath shallow water. Most organic waste materials derived from municipalities are composted aerobically. Composting is being encouraged as a solid waste disposal method because returning the composted products to the land recycles organics to the site where they originated.

Feedstocks for Compost Production

It was predicted in 1988 that annual MSW production in Florida would be 16.7 million t by 1994. However, by 1992, production had already reached about 18.4 million t (Florida Department of Environmental Protection, 1993), which represents over 3.6 kg

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per resident per day, or about 1.4 t per resident per year. These figures are twice the national average, and may result from the impacts of 40 million tourists and from construction debris associated with a rapidly expanding population (Smith, 1994). The increase in MSW has occurred despite the recycling mandated by the Florida legislature in 1988.

About 60% of the total MSW waste stream is composed of biodegradable organic materials, including yard trimmings, paper, and food, which amount to about 10.2 million t per year. Other compostable material includes biosolids (sewage sludge), crop residues, and food processing wastes. Plant material cut from yards and land clearing operations make up 15.5% of MSW, or 2.9 million t per year (Smith, 1994). The largest single compostable fraction in Florida's MSW is paper (Florida Department of Environmental Protection, 1993).

If the entire biodegradable fraction of MSW were composted, about 5.4 million t of compost would be generated. The yard waste fraction, which is now prohibited from landfills, would yield about 1.5 million t. Since yard waste is essentially 100% organic and is easy to segregate and collect, it should have high priority as a compost feedstock. Returning these materials to the land as compost or mulch contributes to biological cycles and is an ecologically benign and sensible way to recycle organic wastes (Smith, 1994).

Potential Benefits of Compost Applied to Agricultural Land

The importance of organic matter (OM) to the productivity of sandy soils has long been recognized (Follet et al., 1987). Most Florida soils have almost no OM because the warm, humid climate provides a highly favorable environment for degrading organic residues. The OM in compost has been converted to highly stable, recalcitrant compounds, and so does not break down as quickly as fresh crop residues. Its positive effects in the soil are longer-lasting, and it can be applied at much higher rates than crop residues.

Organic matter in MSW compost can improve the soil's physical, chemical, and biological properties if applied at a high rate (He, 1992; Shiralipour et al., 1992). It contains many fine pores, both within and between the particles, that are responsible for its high water-holding capacity. Florida's mineral soils are composed mostly of quartz sand particles. While water transmission through these soils is high, their ability to hold water in the root zone is low. Mixing compost with sand increases the soil's water-holding capacity, while the sandy nature of the soil maintains high hydraulic conductivity.

Freshly made compost is in a less decomposed state than soil humus (stabile soil OM), so its chemical activity is limited until it is converted to humus over time. Humus is chemically active because it has a large surface area and therefore a high cation exchange capacity (CEC), which is closely related to soil fertility (Tisdale et al., 1985). Most CEC in Florida mineral soils originates from humus, so added compost eventually will improve soil fertility as it humifies. Fresh compost can affect other soil chemical properties such as pH, which usually rises after adding compost (a liming effect), and soil nutrient levels. Organic matter acts as a storehouse for N, P, S, B, and many micronutrients, which are released slowly as the compost breaks down. Compost with a high concentration of Ca or Mg may precipitate P fertilizer, preventing it from leaching through sandy soils that have no capacity to adsorb P.

Soil quality is defined as "the capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health" (Doran and Parkin, 1994). Perhaps the most important component of soil quality is the soil microbial activity level, which can be measured in terms of microbial biomass, potentially mineralizable N, or soil respiration. Positive functions of soil microorganisms include mineralization of plant nutrients, transformations of soil N, fixation of atmospheric N, degradation of synthetic organic agrochemicals, and suppression of soil-borne diseases. Soil microorganisms require C as a source of metabolic energy, so their activity may be proportional to and limited by C availability. Adding compost to a Florida soil deficient in OM may increase the population and diversity of soil microorganisms, with the associated benefits of improved soil quality.

Compost Utilization Research in Florida

Overview

A comprehensive research program on compost utilization was conducted at ten Florida locations from 1992 through 1994. The projects focused on whether using compost could save irrigation water, but other benefits (and drawbacks) also were identified. The cropping systems in the experiments ranged from high-value horticulture to low-value field crop production and forestry. This report focuses on compost applied to sandy soils used for vegetable production.

The composts were commercially made from household garbage or from a combination of garbage and municipal biosolids (sewage sludge). They were composted for at least 8 weeks at facilities in Pembroke Pines, Florida (Reuter Recycling, Inc.) or Sevierville, Tennessee (Bedminster Bioconversion, Inc.). The resulting products were shipped to field sites throughout Florida and used within a few weeks after they were received.

Compost characterization

The composts contained between 20 and 50% moisture upon arrival. Reuter compost contained large, noticeable pieces of glass and plastic and had an objectionable

Table 1. Chemical properties of Reuter and Bedminster composts.[1]

Property	Reuter	Bedminster
pH	7.6	7.2
Carbon (%)	37.0	17.0
Nitrogen (%)	0.92	0.83
C:N ratio	41	21
Phosphorus (%)	0.31	0.44
Calcium (%)	2.34	1.91
Magnesium (%)	0.17	0.21
Potassium (%)	0.28	0.26
Sodium (%)	0.39	0.14
Zinc (mg/kg)	372	340
Copper (mg/kg)	216	177
Manganese (mg/kg)	162	357
Iron (mg/kg)	3,910	19,600
Cadmium (mg/kg)	4	9
Lead (mg/kg)	233	114
Nickel (mg/kg)	20	23

[1]Source: Eichelberger (1994).

odor. Bedminster compost contained almost no visible inert material and was nearly odorless. Chemical and physical properties of each compost were evaluated in the laboratory. The composts were high in Ca and Fe and low in heavy metals (Table 1). N concentration, which influences future soil N availability to plants, was about 1%. Based on their C:N ratios, Bedminster compost was more mature than Reuter. Although many different plant nutrients were present at low concentrations, substantial quantities would be slowly available to plants if the composts were applied to soil at about 20 t/ha or more.

Composts were mixed with sandy soil in the laboratory at concentrations equivalent to the maximum rates applied in field experiments (112 t/ha for Reuter and 27 t/ha for Bedminster, incorporated to a depth of 15 cm) to investigate the effect on soil water-holding capacity (Table 2). Reuter compost increased the saturation water content (zero water potential) by 5% compared with unamended sand, indicating an increase in pore space. As the soil dried, Reuter-amended soil maintained about 5 to 7% higher water content than unamended soil at any given water potential, a substantial increase for a sandy soil. The practical implication is that the soil would be less droughty and would

Table 2. Water content of sand-compost mixtures at five soil water potentials.

Water Potential (centibars)	Soil Water Content (% by Volume)		
	Sand	Sand+Reuter	Sand+Bedminster
0	37.6	43.0	38.3
-5	26.8	29.2	26.4
-10	15.1	20.5	14.6
-20	9.5	16.3	10.2
-35	6.5	12.8	7.5

have better lateral water movement from a point source such as drip irrigation. Bedminster compost, applied at about one-fourth the rate of Reuter, did not affect soil water-holding capacity.

Eichelberger (1994) mixed compost with sand in the laboratory at a rate equivalent to 135 t/ha and measured C and N mineralization (release of water-soluble forms to the soil) over time. Through 10 weeks, 6% of C in Reuter compost mineralized, while less than 1% of C in Bedminster compost mineralized. Over 17 weeks, less than 0.2% of organic N mineralized from either compost. The composting process assimilated soluble N in the feedstocks while converting easily degraded compounds to more stable ones. These data should allay environmental concerns that a large amount of N would be released over a short time in soils amended with high rates of MSW compost.

Compost utilization in vegetable production

Reuter and Bedminster composts, applied at rates between 13 and 112 t/ha, were incorporated 15 cm deep into typical south Florida soils used for winter vegetable production at Homestead, Bradenton, and Immokalee. The Homestead site had gravelly, alkaline, crushed limestone soil, while the soil at the other two sites was an acidic sand. All soils had OM concentrations of about 1%.

When stable, mature materials were applied to soils, several crops, including tomato *(Lycopersicon esculentum)*, bell pepper *(Capsicum annuum)*, crookneck squash *(Cucurbita pepo)*, and watermelon *(Citrullus lanatus)* grew as well as or better than in unamended soil. When immature composts were applied, followed by immediate transplantation of fast-growing vegetable seedlings, early growth was reduced. The reduction was attributed to either "N rob" (the tie-up of soil N by microorganisms attacking the compost), or phytotoxic organic acids produced from anaerobic decomposition. The reduction in growth was only transient, because the compost continued to mature in the soil. Plant growth returned to normal about 90 days following addition of immature compost, but this was too late to avoid a yield decrease.

At Homestead, adding either Reuter or Bedminster compost increased the yield of large and marketable tomatoes and decreased the yield of culls compared with unamended soil in one of two growing seasons. The size and yield of squash plants also increased as the compost rate increased (Bryan et al., 1994). At Bradenton, yields of marketable tomatoes (all fruit sizes), extra-large tomatoes, and bell peppers increased with addition of mature Reuter compost at 112 t/ha to drip-irrigated soil. There appeared to be more benefit from compost when crops were drip-irrigated than when they were sub-irrigated, most likely because of the altered water retention characteristics of the amended soil, including better lateral water movement away from the drip irrigation tubing (Clark et al., 1994). In one of two growing seasons at Immokalee, adding Bedminster compost at 27 t/ha increased the yield of extra-large tomato fruits with drip irrigation; adding Reuter compost at 112 t/ha increased the yield of drip-irrigated watermelons (Table 3). However, addition of immature composts seriously depressed yields (Obreza, 1994).

Measurements of field soil fertility indexes were made at Immokalee to quantify compost benefits. Reuter and Bedminster composts were applied twice at this site, once at the start of each growing season. Soil was sampled throughout the year and analyzed for OM concentration, pH, and extractable nutrients. Long-term positive effects of compost on soil fertility were evident (Table 4). Reuter compost at 112 t/ha increased soil OM more than 0.5% and 1.0% after the first and second years, respectively. Smaller increases were observed with Bedminster compost at 27 t/ha. Soil pH was increased more than 1.0 by Reuter compost and more than 0.5 by Bedminster compost after two years. Vegetable growers on sandy soils often need to raise soil pH into the range 6.0 to 7.0, so compost use could eliminate the need for regular lime applications.

Table 3. Effect on vegetable yields of composts added to sandy soil.

Soil+Compost[1]	Tomato Yield (t/ha) Ex-large	Tomato Yield (t/ha) Total	Watermelon Yield (t/ha)
Sand	22.2	48.6	32.5
Sand+Reuter	7.4[2]	28.8[2]	50.1
Sand+Bedminster	25.8	52.6	28.4

[1]Reuter and Bedminster application rates were 112 and 27 t/ha, respectively.
[2]Yield depression because of immature compost.

Table 4. Fertility analyses for Immokalee sand soil, and with soil amended with compost.

Soil+Compost[1]	Organic Matter (%)	pH	Mehlich 1-Extractable (mg/kg Soil) P	K	Ca	Mg
			After 1 year (one compost application)			
Sand	1.40	5.7	24	19	500	24
Sand+Reuter	1.93	6.5	50	33	917	36
Sand+Bedminster	1.54	5.9	36	25	645	32
			After 2 years (two compost applications)			
Sand	1.48	5.5	45	20	611	28
Sand+Reuter	2.63	6.8	129	49	2030	75
Sand+Bedminster	1.85	6.2	79	31	977	50

[1]Reuter and Bedminster application rates were 112 and 27 t/ha, respectively.

P, K, Ca, and Mg usually are applied as fertilizer each growing season. In the Immokalee experiment, these fertilizers were applied to the tomato and watermelon crops at recommended rates in the first season, and 25% below recommended rates in the second. Soil extractions at the end of each year (using the double-acid Mehlich 1 solution) reflected differences in the amount of each fertilizer nutrient retained in the soil, as well as nutrients extractable from the composts themselves. Compost can be expected both to aid in retaining fertilizers and to supply nutrients from its own matrix, but the Mehlich 1 extraction did not distinguish between the two forms. Substantially more Ca and P were extracted from compost-amended soil, especially after two years (Table 4). Extractable Mg and K also were higher where compost was applied, but to a lesser degree. Chemical analysis of the composts indicated high Ca levels, which most likely increased the soil's extractable Ca. Phosphorus fertilizer may have been retained by the compost through chemical interaction with Ca or Fe. If the extractable nutrient levels were used in the University of Florida's fertilizer recommendation procedure, which is based on a soil test, less Mg and P would be recommended where compost had been applied.

Watermelon tissue from the second-year crop was analyzed for Zn, Cu, Cd, Pb, and Ni to assess metal bioavailability from composts. There were slightly higher Zn and Ni levels in rind tissue grown with Bedminster compost compared with unamended soil (Table 5). However, there were no differences in Cu, Cd, Pb, or Ni concentrations in

Table 5. Concentration of five metals in watermelon tissue.

		Metal Concentration (mg/kg Plant Tissue)				
Soil+Compost[1]	**Tissue**	**Zn**	**Cu**	**Cd**	**Pb**	**Ni**
Sand	Rind	97	8.0	0.23	3.2	2.3
Sand+Reuter	Rind	104	7.2	0.28	3.5	1.9
Sand+Bedminster	Rind	115	8.3	0.28	3.4	3.4
Sand	Flesh	40	7.4	0.10	2.9	0.9
Sand+Reuter	Flesh	18	5.1	0.10	2.2	0.8
Sand+Bedminster	Flesh	32	5.8	0.13	2.7	0.9

[1]Reuter and Bedminster application rates were 112 and 27 t/ha, respectively.

flesh tissue (the eaten portion). There was more Zn in flesh tissue grown on unamended sand than on sand plus Reuter compost. Thus, metal uptake from compost was negligible compared with uptake from unamended soil.

Comments and Outlook

In general, application of stable, mature MSW composts had benefits for plant growth, such as increased plant size, yield, and quality. Although some positive plant responses were dramatic, compost application did not always make a difference, and sometimes had the opposite effect if the material was immature. Increases in plant growth were associated with increased water-use efficiency and soil fertility. The results emphasize that MSW compost is not fertilizer, because it releases nutrients very slowly. It functions primarily as an amendment that improves the soil's physical and chemical properties, which is why such high application rates are required. In other Florida studies, compost also enhanced the suppression of diseases and adsorption of pesticides. Uptake of heavy metals by plants was not increased by compost addition.

Although application of MSW compost to agricultural land is now being recognized as a way to recycle organics, barriers remain for widespread production of compost by municipalities and its use by agriculture. While composting was quickly accepted as a way to treat yard wastes after they were prohibited in Florida landfills, many municipalities are reluctant to try composting household garbage and biosolids because of the expense and the uncertainty about product markets. Agricultural land users are reluctant to try composts because of potential problems such as aesthetics (presence of inerts), the variability of materials produced by different composting methods, and the lack of maturity standards.

The main barrier that composting will face in the agricultural sector is affordability. Waste generators (the city) and potential compost users differ regarding how to share the cost of making compost and transporting it to its application site. Agriculture, in a sense, is doing urban residents a favor by providing a place to recycle their organics. If the grower cannot afford to use compost, it will not be used on a large scale and there will be no incentive to produce it. However, if the city subsidizes the cost of production and transportation, then using compost becomes much more attractive. Tipping fees at MSW composting facilities should cover some or all of the transportation costs to agricultural areas. Costs could also be defrayed by government subsidies or cost-sharing programs.

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Best Nutrient Management Practices on Watersheds to Protect Water Quality in Massachusetts

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Introduction: The Importance of Nutrient Management

Agricultural activities, especially the heavy use of fertilizers and pesticides, can be significant nonpoint sources of pollution, harming the quality of both surface and groundwater. Some chemicals, such as nitrate, dissolve in water and are readily transported to groundwater by macropore water movement. Phosphorus is adsorbed on sediments and can be transported to surface waters with runoff. Surface and groundwater can be protected by improved nutrient management practices, especially in areas of critical environmental concern, such as watersheds and coastal zones.

Nutrient management on farms is becoming increasingly important, both economically and environmentally. Best nutrient management practices should reduce leaching and runoff of nutrients from the field and provide enough nutrients for realistic crop yields (Shuyler, 1994). Economically, it is important that growers consider all nutrient inputs when calculating crop fertilizer needs, so that they spend only what is needed to reach their yield goals. Frequently, available nutrients from manure and cover crops are overlooked when calculating fertilizer needs. It also is necessary to recognize the environmental consequences of nutrient and manure management practices and to strive to minimize environmental damage while maintaining adequate yields.

A nutrient management plan requires a clear understanding of nutrient cycling and an assessment of the quantity of nutrients entering and leaving a farm. Klausner (1995) observed that nutrients can concentrate on livestock farms if there is a net importation of nutrients onto the farm; he found that a significant proportion of imported nutrients remained on the farm. He further discussed the fact that the proportion of nutrients that remained was related to individual feeding and fertilizer practices, not to farm size. His studies on mass nutrient balances in New York (Klausner, 1995) showed that purchased feed usually is the primary and fertilizers the secondary source of imported nutrients.

Through proper nutrient planning and utilization, manure nutrients can be recycled effectively on a typical dairy farm. N and P commonly accumulate on dairy farms

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because of continuous manure application to corn *(Zea mays)*. Many farmers also add commercial fertilizer, further increasing the potential for surface and groundwater pollution. Ryden (1984) reported that less than 20% of the N input in forage products leaves the farm as milk, meat, or wool, indicating that a large amount of N input remains on the farm.

The objective of this paper is to identify several nutrient management strategies on dairy farms and their role in reducing pollution and improving water quality. We also address the present level of adoption of these practices on Massachusetts dairy farms, as shown by a survey conducted by the University of Massachusetts.

Manure Management

Manure as a fertilizer

Manure is an excellent source of N, P and K, and could supply all crop nutrient needs when managed efficiently. The timing and method of manure application determine the efficiency of nutrient cycling. The nutrient content of manure varies greatly, depending on such factors as its moisture content, the quality of the livestock feeds, the bedding used, how the manure was handled and stored, and the time between spreading and incorporation. When manure is applied at a rate that supplies the N needed by the corn crop, the P and K will likely exceed the crop's requirement and therefore accumulate near the soil surface. To prevent the P adsorbed on soil from being transferred to streams by runoff, it is essential to apply animal wastes to land sufficiently far from streams. Similarly, applying N in excess of the crop's need could be a threat in areas of groundwater recharge (Gburek and Pionke, 1995).

About 85% of the K in manure is available for plant growth in the year of application. Some N and P is in stable organic compounds and must be mineralized before becoming available. About 80% of the P is available in the year of application. All the inorganic N in manure (45 to 50% of the total) is available in the year of application, but is subject to losses from ammonium volatilization and nitrate leaching. A significant amount of organic N is available from the current and previous year's applications through mineralization. To reduce pollution and to supply sufficient nutrients to crops, it is essential to know the quantity of manure being spread and its nutrient content. Because the capacity of different manure spreaders varies, calibration of the spreader is essential for calculating the application rate. Knowing the amount of manure spread and the plant nutrients available from the manure will enable farmers to improve their nutrient management techniques.

Many dairy farmers in Massachusetts apply manure predominately on corn land, and to a lesser extent on hay fields. Previous research (Daliparthy et al., 1994) showed that manure at an N rate of 112 kg/ha can be applied to alfalfa *(Medicago sativa)* without any NO_3^- leaching into groundwater. This alternative of applying manure to perennial forages in addition to corn will greatly increase the area available for manure spreading on dairy farms. Application of manure to forage legumes serving as N scavengers could result in more efficient use of excess available manure N, thereby improving the N mass balance on dairy farms (Daliparthy et al., 1994). Farms that import feed and fertilizer typically will retain a high proportion of the purchased nutrients and therefore need these alternative approaches to prevent nutrient build-up in soils. Where soil N is excessive, applying manure to leguminous crops may limit further N buildup from N fixation.

In our research, applying manure to alfalfa at an N rate of 112 kg/ha for three consecutive years did not significantly affect either herbage yield or NO_3^- concentration in soil water (Daliparthy et al., 1995). However, annual manure applications at a higher N rate (336 kg/ha) significantly increased the NO_3^- level in soil water after three years. Our research also has shown that first-year corn following unmanured or manured alfalfa did not need additional N fertilizer. Any additional N fertilizer application increased NO_3^- leaching without improving silage yield (Daliparthy et al., 1995). However, second-year corn responded positively to manure or N fertilizer application.

Soil and manure testing for nutrients

Testing the soil regularly and basing fertilizer rates on the results is the most efficient way to prevent excessive application of nutrients, and therefore can reduce environmental pollution. Manure management practices should include analyzing manure for its nutrient content and basing application rates on soil fertility and the crop's nutrient requirements. This prevents overapplication of manure on any particular field and reduces the need to buy fertilizers. Application of large quantities of inorganic N to corn in the spring before planting can result in loss of NO_3^- into groundwater. Similarly, overapplication of N, either through fertilizer or manure, can result in loss of NO_3^- throughout the growing season and especially after harvest in the fall (Daliparthy et al., 1994). A high NO_3^- concentration and increased water in the soil profile during the fall make that period critical for NO_3^- monitoring (Daliparthy et al., 1994). A pre-sidedress N soil test (Magdoff and Amadon, 1984) for silage corn is a useful tool to predict in-season N availability. This test not only benefits farmers economically by saving them money on N fertilizer, but also benefits the environment by reducing NO_3^- leaching.

Cover Crops

Winter cover crops have shown benefits in reducing NO_3^- leaching and soil erosion. Cover crops can effectively use residual N in the soil that otherwise might leach into groundwater after the corn harvest. Meisinger et al. (1991) reported that cover crops can reduce both the amount of N leached and its concentration in the soil by 20 to 80% compared with no cover crop. They further concluded that grasses and brassicas are two to three times more effective than legumes in reducing NO_3^- leaching. Similarly, studies in Massachusetts found that rye *(Secale cereale)* and hairy vetch *(Vicia villosa)* cover crops following harvest of corn reduced NO_3^- leaching (Daliparthy et al., 1991; Herbert et al., 1995).

Survey of Nutrient Management Practices on Dairy Farms

As part of a nutrient management and conservation tillage program at University of Massachusetts Extension, 139 dairy farmers from all regions in Massachusetts were interviewed in person regarding their crop production practices (Herbert et al., 1994). The dairy farms ranged from fewer than 25 milking cows to more than 400. About 69% of the farms visited had fewer than 100 cows (Table 1).

Almost all the farmers (96%) test their soil, with most (60%) testing each year (Table 1). However, fewer farmers (25%) analyze manure for its ability to supply nutrients. About 80% have not calibrated their manure spreaders, and of those who have analyzed manure, 20% still have not calibrated their spreaders. Long-term overapplication of manure can result in problems for both crop nutrition and the environment. Overapplication of manure on some fields may result in nutrient shortages on other fields, leading to unnecessary expenses for fertilizers. Also, to assume a certain nutrient contribution from manure but not actually get it can reduce crop yields and profits.

About half the farmers surveyed (49%) indicated that they broadcast fertilizer on corn fields (Table 1). Unless farm nutrient planning shows the need for this, some of this fertilizer may be excessive. To avoid the expense of broadcasting unneeded N fertilizer, we suggest using a starter fertilizer only if the soil test indicates a need for P, or else skipping even the starter except when planting very early. N fertilizer should be side- or top-dressed according to the pre-sidedress N test when the corn is about 30 cm tall. About two-thirds of the farmers reported that they use starter fertilizers, and about one-third side- or top-dress. These means that many farmers are well positioned to refine their soil fertility practices.

Ten percent of the farmers have liquid storage facilities and 25% have semi-solid storage, with the others stacking manure in the field or spreading it daily (Table 2). This suggests that many farmers are not achieving the optimal benefits from manure nutrients, especially N. If manure (either liquid or semi-solid) is not incorporated, N from ammonium and the easily decomposable organic fraction can be lost within 7 to 10 days. These compounds represent about half the total N value of manure. Considering that the remaining stable N is made available slowly during the next 10 to 20 years, most of the N benefit from one year of manure application will be unavailable to benefit plant growth. We observed that most farmers do not usually incorporate manure soon enough to optimize its N contribution. Sometimes the decision to incorporate manure depends on the type of crop or other field conditions.

Table 1. Herd size, use of soil tests, and use of commercial fertilizer on dairy farms surveyed.

Total number of cows	Farms (%)	Frequency of Soil Testing	Farms (%)	Fertilizer Usage	Farms (%)
1 to 50	25	Annually	60	Broadcast	49
51 to 100	44	Occasionally	36	Starter	64
101 to 150	14	Never	4	Side- or topdress	32
151 to 200	12				
> 200	5				

Table 2. Farm manure storage and usage of manure on crops.

Manure Storage	Farms (%)	Manure Usage	Farms (%)
Liquid storage	10	Corn	89
Semisolid storage	25	Hay	80
Field stack	57	Pasture	11
Daily spread	60	Corn land receiving no manure	28

Almost all the farmers (89%) use manure on some corn, 80% use it on hay fields, and 11% use it on pasture (Table 2). However, 28% of corn land receives no manure. Corn fields should have the highest priority for receiving manure, since N losses will be great from surface applications to hay and pasture. However, if there is surplus manure after the corn's needs are met, application to hay fields may be appropriate.

Summary

The present status of nutrient management practices on Massachusetts dairy farms is encouraging. Many farmers test their soils. They should be further encouraged to apply fertilizer or manure according to soil test results. Only 35% of the dairy farms we surveyed have a manure storage facility; the remainder spread manure daily or stack it in fields. Spreading of manure during the winter on frozen soils can increase runoff losses and has prompted environmental regulations in some states. Improvements in storage and application are required to prevent environmental pollution. Application of manure on frozen soils during winter should be discouraged. An important reason that many farmers do not have any manure storage is the high cost of installation. Composting of dairy manure may be an alternative for some farmers.

Another important aspect of environmentally sound manure management is calibration of manure spreaders. Most farmers in our survey had not calibrated their manure spreaders. This could result in overapplication of manure and therefore in nutrient accumulation in soils. Calibration of manure spreaders will improve manure use efficiency and prevent water pollution. Farmers should be encouraged to plant cover crops and to conduct the pre-sidedress N test for corn. Adoption of best nutrient management practices also will improve soil quality, agricultural sustainability, environmental quality, and especially the farm economy. However, farmers' aversion to economic risk is a major obstacle to the adoption of alternative technologies. The farming community must play a more proactive role for the adoption of many environmentally sound and economically sustainable strategies.

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Environmental Enhancement Using Short-Rotation Woody Crops and Perennial Grasses as Alternatives to Traditional Agricultural Crops

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Introduction: Alternative Energy Sources

Short-rotation woody crops (SRWC) and herbaceous crops (perennial grasses) are receiving increasing interest as potential alternative energy sources that also can provide extensive environmental benefits. These benefits can be viewed as occurring on a scale ranging from global (reductions in greenhouse gases) to a specific site (decreases in erosion and the need for chemicals compared with traditional row crops). When grown as biomass feedstocks, these woody and herbaceous crops can be significant sources of energy and fiber in some regions of the country. Besides offering an alternative energy resource, they can provide crop diversity and both economic and environmental benefits to local agricultural communities. The potential environmental benefits of short-rotation woody crops and herbaceous energy crops compared with traditional row crops include improved soil quality and stability (reduced erosion), cover for wildlife, and lower inputs of energy, water, and agrochemicals (McLaughlin, 1992; Wright et al., 1993; Tolbert and Downing, 1995).

The need to reduce national dependence on imported oil and the opportunity to develop the nation's potential to produce high-yielding biomass energy crops have prompted significant research on both the agricultural production and energy conversion technologies necessary to achieve this potential (Lynd et al., 1991; Wright, 1994). To meet projected energy needs using biomass feedstocks could require tens of millions of hectares of primarily agricultural land to supply fuel for electrical generating facilities and for conversion to liquid fuels and chemicals (Ranney and Mann, 1994). Of the 74 million ha of cropland that were projected in 1994 as not required to meet U.S. agricultural needs to the year 2030, only 16 million ha were in regions determined to be well

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suited for energy crop cultivation (Graham, 1994). An estimated 8 to 16 million ha of this cropland could be converted to biomass production in the near future without displacing traditional row crops in any significant way. Energy crop production could extend beyond this 16 million ha without significantly displacing other crops if the additional land is drawn from pastureland or former cropland currently in long-term set-aside programs (Hohenstein and Wright, 1994).

Woody and herbaceous biomass crops are not seen as competing for land with traditional row crops such as corn and soybeans. Rather, they are perennial crops that can be grown on more marginal lands where erosion is a problem, where soil stabilization is needed, or where the economic returns to the farmer's labor and capital are low. Once established, maintaining perennial biomass crops requires little input of labor or resources compared with annual cycles of planting and harvesting of traditional row crops.

Traditional agricultural crops need good quality soils that are easy to work and that have adequate water and nutrient availability to produce high yields and a satisfactory profit for the farmer. Because market forces and farmers' economic needs drive how much of each crop is planted, agricultural production may extend onto marginal sites to meet these needs. Agricultural production on these more marginal, erosive sites harms the environment. In meeting the need for food, fiber and fuel, agriculture inevitably will affect the very resources that it relies on for productivity and profitability. With the need for alternative fuel feedstocks, biomass crops may become an economically competitive option for many farmers in the future. Whether this will happen is not yet known (Walsh, 1995); it will depend on economics, public acceptance, and other factors that are not included in this address of the environmental effects of crop production. State and federal support and commitments by utilities to purchase biomass feedstocks may be required initially to encourage production of these crops and to offer growers a reasonable economic return.

This paper focuses on three areas in which biomass crops may provide environmental benefits while providing income to farmers and agricultural communities: soil loss, water quality, and native wildlife habitat. We highlight physical and management differences between traditional row crops and biomass crops and the ways that the latter may be environmentally preferable to row crops. We also present some results from research supported by the Biofuels Feedstock Development Program (BFPD) at Oak Ridge National Laboratory to quantify the potential environmental benefits of biomass crop production.

Potential Energy Crops

Herbaceous energy crops

Perennial grass crops potentially can provide farm income as both energy feedstocks and forages (McLaughlin et al., 1994). An example is switchgrass *(Panicum virgatum)*, a sod-forming, warm-season grass that was an important component of the native North American tallgrass prairie. After evaluating yield and agronomic data on 34 herbaceous species, BFDP selected switchgrass for further research and development as a primary bioenergy candidate. This choice was based on its high yields and excellent versatility in early field trials and its many positive environmental attributes.

Switchgrass has the economic advantage that it can be harvested using traditional agricultural equipment to produce large round bales that can either be stored on-site until needed or transferred directly to conversion facilities following harvest. Depending on the region and the time of harvest, farmers may be able to get a second growth for use as forage for livestock. Switchgrass and other native prairie grasses have become increasingly important as forage grasses, particularly in the Midwest, because of their ability to grow during hot summer months when water availability can limit growth of most other species (Moser and Vogel, 1995).

Because of its extensive rooting system, switchgrass provides environmental advantages such as increased soil organic matter, soil stability, and lower requirements for energy, water, and agrochemicals compared with traditional row crops (McLaughlin, 1992). Its extensive rooting system increases the efficiency of nutrient and water uptake and provides strong energy storage reserves that contribute to more stable yields during stress years. The extensive rooting system of switchgrass reduces soil erosion and enhances nutrient storage and availability. This increases the plant's ability to persist for a number of years without the annual replanting cycle and soil and nutrient losses associated with annual row crops. These attributes make perennial grasses valuable for reclaiming marginally productive sites that have been degraded by erosion and soil depletion (Aguilar et al., 1988).

Short-rotation woody crops

One hundred twenty-five tree species have been examined at various levels of detail by the BFDP since 1978 to identify those with the greatest potential for rapid growth, wide adaptability, and resistance to insect pests and diseases. To date, the species with the greatest potential for extensive development are poplar (*Populus* spp.), willow (*Salix* spp.), sweetgum *(Liquidambar styraciflua)*, sycamore *(Platanus occidentalis)*, and maple (*Acer* spp.) (Wright, 1994). Experimental yields of SRWC have been 2 to 5 times those currently obtained in natural forest stands and conifer pulpwood plantations in the United States. The increased yields of these tree species are the result of good matching of species to site, careful establishment techniques, use of improved clones or carefully selected seedlings, and recognition of the importance of weed control until the canopy closes (Wright, 1994). Methods for establishing SRWC are the same as for most other agricultural crops, although no-till establishment has not been effective because weeds must be removed and any underlying hardpan must be broken for maximum root penetration. Wright (1994) provides more detailed information on site establishment, maintenance, and harvesting needs for SRWCs. A possible obstacle to production of woody crops is the need for traditional forest harvesting equipment that may not be readily available to agricultural growers.

Studies of small-scale plantings of hybrid poplar in the North Central states have shown that over time, trees grown on tilled agricultural lands that previously were in prairie grasses sequestered significant quantities of soil carbon as organic matter (Hansen, 1993). Unlike perennial grasses, which can cover the soil surface in one to two years, tree crops continue to leave most of the soil surface exposed (assuming weeds are controlled or removed) until the canopy closes in three to five years after establishment. Until then, soil erosion and loss of organic matter continue, although losses are less than with annual crops. Once the tree canopy has closed, weed control no longer is required because there is little light penetration and weed growth, consequently, is low. Fertilization requirements for SRWC depend on soil type and fertility. Studies are currently being conducted by the BFDP to determine fertilization and irrigation requirements of hybrid poplars in the Pacific Northwest and of sweetgum, sycamore, and cottonwood *(Populus deltoides)* clones in the Southeast to maximize yield while limiting production costs.

Environmental Enhancement Using Biomass Crops

The BFDP's environmental research task currently supports several studies to help determine the environmental effects of converting agricultural lands to biomass crop production. These studies, which are conducted by several universities under subcontracts with the BFDP, investigate how soil characteristics change with conversion of agricultural land to biomass crops, the fate of chemicals applied to energy crops compared with annual agricultural crops, and the effects on habitat availability for native wildlife species. Information from these studies will help identify how environmental enhancement can be achieved through biomass crop production as part of the existing agricultural setting.

Soils and nutrients

Studies by the University of Minnesota, Duluth, are characterizing agricultural soils planted to biomass crops. These studies will provide information on how organic matter changes over time and whether biomass crops can be used to reclaim eroded sites and eventually restore their productivity. The study addresses the potential for biomass crops in a farm rotation system to increase crop diversity, minimize erosion, and increase soil fertility, while diversifying the economic base of individual farms.

Other studies are examining the fate of chemicals applied to short-rotation woody crops both with and without cover crops, to a herbaceous crop (switchgrass), and to traditional row crops. This work will quantify the movement of nutrients and herbicides across the soil surface as well as into the soil and groundwater beneath research-scale sites. The study in Alabama, part of a three-site southeastern study funded jointly with the Tennessee Valley Authority, also is addressing the amount and chemical composition of surface water runoff from switchgrass, corn, and tree crops to quantify erosion and nutrient movement. These studies will provide information on uptake, release, and off-site movement of nutrients and pesticides on various soil types, and will help define hydrologic and environmental pathways of chemicals applied to biomass crops and their long-term effects on the agricultural environment.

A study conducted by the BFDP in conjunction with an industrial partner in the coastal plain of South Carolina is determining the growth response of cottonwood clones, sycamore, and sweetgum to different irrigation and fertilization regimes. The nutrient content of water percolating through each experimental plot is being monitored to develop guides for the application of nutrients and water to maximize growth and minimize costs to growers. A related study by Clemson University, supported by the BFDP and the National Council for the Pulp and Paper Industry for Air and Stream Improvement, is addressing the use of paper and pulp sludges applied either alone or in combination with agricultural wastes as soil amendments for production of hardwood crops. This study offers the opportunity to: 1) determine the potential for using agricultural residues to enhance productivity and soil quality; 2) address the quantity and composition of the residue required to increase productivity; 3) provide environmental benefit; and 4) minimize economic costs for agricultural producers. All these studies will help address how tree crops' response to different nutrient regimes varies with species, soils and climate. Therefore, they will help us predict the effects of large-scale deployment of biomass crops in agricultural landscapes.

Biodiversity

SRWCs and switchgrass energy crops can enhance biological diversity by creating or increasing the habitat for native species. For example, fast-growing energy trees planted around existing forest remnants may buffer the forest habitat from predation by edge-using species such as the raccoon *(Procyon lotor)* and the brown-headed cowbird *(Molothrus ater)*. The additional wooded area provided by these buffers may increase the habitat value of the adjacent forest remnants for various disturbance-sensitive species, including an entire suite of migrant birds that need interior forest habitat to survive and breed. Many of these interior forest birds are Neotropical migrants that migrate between breeding areas in temperate North America and tropical wintering areas in Latin America and the Caribbean. These migrants are declining as the result of forest fragmentation and competition from edge-using species (Wilcove, 1985; Blake and Karr, 1987; Robinson et al., 1995).

Some of these Neotropical migrants, such as the prairie warbler *(Dendroica discolor)* and the yellow-breasted chat *(Icteria virens)*, require large expanses of regenerating forest, and may benefit directly from habitat created by SRWCs. Others, such as the sedge wren *(Cistothorus platensis)* rely on grassland habitats, and could benefit from switchgrass energy crops or from switchgrass planted to buffer existing native grasslands from other land uses, such as traditional row crops. In other areas, small plantings or windbreaks of native grasses or SRWCs can provide additional edge habitats in primarily agricultural landscapes for species that can access different habitat types near their preferred habitat. Placing native grasses and SRWCs to buffer existing forests, to form linear corridors for wildlife movement between otherwise isolated forests or grasslands, or to provide greater habitat diversity in agriculturally dominated areas all can enhance biodiversity, but the benefit will depend on how wildlife species use the habitat provided by energy crops.

The role of these crops in enhancing biodiversity has been an area of active research supported by the BFDP on several sites since 1992. Research on small-scale hybrid poplar plantings in Minnesota has shown that these plantings support increased bird diversity compared with row crops; however, the young tree plantations were less valuable as habitat than were the adjacent forests and shrubs (Hanowski et al., 1994). Few bird species that require mature forest habitat have been found in the young woody plantings, which are dominated by more common bird species (Hanowski et al., 1994). In the same plantings, small mammals use sites without canopy closure more like grasslands than forests; small mammals requiring mature forest habitat have not yet been found using young woody energy crops (Christian et al., 1994). How the energy crop is managed, including ground-level vegetation cover and diversity, was found to be important in determining its value as habitat for small mammals. In National Audubon Society studies in Iowa (Hoffman et al., 1993; 1995), switchgrass plantings extended the habitat for grassland birds, but not all species in the surrounding landscape used them. Additional studies of larger plantings are needed to validate the results of the small-scale studies and to determine the value of more extensive plantings of biomass crops.

Research in the Southeast by the BFDP and the National Audubon Society in conjunction with an industrial partner is addressing which energy crops, planting sizes, ages, management regimes, and placement in the landscape are of the greatest benefit for regional biodiversity. BFDP-sponsored research has shown that energy crops provide greater habitat structure and benefits for native biodiversity than do row crops, and could benefit biodiversity on a regional level with large-scale production of biomass energy crops.

Conclusions

Conversion of agricultural lands to energy crops is being closely monitored to determine its environmental effects and possible benefits. Research on short-rotation woody crops and herbaceous energy crops conducted or supported by the U.S. Department of Energy's BFDP has shown that these crops have significant environmental benefits and can contribute to the economic viability and diversity of individual farms and agricultural communities. Studies on a research scale have shown that biomass crops grown on more erodible agricultural lands increase soil stability, nutrient retention, and soil organic matter. These studies can provide initial guidance in determining the environmental effects and benefits of converting larger areas of land to biomass crop production in different regions of the U.S.

If biomass crops grown under specific management techniques and located on more marginally productive or erosive land are found to be valuable for improving soil and water quality, decreasing chemical use and runoff, and improving native biodiversity, it will be important to determine cost/benefit ratios for growers who want to consider planting energy crops to provide both economic and environmental benefits. Determining what works best and developing guidelines on how to produce energy corps at a profit while benefiting the environment are important priorities. Information on how wildlife use biomass crops is important for growers who want to manage their biomass plantings to provide additional economic value from such activities as hunting and wildlife viewing leases. We need to develop an environmental decision structure to help determine the best locations and management methods for large-scale plantings to achieve environmental benefits for soil, water, and wildlife diversity while meeting the economic needs of individual growers and regional and local agricultural communities.

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Perennial Grasses for Energy and Conservation: Evaluating Some Ecological, Agricultural, and Economic Issues

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Introduction

Perennial prairie grasses offer many advantages to the developing biofuels industry. High-yielding varieties of native prairie grasses such as switchgrass *(Panicum virgatum)* have low nutrient demand, a diverse geographical growing range and high net energy yields, and offer important soil and water conservation benefits. These crops can supplement annual row crops such as corn in the developing alternative fuels market. However, displacement of row crops by perennial grasses will have major agricultural, economic, social and cross-market implications.

To analyze the implications of using lignocellulosic materials to produce ethanol or other fuels, we discuss four related topics: 1) the U.S. energy markets and the niche that biofuels may fill; 2) the contribution of agriculture; 3) economic barriers and the role of technology in reducing them; and 4) the environmental effects of biomass fuels. The need to integrate these considerations is the reason that the eventual benefits of producing liquid fuels from biomass are so complex and often misunderstood. We first outline the U.S. energy situation and the opportunity for producing ethanol from lignocellulosic crops. However, this opportunity is affected by the heavy subsidies currently given for converting corn grain to ethanol. Technological development and advanced engineering could produce vast quantities of ethanol cheaply in a fixed market. Another consideration is that significant environmental issues recently have become important in the debates over producing energy crops. Environmental concerns also have been voiced with respect to current agricultural production, but not with the same intensity.

The Energy Situation in the United States

The need for alternative fuels

Transportation fuels in this country have been dominated by oil for nearly 100

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years. The supply of oil is finite and its extraction and use are environmentally damaging. Energy price shocks have had dislocating effects. Eventually, we will need alternatives to current transportation fuels, although we do not know exactly when. A longer-term perspective is important in developing bioenergy systems. Most current development in this area has been catalyzed by environmental mandates from the U.S. Environmental Protection Agency (EPA) and by supply and demand shocks in the oil market.

Fuel cells and methanol for internal combustion engines are two alternatives to gasoline. Fuel cells that generate electricity from hydrogen or methanol are still being developed. Energy from fuel cells is currently seen as more expensive than gasoline. To operate fuel cells on methanol contributes to the greenhouse effect. To operate them on hydrogen requires remote generation of hydrogen. For internal combustion engines, methanol is less expensive than gasoline, but it must be produced from natural gas and therefore does not reduce the greenhouse effect (Foody, 1988).

Ethanol is another alternative to fossil fuels for powering internal combustion engines, and is the focus of this paper. Ethanol can be blended at 10% with 90% gasoline or used neat (100% ethanol). It currently is used to enhance octane levels in gasoline and as a cosolvent for other fuel additives. Its ability to substitute for other additives that have harmful emissions eventually may add economic value beyond its value simply as a gasoline additive.

The increased use of renewable fuels offers the United States a strategy for significantly reducing its dependence on imported oil (Lynd et al., 1991; Robertson and Shapouri, 1993). Several renewable feedstocks can be used to produce ethanol while providing diverse benefits to the national agricultural economy: sugar, grains, wood, agricultural residues, herbaceous crops (such as sorghum and switchgrass), municipal wastes, and paper.

Currently, U.S. ethanol production is 1426 million gallons per year, of which 1235 million gallons is produced from corn (Gist-brocades, 1995). Projections for future supply and economic gain are largely based on corn as the feedstock.

Net energy projections

The capacity of energy crops to offset imported energy will depend on their energy yield net of the energy used to grow, harvest and convert them. Extensive studies have found a conversion efficiency of nearly 5:1 (units of energy out per unit in). Switchgrass requires less energy to produce than does corn. One acre of corn grain contains 50 million BTU and requires 7.6 million BTU to produce, for an energy output/input ratio of 6.6. When the corn stover is included, the energy efficiency ratio improves to 8.8.

In comparison, switchgrass will produce 20.6 times the energy required to produce it if it is transported directly to the ethanol plant. The higher ratio for switchgrass occurs largely because it is a perennial (remaining in production for ten years or more before replanting) and because of its lower chemical and fertilizer requirements. These calculations used chemical and fertilizer application rates from U.S. Department of Agriculture (1991a), Fertilizer Institute (1988; 1992), DeLuchi (1991), and Pimentel (1980). Transportation energetics were derived from Fluck (1992). We assumed that corn and switchgrass needed identical equipment for soil preparation and planting; however, their harvesting and handling equipment obviously differed (Fluck, 1985; Bowers, 1992). Although net energy returns vary regionally, the energy advantage of grasses has been found to be consistently and significantly higher than for corn in all regions considered.

Agricultural Benefit and Agronomic Potential

After it screened numerous annual and perennial species (Wright et al., 1994), the Biofuels Feedstock Development Program (BFDP) of the U.S. Department of Energy (DOE) selected switchgrass as a model herbaceous energy crop (McLaughlin, 1992). Switchgrass is an indigenous American prairie grass that is particularly hardy and widely adapted. The reasons it was selected were its reduced cultivation requirements, its generally lower nutrient demand, and its positive environmental attributes. Research suggests that switchgrass could provide significant ecological, agricultural and economic advantages over annual crops such as corn, as discussed below.

Perennial grasses were an ecological cornerstone of the early American prairie because of their forage quality and soil stabilizing attributes (Weaver, 1968). Until now, switchgrass has been bred primarily to enhance its nutritional value as forage (Vogel et al., 1989). It has been managed primarily as a hay crop; its yields, ranging from 4 to 17 t/ha (metric tons/ha), have averaged approximately 60% higher than the average yield on the 25 million ha harvested for hay (U.S. Department of Agriculture, 1991b). Recent DOE research on several switchgrass varieties (McLaughlin, 1992) focuses more on total biomass production than foliage composition. This research and the evaluation of better-adapted varieties has resulted in yields on research plots in Alabama as high as 35 t/ha in a single year and an average of 24 t/ha over five years (Sladden et al., 1991). During the latest test cycle, yields have averaged approximately 11 t/ha across 17 locations in the Midwest and Southeast for still-aggrading two-year-old stands. These yields were achieved without irrigation, without the annual cultivation and planting cycle of annual crops, and with nitrogen and phosphorus fertilizer applications that typically were only one-fourth to one-half those of corn production. New breeding activities underway in the BFDP are emphasizing increased total biomass production and optimal leaf nutrient content. Some components, such as nitrogen and potassium, may reduce biomass conversion efficiency. We estimate that an annual yield of 11 to 22 t/ha could be achieved with current varieties and production techniques in better growing regions.

Economics

The BFDP staff, economists at Oak Ridge National Laboratory, and others have extensively researched the economics of switchgrass production and its potential in the United States. Production budgets are now being empirically verified as DOE begins to fund large plantings of switchgrass for energy.

Expansion of ethanol production from its current level of 0.8 billion gallons per year to one that will significantly reduce dependence on foreign oil imports is anticipated to increase agricultural production and productivity and provide additional income for farmers. Thus it will have implications for production of several crops. Under the assumption that increased ethanol production will be achieved using corn, USDA's Economic Research Service estimated agricultural impacts for two scenarios: an increase to 2 billion gallons by 1995; and an increase to 5 billion gallons by 2000. In the first scenario, corn area increases by 1.1 million ha and net farm income by $153 million; in the second, corn increases by 3.8 million ha and net farm income by $1.6 billion. Only the second scenario is projected to affect other agricultural production significantly, including a loss of $550 million in livestock production because of higher feed costs from the increased competition for corn.

There will be important regional differences in the gains and losses from meeting additional bioenergy needs solely with corn. The main economic gains will be in the major corn producing regions: the Corn Belt, the Lake States, and parts of the Great Plains. Cattle production losses will be spread more evenly across all cattle producing states. Thus, despite a national agricultural gain, the southeastern and mid-Atlantic states will experience a net economic loss that will be augmented by a loss of approximately 240,000 ha of soybean and cotton because of shifts in grain production.

In contrast, a shift to perennial grasses could be achieved using land with a much broader quality range. This would have little effect on other crops and would spread the benefits more evenly across the country. The South, which currently has a depressed agricultural economy, so far has the highest yields of warm-season perennial grasses and would be among the most suitable areas for biofuel production.

Economic factors affecting commercial feasibility

Foody (1988) noted that the technology for producing ethanol from biomass was improving rapidly and that laboratory results were approaching the limits of technical and economic feasibility. Neat ethanol could compete with gasoline in the current marketplace at an oil price of $20 to $30 per barrel. A successful demonstration of economically competitive ethanol production would dramatically change the debate over energy-related environmental problems. Fuel ethanol's primary advantage is environmental, as it burns much more cleanly than gasoline. When derived from lignocellulosic biomass, it is the only liquid transportation fuel that does not contribute to the greenhouse effect (Foody, 1988).

Many additional factors will affect its commercial feasibility. Successful development of enzymatic hydrolysis technology will be crucial. The process for making ethanol from lignocellulosic biomass involves seven major steps: biomass production, pretreatment, enzyme production, enzymatic hydrolysis, fermentation, distillation, and by-product processing. (For more on these steps, see Foody, 1988.) Since these processes are interdependent, improving one may decrease the ability to make improvements in another. Finally, the ability to market by-products and co-products is crucial to the economic viability of a commercial system (International Council on Agriculture, Science and Technology, 1994).

Conservation Reserve Program

The Conservation Reserve Program (CRP) was initiated under the Food Security Act of 1985, largely to stabilize and improve soils degraded by overcropping. Almost 15 million ha were idled by this law, primarily in the Great Plains and Southeast. Much of this land was replanted to perennial grasses that were the principal species of the original prairie. Predominant species were big bluestem (*Andropogon gerardi* Vitman), Indian grass (*Sorghastrum nutans* [L.] Nash), western wheatgrass (*Agropyron smithii* Rydb.) and switchgrass.

CRP is at a critical point after 10 years of contracting with agricultural producers. Renewal or elimination options are currently being considered in the 1995 Farm Bill. Critics see it as an unnecessary expense with questionable benefits to taxpayers. However, recent consideration of both the resource conservation benefits of CRP and the cost of subsidies if these lands are returned to annual crops, notably wheat, suggests that CRP represents a gain to taxpayers. An alternative to returning these lands to the very practices that made CRP necessary would be to use them for energy crops that can both enhance land quality and provide an economic return to landowners. This possibility is strengthened by the fact that the native perennial grasses planted under the CRP also are excellent for production of liquid fuels.

Environmental Considerations

Perennial grasses grown under CRP conserve the soil and improve its quality. They also provide excellent protective cover and food for wildlife. The significant reduction in soil erosion is their most obvious advantage over row crops such as corn. Soil loss from annual cropping of erodible land can be very high, resulting in the loss of valuable nutrients and the contamination of adjoining areas and wetlands by sediments and chemicals. Typically, soil loss is several orders of magnitude greater with annual crops than with perennial grasses (Shifflet and Darby, 1985), especially during heavy rains.

Loss of soil organic matter (SOM) also is greater with annual crops, because it breaks down faster under tillage and because more SOM-rich topsoil is removed by erosion (Buckman and Brady, 1960). The current loss of soil organic matter in the US through annual row cropping is estimated at 2.7 million t per year (Council for Agriculture, Science, and Technology, 1992). This loss is important not only because it equals 7.5% of the total carbon released to the atmosphere by combustion of fossil fuels, but because SOM is critical for soil productivity. The soil's moisture-holding capacity, density, aeration, and ability to supply and conserve plant nutrients all are improved by SOM (Anderson and Coleman, 1985).

Recent studies of the changes in SOM during five years of perennial grass production on CRP lands indicate that perennial grasses added C at an annual rate of 1.1 t/ha to the upper 100 cm of CRP soils (Gebhardt et al., in press). These additions replaced 23% of the soil carbon that was lost during decades of prior tillage. The source of this carbon is the large standing pool of roots, which can equal or exceed annual aboveground production (Anderson and Coleman, 1985) and which turn over rapidly. Preliminary data from research on switchgrass grown for energy indicate that belowground root mass is very high, totaling almost 8 t/ha just in the top 75 cm (Bransby et al., 1994). With Alamo switchgrass (*P. virgatum* cv. 'Alamo'), over 1 t/ha was found just in the interval 60-75 cm.

Summary

Perennial grass production for biofuels offers significant advantages for a national energy strategy that considers both environmental and economic issues. The benefits of using a native prairie species such as switchgrass rather than annual crops such as corn include: improved soil quality; reduced soil erosion and associated water pollution; reduced emissions of greenhouse gases; increased efficiency of land and energy use; and a more equitable distribution of economic benefits to farmers. To achieve these benefits in a timely manner will require us to look beyond the short-term and consider not just the supply of municipal wastes, crop residues and other wastes that can serve as feed-stocks for industrial uses; we also should consider growing crops specifically for energy.

Our planning should include accelerated commercialization of both ethanol conversion and grass-fired combustion systems. We also should study the options for maintaining landowner participation in a conservation reserve program that achieves conservation objectives with reduced subsidies, and for involvement of landowners in energy crop production. The benefits of these strategies for the economy and environment of the nation are too obvious to ignore.

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The Environmental Benefits of Cellulosic Energy Crops at a Landscape Scale

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Introduction: The Role of Cellulosic Energy Crops

This paper presents a broad overview of the potential environmental impacts of biomass energy from energy crops, particularly the cellulosic energy crops currently under development. We use the term *energy crop* to mean a crop grown primarily to provide a feedstock for biofuels such as ethanol or to be burned for heat or electricity. Energy crops currently in production include corn *(Zea mays)*, sugarcane *(Saccharum officinarum)*, and short-rotation plantations of poplar (*Populus* spp.), sycamore *(Platanus occidentalis)* and eucalyptus (*Eucalyptus* spp.). We use *cellulosic energy crop* to differentiate those grown for their cellulose content from those grown for carbohydrates (starch or sugars), such as corn or sugarcane. Cellulose and carbohydrates both can be converted to ethanol, but more cellulose can be produced per unit land area than carbohydrates. Therefore, cellulose-based ethanol production is a more efficient use of land.

Cellulosic energy crops currently under development in the U.S. include switchgrass *(Panicum virgatum)* and short rotation woody crops, especially poplar and willow (*Salix* spp.). Switchgrass is a drought-tolerant prairie grass with an extensive natural range in North America. It is the model herbaceous energy crop selected by the U.S. Department of Energy and is well suited for cellulose-based ethanol conversion (Wright et al., 1993). Cellulosic energy crops also are appropriate for producing heat and electricity.

From the perspective of the farmer, energy crop production generally is compatible with food crop production. Farmers most likely will use energy crops as part of a mix of several crops. However, introducing them into the larger farming scheme requires careful planning, because most cellulosic energy crops are perennials, with stands lasting five to twenty years.

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Assessing the environmental impacts of biomass energy from energy crops is complex because two different kinds of impacts are involved: *using biomass for energy* must be considered in the context of alternative energy options, while the environmental impact of *producing biomass from energy crops* must be considered in the context of alternative land uses. Using biomass-derived energy can either reduce or increase greenhouse gas emissions; growing biomass energy crops can enhance soil fertility or degrade it. Therefore, one must know the specific circumstances to be able to make a statement about the environmental impacts of biomass energy. We focus on the environmental impacts of growing cellulosic energy crops, especially its impacts on a landscape or regional scale. However, we first compare the environmental advantages and disadvantages of using biomass-derived energy to those of other energy sources, including coal, gasoline, natural gas, nuclear power, hydropower, and photovoltaics.

Comparing Biomass Energy with Other Energy Sources

Coal. Biomass energy is most advantageous when compared with coal. Using it to displace coal in power generation has the greatest benefit in reducing greenhouse gases and air pollution. A recent analysis calculated that using the wood from 1 ha of short-rotation woody energy crops instead of coal would displace 5.2 t (metric tons) of fossil C in CO_2 (Graham et al., 1992). Biomass burns cleanly, with much lower SO_x and somewhat lower NO_x emissions. Two additional environmental benefits come from the reduction in coal mining and the avoidance of coal ash disposal. Wood combustion produces much less ash than does coal, and the ash can be returned to agricultural soils.

Gasoline. Using biomass-derived ethanol to displace gasoline also has a considerable greenhouse gas benefit, but it is much smaller than the benefit when biomass displaces coal because gasoline has a much higher energy value per unit of fossil carbon. The CO_2 benefit of using ethanol made from cellulosic crops to displace gasoline is estimated to be about half as great as when it displaces coal (Graham et al., 1992). When the ethanol is produced from a crop grown with large inputs of fossil fuel, such as corn, the greenhouse gas saving may be very low; the current process of growing corn and converting it to ethanol produces 0.6 to 0.8 units of CO_2 for every unit of gasoline-CO_2 that is displaced (Marland and Turhollow, 1991). The low ratio is due to the heavy use of nitrogen fertilizers and the use of fossil fuels (coal) in the conversion.

Ethanol has air pollution benefits over gasoline as an automobile fuel. It emits less CO, SO_2, and hydrocarbons, but slightly more NO_x (Graboski, 1993). It emits more aldehydes, but mostly as acetaldehyde, which is less reactive and less toxic than the formaldehyde produced by the combustion of gasoline (Macedo, 1993). In general, ethanol emissions are less toxic than gasoline emissions (La Rovere and Audinet, 1993). Compared with reformulated gasoline to which oxygenates have been added, biomass-derived ethanol has no air pollution advantages or disadvantages other than the reduction in CO_2 (Tyson et al., 1993).

Natural gas. The environmental advantages of displacing natural gas with biomass-derived electricity are less than for displacing coal, oil or gasoline. Natural gas contains twice as much energy as coal per unit of carbon. Also, natural gas power plants are more energy efficient than coal-fired plants (Turhollow and Perlack, 1991).

Nuclear and renewable energy sources (hydro, wind, photovoltaics). Biomass energy has less of an environmental advantage when compared with greenhouse-neutral energy types such as nuclear, wind, hydropower, and photovoltaics. It releases some greenhouse gases, because fossil fuels are likely to be used to produce energy crops (to power tractors, manufacture fertilizers, etc.). Although biomass releases only 1/10th to 1/20th as much greenhouse gases per unit of power as does coal, the emissions still are not zero (Turhollow and Perlack, 1991). However, biomass energy avoids the safety and waste disposal problems of nuclear power. Also, it does not impose the loss of land and the damage to fisheries that occur with dams and hydropower.

Land requirements. Biomass energy's universal disadvantage is its high land requirement. An efficient biomass power plant (33%) will require between 200 and 400 ha of land in energy crops per MW of baseload power, depending on the biomass yield. Cellulose-to-ethanol technology is expected to require 150 to 300 ha per million liters of annual capacity, assuming moderate cellulosic energy crop yields (10 to 20 dry t/ha); U.S. ethanol production from corn requires close to 300 ha per million liters (Hohmann and Rendleman, 1993). It is important to quantify the environmental impacts of major shifts in land use to grow energy crops. Shifting from current agriculture to energy crops could change soil erosion patterns, water quality of regional streams, wildlife populations, and regional air quality. Characterizing these impacts is challenging because they depend on many site- and crop-specific factors.

Factors Determining the Environmental Impacts of Energy Crop Production

Crop factors

The type of crop grown is a decisive variable in predicting environmental impacts from energy crop production; crops have different effects on erosion, water availability and quality, wildlife habitat, and air quality. For example, growing corn is likely to cause more soil erosion and use more fertilizers than growing short rotation poplar. However, because trees use more water than herbaceous crops, they may reduce stream flow. Wildlife will differentiate among crop types; for example, tree crops can provide habitat for forest bird species (Wright et al., 1993; Hoffman et al., 1995; Tolbert and Schiller, 1996). Perennial grasses enhance soil carbon more than do annual crops. Tree crops release more hydrocarbons into the air than do herbaceous crops (Perlack et al., 1992).

How the crop is managed also is important (Cook et al., 1991). Interplanting a cover crop between trees early in short-rotation woody crop production is likely to reduce erosion compared with leaving the soil bare. The types and amounts of pesticides and fertilizers applied and the timing of applications will affect water quality. Harvesting trees during the winter reduces the loss of nutrients from the site because the leaves are not removed. Burning crop residues in the field, as is done with sugarcane, can harm air quality locally and regionally (La Rovere and Audinet, 1993).

Site factors

Physical characteristics of the land will strongly influence the productivity of energy crops and therefore the likelihood that they will be grown (Liu et al., 1992; 1993). Soil type, climate, and topography will affect erosion and runoff (Office of Technology Assessment, 1993; Hoffman et al., 1995; Tolbert and Schiller, 1996). Soil type also will influence the need for fertilizers and the rate at which pesticides and fertilizers leach to groundwater. A high organic matter content increases the soil's retention of pesticides and nutrients. In a warmer climate, pesticides break down and volatilize more rapidly.

The previous use of the land is an especially important consideration when developing policies to promote or discourage energy crops. The difference between the environmental effects of the former land use and of the energy crop determines the environmental value of the energy crop. For example, growing switchgrass rather than soybeans *(Glycine max)* has many environmental advantages. Compared with soybeans, switchgrass will increase soil carbon, reduce erosion, improve water quality, and provide better animal habitat. Thus, a policy that encouraged the production of switchgrass on former soybean land would have environmental benefits, but a policy that encouraged conversion of forests to switchgrass would be environmentally damaging. Valuable forest habitat would be lost and water quality would likely be degraded.

Finally, the location of the energy crops in relation to other land uses will strongly influence water quality and wildlife impacts. Perennial energy crops such as trees or grasses that receive low levels of fertilizers or pesticides can serve as filters if planted along streams. These crops can absorb nutrients coming from more heavily fertilized conventional crops upslope and can catch sediment as it moves downslope. Both actions can improve local water quality (Ranney and Mann, 1994). If streamside planting is extensive and nonpoint-source pollution from agriculture is a regional problem, perennial energy crops could improve regional water quality (Office of Technology Assessment, 1993). Planting energy crops on a small amount of land adjacent to streams could have a much larger influence on water quality than planting two or three times as much land upslope.

If planted in a landscape dominated by annual crops, energy crops may enhance regional and local wildlife. In particular, woody energy crops add structural diversity to agricultural landscapes, which should enhance biodiversity on a regional scale. Measurements of abundance, type, and number of bird species have shown that woody crops can serve some of the habitat functions of natural forests (Office of Technology Assessment, 1993; Wright et al., 1993; Hoffman et al., 1995). However, woody energy crops are not a substitute for natural forests (Cook et al., 1991; Tolbert and Schiller, 1996). Producing energy crops can harm wildlife if the crops displace a food source in the original land use. For example, birds migrating from Canada to Mexico and South America use the corn left in the fields of the midwestern U.S. If switchgrass displaced large areas of corn in this region, this food source would disappear, with no obvious replacement.

Quantity of land dedicated to energy crops

Clearly, the more land converted to energy crops, the greater their regional impact. However, their impact cannot simply be assumed to be proportional to the amount of land planted to them, particularly for wildlife and water quality impacts. Even an impact such as erosion, which can be calculated on a per hectare basis and does not depend on land use changes elsewhere, will not simply be proportional to the amount of land planted to energy crops in a region, because soil type, topography, and former land use all will vary within the region (Graham and Downing, 1993).

Interactions among factors

These factors cannot be considered in isolation, because they interact strongly in affecting the environment. For example, soil, climate, topography, crop type, and crop management all will affect energy crop productivity and therefore the quantity of land needed to produce a specific supply. Even former land use by itself can affect energy crop productivity. For example, soil compaction as a result of pasture use may reduce expected energy crop yields. Assessing the potential environmental impacts of energy crop production requires an integrated approach that considers all these factors. To be successful, however, the approach must also include the economic forces and policies that will control where energy crops will be grown and what land uses they will displace.

Quantitatively Predicting Environmental Impacts

It is difficult to predict quantitatively the environmental impacts of cellulosic energy crop development on a landscape or regional scale because most cellulosic crops are not yet planted in regionally significant amounts. Thus, the necessary empirical information on environmental impacts is lacking and a modeling approach is needed to predict the effects these crops might have if planted on the scale of a major crop such as corn, or even a less important crop such as barley *(Hordeum vulgare)* or oats *(Avena sativa)*. We have developed a six-stage modeling approach for assessing regional or landscape-scale environmental impacts. It includes economic considerations, since economics will determine where energy crops are profitable, what conventional crops they will displace, and what management regimes will be used to produce them. After briefly outlining the approach, we present some results on the environmental consequences of growing switchgrass to supply bioenergy conversion facilities in North Dakota and Tennessee.

1. *Characterizing the region.* In the first stage, we characterize the region's climate, topography, soil quality, and the types, location, management practices and profitability of current land use. If possible, we determine the relationship between profit and soil type. Understanding this relationship greatly improves the projections of where energy crops will be grown.
2. *Developing energy crop management scenarios and production costs.* In the second stage we determine management practices for energy crops and estimate production costs. This determination is based in part on our characterization of the region. Some energy crops are more appropriate for certain soils and climates than others.
3. *Modeling crop yields and on-site environmental impacts.* The third stage predicts variations in crop yield associated with soils and climates. It also predicts crop-specific, on-site environmental parameters such as erosion, runoff, and losses of nutrients and pesticide. This stage uses EPIC (Erosion Productivity Impact Calculator), a crop simulation model developed by the U.S. Department of Agriculture (Williams et al., 1989). The model is sensitive to many factors that control regional environmental impacts: soil type, topography, climate, crop type, and crop management. The model can predict not only crop yield but also the rates of erosion, runoff, and nitrogen and phosphorus losses in runoff or groundwater, all as functions of climate, soil, and topography. Changes in the environmental values associated with switching land to a specific energy crop can easily be calculated with EPIC. The crop yield information provided by EPIC is combined with empirical crop yield information to predict variations in yield associated with different soil and climate conditions.
4. *Calculating probable farmgate biomass price.* Using information generated in Stage 1 on the profitability of conventional crops and information on energy crop yields and production costs, we next calculate the price of biomass at the farm that gives the farmer the same profit as conventional crops. It does not include the cost of transporting the biomass to where it will be used. The break-even farmgate price is used to identify the lands most likely to be converted to energy crop production.
5. *Determining where land use change will occur.* In the fifth stage we predict land use changes, assuming that with transportation costs to the conversion facility being equal, land with the lowest farmgate price for biomass crops will be converted first, since it will produce the least expensive biomass for a conversion facility.

6. *Evaluating environmental impacts*. Regional impacts on soil fertility, water quality, and air quality largely depend on how much and what type of land is converted. They can be calculated by linking the environmental impacts per hectare determined in Stage 3 to the land-use changes predicted in Stage 5. Regional wildlife impacts depend not only on how much and what type of land is converted, but also on the location of that land in relation to other land uses. To evaluate these impacts, one must create maps of the changes in landscape pattern created by the projected land use changes. These maps are then used as inputs to spatial models of animal behavior and habitat to examine wildlife impacts. Effects on regional water quality depend on how much and what type of land is converted, where it is in relation to other land, and the topographic position of the land in relation to streams and lakes. Besides mapping projected land use changes associated with biomass production, one must also link those maps with topographic maps of the same area. Water quality models such as AGNPS (Agricultural NonPoint Source pollution), which predicts stream water quantity and quality as a function of topography, climate and land use pattern (Engel et al., 1993), can then be used to predict regional impacts on water quality.

Some results from two environmental analyses using this six-stage approach are shown in Fig. 1. Figs. 1a and 1b show the predicted impacts on regional soil erosion and nitrate loss from growing switchgrass for a hypothetical biomass energy facility near Fargo, North Dakota (English et al., 1993). The figures were created by comparing the expected water erosion and nitrate loss in runoff under two scenarios: 1) only conventional crops (wheat, oats, barley) are grown on all cropland within 50 km of the facility; 2) this land also produced switchgrass to supply an energy facility needing varying amounts of biomass (1,000 to 10,000 t/day). The corresponding land requirement ranged from 47,000 to 320,000 ha. Switchgrass production is predicted to reduce soil nitrate loss and water erosion in this region but the absolute amounts are low because the land is flat and rainfall is low.

Figs. 1c and 1d show some results from an analysis of the regional implications of growing switchgrass in two multi-county areas in Tennessee, one centered in Memphis, the other in Nashville (Graham and Downing, 1993). Converting 20% of the cropland in each region to switchgrass is predicted to reduce regional erosion by almost 20% (Fig. 1c). The absolute reduction in erosion is predicted to be greater in the Memphis region because of its significantly higher initial erosion rates. Increased switchgrass production reduces nitrate losses in both regions. Because of high predicted nitrate losses from soybeans, the benefits of producing switchgrass are higher in the Memphis region because of the greater displacement of soybean in that area (Fig. 1d). Thus, conversion of 20% of the cropland to switchgrass production is predicted to reduce regional nitrate loss in runoff by almost 20% in the Memphis region, but by only 10% in the Nashville region.

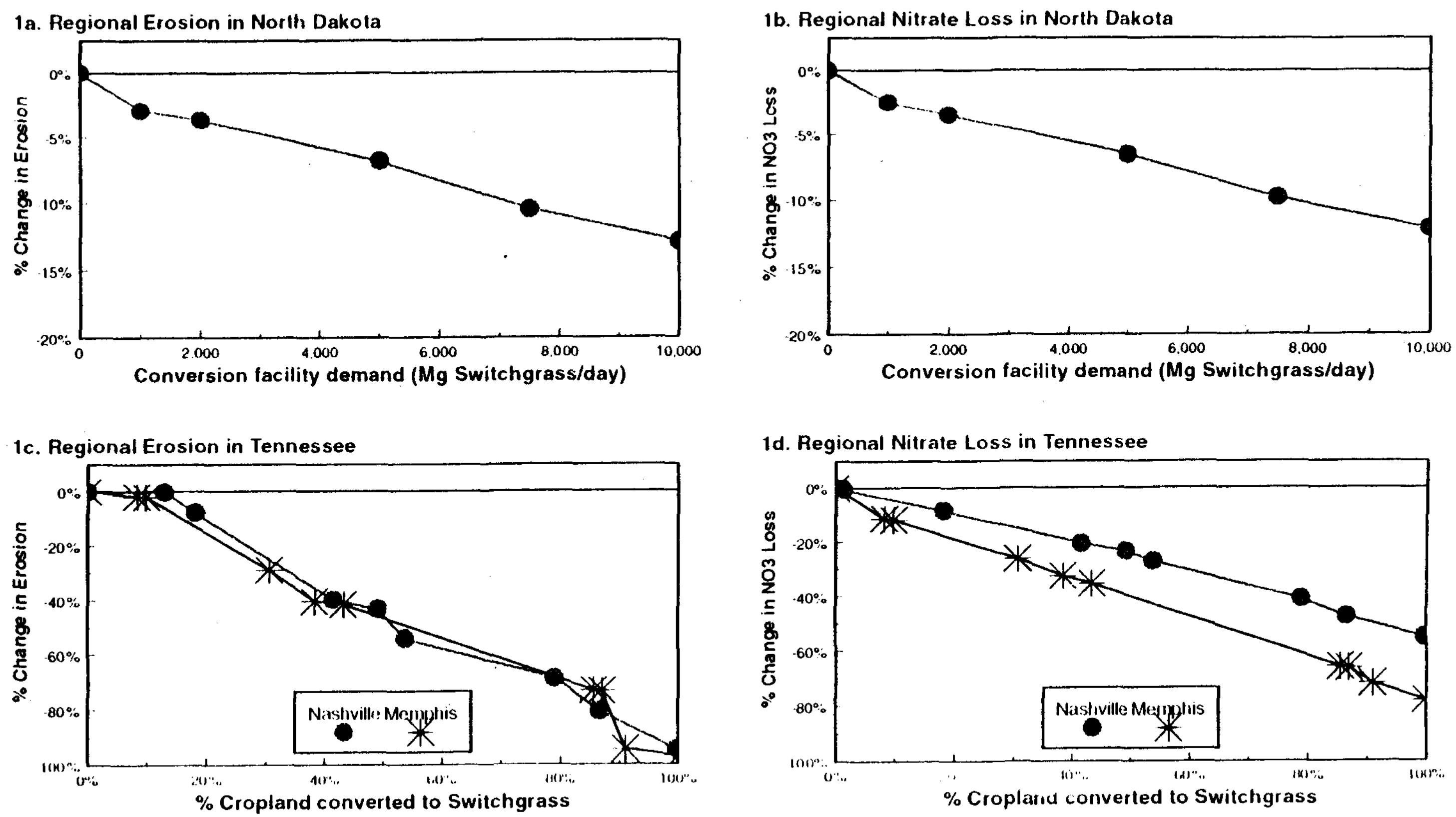

Fig. 1. The regional effect of switchgrass production on erosion and nitrate losses in runoff from cropland in eastern North Dakota and Tennessee.

The results illustrate the potential environmental benefits of switchgrass production, but also emphasize the regional differences that may be expected. Biomass energy crops have many environmental benefits if they are well managed and well suited to the site; however, they are not universally advantageous. The government faces a serious challenge in developing policies and regulations that take advantage of the potential environmental benefits of energy crops and minimize their potential negative impacts. The value of the environmental benefits needs to be quantified and incorporated in cost comparisons between biomass and other energy sources.

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Regional Farmers' Market Development as an Employment and Economic Development Strategy

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This paper examines the experience of Cornell Cooperative Extension and several not-for-profit collaborators in the second year of the New Farmers/New Markets Program, which aims to rebuild and expand the farmers' market system as a catalyst for both expanded community-based economic development and employment on a regional scale. Its goals are:

- To expand consumer and farmer participation in existing farmers' markets, while developing new, viable markets in underserved neighborhoods and communities.
- To work with community-based organizations to train and educate neighborhood youths and other residents year-round in market-oriented food production.
- To build an education program that targets new immigrants and other interested adults through hands-on experience in growing and marketing, emphasizing sustainable and organic production.

Regional Concerns and the Program's Approach

The Program's originators come to this issue from a metropolitan perspective, as educators with Cornell Cooperative Extension's New York City Programs and as marketing staff with the state's Department of Agriculture and Markets. The role of urban (here NYC) programs in extension deserves discussion, for two reasons.

First, Extension's urban programs historically have focused on consumers through efforts such as the Expanded Food and Nutrition Education Program, delivered to targeted low-income households. It is unusual for formal extension education programs to consciously link urban and rural regions through integrated efforts that respond to common issues like regional market development through sustainable agriculture.

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Second, New York State's early national preeminence in regional planning, a role predating the Great Depression, has almost disappeared. The state lacks the institutional structures and legislative framework needed to address comprehensively and resolve on a meaningful scale (the region) such pressing issues as land use planning, sustainable agriculture and sustainable energy use, regional farm market development, integrated community development, and labor force enhancement. In contrast, barely 500 miles away, the Royal Commission on the Future of the Toronto Waterfront (1992) is addressing issues such as "Framework for Ecosystem-Based Planning" and "Planning for Sustainability." Meanwhile, we (in New York State, at least) studiously avoid a regional approach to planning, contenting ourselves with reacting to local conflicts and concerns through patchwork.

The regional approach taken in the New Farmers/New Markets Program emphasizes the connections between residents and resources and the realization that issues of watershed protection, commuting, jobs, and housing all are regionally connected. Though the food production and supply system is corporate-based and transcontinental in scale, there is a clear historical connection between organic, sustainable production and a regional food system (or "foodshed" or food network) that exemplifies sustainable development.

There is great potential for regional collaboration among extension educators through an effort such as New Farmers/New Markets because it lets participants build capacity among a range of audiences previously involved with different elements of extension education: community-based organizations involved in local economic development; farmers looking to convert to or continue using sustainable practices; nonurban communities seeking economic diversity and incubator industrial growth; and organizations throughout the region involved in the long-term development of a regional farmers' market system.

Context and Community Need

The continued growth and success of farmers' markets in New York City provides a base for local economic development in urban and nonurban communities throughout the region. With 32 farmers' markets in New York City serving as outlets for nearly 200 farmers from New York and surrounding states, one can find farmers who have come 120 miles from Kinderhook to the 14th Street Greenmarket, and high school students marketing produce from Extension programs on Staten Island at farmers' markets in the South Bronx.

Since 1989, the Federal-State Women/Infants/Children (WIC) Farmers Market Nutrition Program (FMNP), administered by the state's Department of Agriculture and Markets and Department of Health, has increased the use of farmers' markets by low-income households at nutritional risk. In 1993, special FMNP Coupons were issued to over 42,000 families throughout New York City for locally grown, fresh fruits and vegetables, generating nearly $600,000 in sales by farmers at markets city-wide.

The FMNP has fostered the growth of urban farmers' markets in areas without access to high quality, locally grown fresh fruits and vegetables, thereby creating new opportunities for farmers to participate in these markets. This growth will continue, bolstered by the Congressional enactment of the WIC Farmers Market Nutrition Act of 1992 that made the FMNP the fourteenth permanent federal domestic food assistance program. In spring 1995, congressional appropriations expanded the program in New York and the ten other states initially involved, and added thirteen new states, the District of Columbia and three Indian Tribal Organizations.

Despite the success of farmers' markets and FMNP coupons, many low-income city neighborhoods still lack access to markets and their attendant nutritional benefits. Although requests for markets are being received continually by the state's Department of Agriculture and Markets and other sponsors, further growth is limited by the number of participating farmers at existing and new sites. Currently there are markets in Harlem, Washington Heights, the South Bronx and South Jamaica, but none in Bedford-Stuyvesant, the Lower East Side and elsewhere.

Responses to Participants' Needs

The New Farmers/New Markets Program was designed to respond to these issues and to increase the level of benefits to its various clienteles. Its benefits for each of these groups are the following:

- For *practicing farmers:* expanded participation in the farmers' market system and added options for direct marketing; expanded regional production of fresh fruits and vegetables, thereby increasing New York State's net farm income; preservation and expansion of jobs in sustainable agriculture.
- For *open space preservation groups:* through increased involvement of groups interested in farming for the market, preserving farmland throughout the region and opening it to productive farming. In Dutchess County, for example, 15,000 acres of dairy farms left production in 1994 alone, opening the potential for a range of market farming initiatives.
- For *Cooperative Extension:* better use of the Extension system on a regional scale to recruit existing farmers and educate potential farm market producers. Linking urban and rural people through the market network also expands and varies the roles of Extension beyond what has been traditional (factory-scale production in rural areas, nutrition education in low-income urban communities, etc.) through new emphasis on direct marketing and specialty production by groups not usually involved in these issues. The program recognizes that organic

produce and prepared foods are continuing trends, representing emerging markets to which organizations and interested individuals throughout the region can respond.

- For *consumers:* increased access by inner-city households, particularly those presently unserved by the FMNP, a direct outcome of the marketing of nutritious, locally grown fresh fruits and vegetables through new market development. Use of FMNP has grown measurably, with an estimated 90,000 households reached by the program in New York City during 1995, and 175,000 households statewide.
- For *residents in impacted city neighborhoods:* development of job and career paths in agriculture and farm marketing for residents, inner-city youths, immigrants and minority groups at existing and new farmers' markets; development of a range of nontraditional employment opportunities in the food sector, with education about food production also enhancing skills and literacy. The program can be a focus for increased community economic activity in impacted neighborhoods by using farmers' markets as an economic catalyst for producing craft items and prepared foods as markets are initiated or expanded.
- For *not-for-profit organizations* with facilities, camps or retreats: a summer program that provides youth with team-building and science-based literacy skills; a source of fresh produce for camp kitchens that measurably reduces operating costs; a source of program income as the summer residents sell produce at local or regional farmers' markets and gain marketing experience.

Organizations with both urban and rural programs can build on this program to develop year-round activities in the city. Early participants recognized the clear potential for value-added food production; direct outcomes of New Farmers/New Markets' summer activities include the employment and economic development potential of food processing, related greenhouse production and research, small incubator aquaculture projects, and science initiatives linked to the local schools.

Urban Farm Marketing Focus

The Program's urban farm marketing element should be seen as distinct from the more familiar community gardening movement. Community gardens involve local residents who are organized cooperatively to produce fresh fruits and vegetables for their own consumption and enjoyment. Urban farm marketing, on the other hand, involves production sponsored by a community-based group to promote participants' skills and career development and to generate income by producing food and selling it at farmers' markets.

The urban element of New Farmers/New Markets emphasizes hands-on, experiential education using gardening and plant science to build and improve literacy, team skills, and awareness of the region's environment and food system. Neighborhoods where Cornell is actively engaged in education are homes to youth and adult participants in summer programs in outlying counties. When they leave the Mission Society's camp in Dover Plains, for example, they return to Harlem and a neighborhood 15 blocks from Cornell's Upper Manhattan Center; when they leave the Goshen retreat, they return to Highbridge and to a Bronx neighborhood with ongoing programs offered by Cornell and by Highbridge Community Life. This connection across the seasons and between the rural and urban offers multiple opportunities to expand a summer program of food production into a year-round experience in education and preparation for the work force.

The focus on urban farm marketing has had the following outcomes:

1. Development and expansion of an urban farm marketing program that encourages residents' participation in impacted communities, including audiences such as:

- youths involved in community- or school-based education programs, organized and trained to grow and market fresh produce cooperatively in a career-oriented manner;
- adults in career or special needs programs, immigrants with previous agricultural experience, and others trained to grow produce cooperatively and market it at farmers' markets.

2. Ongoing work with community-based organizations to identify, secure access to, and use vacant land to produce fresh vegetables for farmers' markets in low-income communities that do not now have such markets, such as Bedford-Stuyvesant, Bushwick, and Coney Island. With Extension colleagues in surrounding counties, the program also identifies leasable land outside the city for use by motivated groups of adults.

This orientation of groups and local "urban farming" sponsors involves contact with community organizations and with gardening and farming groups, followed by attention to selecting crops and sites for market farming.

Nonurban Farm Marketing Focus

This focus is based on two important points: 1) there is more good farmland outside the city than within it; 2) most of the larger not-for-profit service/settlement organizations have retreats, camps or conference facilities outside New York City that are used continuously by residents of inner-city neighborhoods.

Building on these conditions, New Farmers/New Markets offers the following opportunities:

- Development of a work force preparation program that links interested adults and youths with commercial farmers who presently sell at farmers' markets in New York City. This can link farmers either with apprentices/interns or with trained adults and older youths. Participating farmers currently employ over 80 city residents in market-related jobs and routinely seek additional qualified workers.

- Creation of an information system connecting potential adult audiences, the statewide Cooperative Extension system, and groups such as immigrants and new farmers seeking farming opportunities near the city, either on existing working farms or on productive but vacant farmland. Such a network could identify lease/purchase options and relevant federal financial, housing and technical assistance, such as FmHA Minority Farmer financing.

- Expansion of contacts with land preservation organizations in identifying and securing land for individual or cooperative farming that preserves working farmland, retains open space, and supports the farmers' market system. This would increase both regional food production and market-based agricultural employment. Examples of potential cooperating organizations include: American Farmland Trust; Hudson River Foundation; Hudson River Valley Greenway Council; Trust for Public Land; Peconic Land Trust; Westchester Land Trust; and Pace Law School's Land Use Law Center.

Cooperative Extension's Role

With educational programs and site preparation taking place in several surrounding counties and several New York City boroughs, New Farmers/New Markets involves Extension personnel who work with local organizations in various activities:

- With *participating not-for-profits:* train and assist staff in production and marketing via farmers' markets; identify program participants motivated to develop and sustain cooperative farming through the farmers' market network.

- With *farming alternatives groups, land preservation groups, and Extension colleagues:* identify land suitable for use by community-based groups for food production; work with Extension staff and land preservation activists to identify land for purchase or lease, especially land likely to be converted to nonagricultural uses.

- With *Extension nutrition educators and market sponsors:* increase consumer awareness of farmers' markets as sources of locally grown produce, and of FMNP's support.

- With *regional collaborators:* develop orientation, apprenticeship and referral systems for new farmers; collaborate with farmers' market sponsors to develop new markets in unserved neighborhoods and find new farmers for them.

In 1994, New Farmers/New Markets helped establish a new farmers' market at Beach 56th Street in Far Rockaway (Edgemere Houses, a New York City Housing Authority development) sponsored by the Arverne/Edgemere Tenant Associations, Congressman Floyd Flake's office, and People United for Local Leadership. A second market was initiated in 1995 in the Highbridge district of the Bronx (see below). Both communities are economically depressed, offer little access to fresh fruits and vegetables, and have concentrations of poor households with high rates of unemployment and public assistance. The new markets are well patronized, attracting growing participation from residents and increased use of FMNP coupons to buy fresh food.

Progress and Plans

Two City-to-County initiatives described below are already underway and are being expanded; several others are planned for 1996. Each does three things: provide training and educational opportunities in farm market production, from planting and harvesting to marketing at nearby and city farmers' markets; raise fruits and vegetables that support the operations of the organization involved; and engage staff from Extension and the participating organization, building on the year's efforts to support overall organizational goals. Each initiative is tailored to the specific needs and priorities of the group, further linking counties in the region to parallel efforts in city neighborhoods.

Initiative I: Linking Dutchess County to Harlem

Cornell staff worked during summer 1995 with the New York Mission Society at its Dover Plains complex, where camp participants, along with adults from church-based coalitions and a Vietnam Veterans' volunteer organization, have adjacent farm market plots.

A Cornell graduate student in Plant Science worked part-time to assist camp staff and residents to develop food production and marketing expertise. Food was grown for the camp kitchens and for nearby markets, with produce sold in New York City at a farmers' market near the Mission Society's program site in Harlem. A group of youths from East Harlem travelled to the camp weekly via Metro-North rail (the Dover Plains Station was originally a milk-stop for farmers), thereby making energy-efficient transportation part of the Northeast sustainable agriculture picture!

Fall 1995 through 1996: In New York City, Mission Society youths at its Harlem Center will be involved in preparing for the next growing season. Dutchess County Extension's Les Hulcoop, with funding from the Dutchess County Executive, will continue his training program for new market farmers at the local Board of Cooperative Education Services; his initial eight-session evening course (Spring 1995) attracted nearly 30 participants, ranging in age from their late twenties to early seventies. Two additional sessions are scheduled (Fall 1995 and Spring 1996), and the staff will continue to work with the Mission Society at Dover Plains and will initiate planning to promote markets and farmland preservation in Dutchess County. Graduate students from Cornell are recruiting interested students to live at Dover Plains during the summer, providing day-to-day support for participants from the community and resident campers.

Initiative II: Linking Orange County to Highbridge, the Bronx

The Goshen Empowerment Center, operated and owned by the Dominican Sisters who staff the Highbridge Community Life Center, links Highbridge with Cornell's ongoing work in the Highbridge community. In 1995, eleven youths from the Summer Youth Employment Project raised and marketed food from plots in Goshen and small plots in Highbridge, and were involved in the greening of their neighborhood through a street tree survey for the NYC Department of Parks. Supervised by two Cornell summer interns, the youths participated in the farmers' market that opened in Highbridge in July, sponsored by Highbridge Community Life.

Program participants were on-site in Goshen two days each week, supervised by a resident Master Gardener trained by Cornell. They grew fruits and vegetables for the Center's summer camp and retreat activities, which serve both families and single adults. The site has extensive, south-sloping farm fields that have been enhanced by organic material delivered in five-ton dump trucks "on call" from the nearby Middletown racetrack! The Highbridge program's start-up costs in 1995 were calculated as follows: planting assistance, materials, supplies and other costs totalled $7,300; less sales of vegetables and prepared foods totalling $3,055; and less the $2,000 reduction in the retreat's food bills, for a start-up cost of $2,245.

In addition, staff members delivered baskets of sample produce to nearby restaurants and developed direct marketing relationships by the end of the season that will allow much more of what they raise in the coming year to be sold locally. One finding from this effort is its potential for transforming the staff's approach from a social service outlook to one that recognizes the elements of self-reliance in market-oriented production.

Fall 1995 through 1996: Working with a Cornell graduate student with extensive farmers' market experience, an "intern residence" program is being developed, allowing on-site support for food production at the retreat site and expansion of the efforts in Goshen. Congress has eliminated Summer Youth funding for 1996, so Highbridge Community Life will have to recruit participating youths.

Planned, 1996: Linking upstate New York and Bedford-Stuyvesant, Brooklyn

This program will work with the Putnam Avenue at Broadway Association and the Howard Block Association in a literacy and job training effort that also will involve Altamont, a statewide training and residential care program for recently released prison inmates. Altamont's Culinary Arts Program will develop market gardens in Bedford-Stuyvesant and at sites in suburban Westchester and other upstate locations. These will involve hands-on organic vegetable production and development of literacy and work force skills tied to market production at residences and local farmers' markets. The Bed-Stuy farmers' market, which is just one such location, is within the recently announced City Commercial Development Zone.

Final Remarks

The New Farmers/New Markets Program is only one element in an emerging system of regional production and community development. This initiative is an ensemble effort, with participating groups and organizations providing their own physical and staff resources as part of a shared vision that changes all participants' roles. Extension educators, though still doing what they have always done, namely, helping people produce food, are focusing on training and work force preparation as they "grow new farmers" by introducing urban youths and neighborhood residents to the potential for sustainable, market-oriented farming. Not-for-profit groups with retreats and camps still run summer programs, but are learning to integrate work-related skills. Their camps become "learning laboratories" where concepts of economic literacy and direct marketing can be developed in the people they serve through hands-on, experiential education. As a combined, collaborative effort, it helps to meet local needs by developing resources based in both rural and urban communities.

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Community Food Security, Agriculture, and the Environment: A Massachusetts Perspective

Hugh M. Joseph[1]

The Concept of Community Food Security

The conference theme *Environmental Enhancement through Agriculture* may seem to refer only to agriculture's relationship to the rural environment. But in highly urbanized states like Massachusetts, many farms are located within metropolitan areas, and it is urban residents, organizations, and policy makers who primarily shape the programs and policies that affect both agriculture and the environment. I examine these relationships, as well as farming's influence on the urban environment, through the perspective of *community food security* (CFS), an emerging food systems model that deals with access to and availability of an adequate local food supply.

The concept of community food security has evolved from earlier hunger and food security models. *Hunger* is a familiar concept, but it is inappropriately restricted to persistent and severe malnutrition, which is uncommon in the U.S. population. Furthermore, hunger relief programs primarily address the immediate food needs of individuals, rather than the structural conditions in the society or economy that lead to food insufficiency (Ashman et al., 1993). But as Cohen (1990) makes clear, hunger is the product of a sequence of events leading to inadequate food intake. Therefore, the term *food security*, often used internationally to describe the ability of a country or region to feed itself, provides a more useful framework for linking food, agriculture, and the environment (Clancy and Wilkins, 1994).

The Urban Institute (1989) defines *food security* as "all people obtaining a culturally acceptable, nutritionally adequate diet through non-emergency (or conventional) food sources at all times." The term characterizes not only individual food intake but also access to and availability of food at all levels: household, community, regional, national, and even global (Alamgir and Arora, 1991). In countries where hunger is more widespread and where much of the population is directly involved in food production, socioeconomic factors such as land and labor conditions, aid and trade, markets, prices, and incomes directly affect the production and availability of food for most of the population. Agriculture is therefore a fundamental component of food security policy in poorer countries.

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In the U.S., where the farm population is small and hunger affects only a small portion of the population, food security policy has focused less on agriculture and more on the conditions that determine whether individuals obtain adequate diets, such as household incomes, proximity to food markets, transportation, and food prices (Gottlieb and Joseph, 1995). The hunger problem is typically handled through publicly and privately funded emergency food assistance programs. But hunger and food security can also be addressed through a community-based "food systems" approach that relies on local means to increase food security for all residents (Cohen, 1990).

CFS represents a comprehensive strategy to provide an affordable and high-quality food supply for all members of a community (Ashman et al., 1993). It addresses a broad range of problems affecting the food system, economic opportunity, community development, and the environment, such as: the diminishing food safety net; disappearing farmland; inadequate inner-city supermarkets; increasing poverty and hunger; joblessness and homelessness; community disintegration; inadequate green space; and diet-related health problems. Because community food security is rooted in anti-hunger work, it incorporates immediate and longer-term means of feeding the needy, such as food stamps, soup kitchens, and food pantries. But CFS focuses primarily on developing community-based resources and access to a high-quality, affordable food supply, particularly in poorer neighborhoods where the need is greatest. The term "community food security" is of recent origin, but the model builds on programs that have been sponsored for many years by community-based organizations across the country.

Community Food Security, Farming, and the Environment: A Local Food Systems Approach

Community food security emphasizes local solutions to issues such as food access, supply, cost, diversity, and quality. However, most food originates from outside a community, and local suppliers such as supermarkets often are owned or controlled from the outside. Therefore, a *local food systems* approach is more appropriate to address local agriculture and the environment in the context of CFS. According to Dahlberg (1993), this includes not only food production, but also processing, distribution, access, use, and disposition or recycling of wastes. Local food systems planning by a community attempts to address these issues through local/regional solutions, to grow more food locally and regionally, and to provide more opportunities to deal with problems of hunger, joblessness, urban decay, and environmental degradation.

Anderson and Wilkins (in preparation) outline three essential components of local food systems: providing food security within the locality; supporting environmentally responsible practices; and supporting local growers. They suggest that a local food system succeeds when it reduces hunger and malnutrition, encourages greater community participation with respect to food access and supply, and stimulates more environmentally responsible food-related practices. Within this framework, my objectives for local farming and food production systems are differentiated from conventional agriculture's with respect to at least three factors: production methods, food distribution systems, and the boundaries of what constitutes agriculture.

Local food systems models support sustainable farming practices. Dahlberg (1993) contends that "localizing food systems challenges our amorphous conceptions of an undifferentiated national food system." He argues that food and agriculture production systems will be more sustainable when adapted to local and regional variations in soils, species, climate, culture, and institutions. But Anderson and Wilkins (in preparation) also note that local or regional food systems require that other components play a role: consumer education; certification to label foods as locally grown; local markets; and policy incentives that favor local foods grown with environmental responsibility. Hence, agriculture can be sustainable only as part of a food system that is sustainable or regenerative overall.

Local food systems seek to connect farmers and consumers within a geographic region or landscape. In his keynote address to this conference, Karl Stauber argued that the public provides incentives for sustainable production; for example, organic marketing can drive production standards. These relationships can make farmers more accountable to their public, which in turn can influence the environment through consumers' power to affect farmers' choices of production methods (Anderson and Wilkins, in preparation).

A local food systems model also can expand the definition of agriculture in the U.S. beyond commercial production, specifically to include more urban-based types of small-scale food production, notably gardening. For example, the National Gardening Association estimated in 1989 that about $18 billion worth of food is produced each year by household and community gardens, which is "enough to rival that of the corn crop" (Dahlberg, 1993). Yet this production is not considered "agriculture" by USDA or the land-grant system. Beyond the value of their own production, urban gardeners also support commercial agriculture when they buy seeds, seedlings, and fertilizers at farmstands and farmers' markets, and through their use of extension services.

The environmental emphasis within CFS and local food systems models is consistent with sustainable community models that are increasingly used in urban planning. According to Cortese (1995), a sustainable community represents "the ability of a community to utilize its natural, human and technological resources to ensure that all members of present and future generations can attain a high degree of health and well-being, economic security and a say in shaping their futures while maintaining the integrity of the ecological system upon which all life and production depends." A local food systems approach can increase a community's food self-reliance with greater environmental benefit compared with food produced through conventional food systems. For this reason, Van der Ryn and Calthorpe (1986) illustrate how local food production can be incorporated into the overall design for a sustainable community.

Across the country, food policy councils have been organized to address community food security issues in the context of local food systems. To a varying extent, they bring together community development groups, municipal and regional government agencies, nonprofit organizations, anti-hunger advocates, emergency food providers, nutritionists, public health providers, local agriculture and environment advocates, and business interests. Typically, they advise local governments or agencies, advocate for specific programs and policies, and serve as a means of information exchange for participants and an educational resource for the public. Their goals with respect to environmental enhancement in rural and urban settings are articulated in their organizational mission statements (Ashman et. al, 1993; Gottlieb and Fisher, unpublished), and include:

- *Preserving farmland and sustaining local agriculture.* This will conserve open space and contribute to a viable rural economy. Encouraging more farming and expanded on-farm activity is essential to building farm-to-community linkages.

- *Promoting more sustainable agricultural production practices.* This includes reducing the use of fossil energy, chemical fertilizers and pesticides, improving soil quality, and decreasing farm and food waste; that is, the types of environmental benefits commonly associated with alternative farming practices.

- *Expanding urban agriculture.* This can benefit cities in many ways: expanding neighborhood green space and beautifying local landscapes; expanding linkages to local food systems; helping to recycle household and municipal food and yard wastes; and fueling consumer support for local, sustainably grown farm products.

- *Promoting good nutrition.* Nutrition education can support consumption of fresh, local produce, in turn reducing food waste, packaging, and the use of energy and other resources associated with commercial food production, processing, and distribution.

- *Providing locally produced food for the hungry.* This can reduce food waste at the farm and throughout the food system, while ensuring that all members of a community can benefit from local food production.

Massachusetts has shown national leadership in developing farm-to-city projects that reflect these goals, such as the following:

Direct marketing. Direct farmer-to-consumer marketing has become a principal source of revenue for hundreds of smaller farms and a critical marketing strategy for many beginning farmers. The stability of Massachusetts agriculture in the past two decades, after decades of precipitous decline in the number of farms, in large part is attributable to direct marketing, such as farmers' markets. In many low-income neighborhoods, locally produced foods sold at farmers' markets would otherwise not be available to most residents. Some of these markets have stimulated improvements in the locations where they operate and have facilitated community and home gardening by making seedlings available and by familiarizing customers with the quality and taste of fresh produce.

Sales to supermarkets. Massachusetts also pioneered a resurgence of direct sales from farms to supermarkets during the 1980s. Many supermarkets and food cooperatives now feature local produce in season and increasingly carry other specialty items produced by local farms, such as cheeses and meat products. Direct sales to restaurants have helped foster the new American cuisine, characterized by healthier menu options that increasingly include fresh produce, often involving less common varieties. One Cambridge restaurant owner purchased a farm in Natick, about 20 miles to the west, to raise organic produce for his restaurant. Institutions such as school systems and universities (including Tufts) are increasing their use of local farm produce. The Chefs Collaborative 2000, originated by Oldways Preservation and Trust in Cambridge, encourages its member chefs to feature locally grown, seasonally fresh and whole or minimally processed ingredients.

Urban agriculture. Massachusetts groups such as Boston Urban Gardeners were national leaders in developing community gardens in low-income neighborhoods over the past two decades. Urban food production has substantial environmental value. Ratta and Smit (1993) characterize urban agriculture as "regenerative agriculture that restores degraded land, recycles waste and reduces urban pollution even while it is feeding the masses." According to Atkinson (1993), urban agriculture contributes food to households, builds community identity and participation, and enhances the urban landscape where the poor live. Farming or gardening in cities often uses (and improves) unbuildable land, such as vacant lots, rooftops, spaces around homes, and steeply sloping terrain (Urban Agriculture Network, 1993). Urban farming reduces the costs of food transportation, production inputs, storage, and wholesale handling. Gardeners more often use organic methods than do commercial farmers. Because it is more labor-intensive than commercial farming, gardening also uses less machinery and energy in production and can use food and yard waste and collected rainwater, resources that are not generally available to farms. Urban gardening also can promote better diets and encourage residents to participate in other projects that improve neighborhoods or support local food production (Gottlieb and Fisher, 1995).

Urban and community farms. Many of the remaining commercial farms located in urban areas, including nonprofit community farms, grow food to feed the hungry and engage in other projects that educate or involve community residents. For example, the Food Project at Drumlin Farm in Lincoln, Massachusetts uses volunteers to pick food for the hungry and has had a training program for inner-city youths to grow and harvest produce and market it at the Dudley Farmers' Market in the Roxbury section of Boston. Nesenkeag Farm, across the border in New Hampshire, has for several years produced over 50,000 pounds of fresh produce annually for redistribution by the Boston Food Bank to the emergency food system.

Emergency food programs. Many other Boston-area farms support local anti-hunger programs through gleaning and by donating harvested foods to food banks, local meals programs, and food pantries. Every week during the season, growers who sell at farmers' markets donate thousands of pounds of unsold produce to feed the hungry. Most of this food would otherwise be thrown away or composted. In 1994, the Greater Boston Food Bank launched KitchenWorks, a project to provide food service training to unemployed and under-skilled persons while doing large-scale processing of perishable foods, including donated local produce, for distribution to emergency food providers.

Community Supported Agriculture. A CSA is a production and marketing system in which households buy annual "shares" in the farm that entitle them to receive a wide variety of farm produce throughout the growing season. CSAs are strongly committed to ecological farming principles, and most use organic, biodynamic, or similar production methods (Groh and McFadden, 1990). Great Barrington's Community Supported Farm was among the first in the United States. The Western Massachusetts Food Bank operates a CSA program that donates tens of thousands of pounds of fresh food each year to pantries and meals programs to feed hungry and homeless people.

Community Food Security: Implications for Agriculture and Environmental Policy

If they are to prosper, programs that benefit farming and the environment require funding, research and development, legislation, and other forms of institutional and public support. With the decline in the farm and rural populations and the resulting decline in their political representation, support for agriculture relies increasingly on urban policy makers and consumers. Stauber (1995) noted that in the 1992 presidential election, a majority of votes cast came from suburban districts. If the city vote is also considered, clearly the rural vote is rapidly shrinking in influence at both the state and federal level.

In Massachusetts, urban and suburban legislators generally have been supportive on agricultural and environmental issues over the past two decades. The legislature funded one of the earliest and strongest farmland preservation programs in the country. The Massachusetts Department of Food and Agriculture (MDFA) was instrumental in the resurgence of direct retail and wholesale marketing and developed one of the nation's first "buy local" promotional campaigns, using the slogan "Massachusetts Grown and Fresher." In cooperation with the University of Massachusetts, MDFA sponsors an Integrated Pest Management production and marketing program called "Partners With Nature." Other state and federally funded programs support community economic development and benefit urban and rural environments, including the following:

- *On-farm composting*. Better use of agricultural waste remains a largely neglected aspect of agriculture. The Massachusetts state government, including MDFA, collaborates with farms and municipalities to promote self-supporting on-farm composting that uses farm, municipal, and urban wastes to produce high quality natural fertilizers. The compost is used by those farms or sold to other farms, to municipalities, or to individual households. Allandale Farm, the only remaining farm in Boston, composts waste from Haymarket (Boston's famous open-air produce market) and sells what it doesn't use to landscapers and other customers.
- *The Farmers Market Nutrition Program (FMNP)*. This federal- and state-funded program was initiated by MDFA in 1986 to provide coupons to participants in WIC (Special Supplemental Nutrition Program for Women, Infants and Children) and to elders, who redeem them for fresh produce at local farmers' markets. Since its inception, some 200,000 low-income households in Massachusetts have used the coupons to shop at farmers' markets for the first time. The program now operates in 30 states.
- *The Temporary Emergency Food Assistance Program*. In 1995, the Massachusetts legislature appropriated $1 million to offset federal cuts in TEFAP, which provides food to needy households and to the emergency food system. MDFA collaborated with other state and local agencies, farmers, and area food banks to distribute locally grown apples to over 200,000 program beneficiaries. This year, the program expects to include locally grown potatoes and apples in the food packages.

Initiatives such as these represent partnerships between government agencies, community organizations and farms to address food needs for low-income people in ways that can benefit and empower the entire community and produce creative solutions to the important problems of food security, farmland preservation, and environmental protection. By providing direct benefits to farmers, these efforts can build farmers' support for programs such as WIC, food stamps, and urban gardening. Such programs also extend the benefits of sustainable agriculture to low-income people. For example, through FMNP, CSAs, and similar programs, formerly premium-priced local produce and organic foods have been made more accessible and affordable for low- and middle-income people and available to feed the hungry.

Massachusetts, like much of the U.S., has great potential for expanding local food production. In most of the world, more urban green space is used for food production than in the U.S. This does not just include conventional farming. For example, Berlin has 80,000 community gardens, while New York has 1,000 (Helmore and Ratta, 1995) and Boston has far fewer still. Strategies to build support for local food systems and community food security among the public and politicians are critical to maintaining and expanding such programs. Often, an urban legislator's exposure to agriculture comes through a visit to a farmers' market, a community farm, or another urban-based food project.

More effort also is needed to incorporate urban-based environmental interests into community food security policy and planning. Including their representatives in local food councils or making them partners in community food-related programs will help broaden awareness and appreciation of the environmental benefits of these programs and expand the environmentalists' agenda to include support for food issues. Since access to food should also be a community development objective, CFS might better integrate environmental justice, land preservation, and social justice issues into its own agenda (Allen, 1994; Gottlieb and Fisher, unpublished).

Recent efforts to expand community food security include the establishment of a national Community Food Security Coalition in 1994 that now comprises over 125 anti-hunger, sustainable agriculture, environmental, and community development organizations (Community Food Security Coalition, 1995). The coalition has been the driving force behind passage of a new federally funded *Community Food Security Act*. This will provide one-time funding for innovative programs "designed to meet the food needs of low-income people, increase the self-reliance of communities in providing for their own food needs, and promote comprehensive responses to local farm, food, and nutrition issues" (U.S. Congress, 1995). The Community Food Security Coalition also is trying to get the U.S. Department of Agriculture to conduct an agency-wide mission review to determine how CFS objectives can fit within existing USDA programs, and to cooperate with other federal agencies to do the same.

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Protecting Important Natural Areas, Wildlife Habitat and Water Quality on Vermont Dairy Farms through the Vermont Farmland Protection Program

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Introduction: Vermont's Land Acquisition Program

Since 1987, Vermont has funded an active land acquisition program. The program works through a state trust funded by the state and federal governments and administered by the Vermont Housing and Conservation Board (VHCB). VHCB's conservation mission is to protect farmland, natural areas, and historical resources and to provide public access to recreation areas. The program uses two types of transactions: fee simple ownership by a state agency or private nonprofit organization; and conservation easements on private land. Conservation easements are used to conserve farms; they include provisions preventing property development or subdivision in perpetuity, but specify few controls over land management, allowing farm owners to make decisions about their business operations. Easements are permanently recorded in town land records as encumbrances on property titles.

When a conservation goal can be met only by intensive land management, it is preferable to have fee ownership by an organization committed to achieving that goal. Because many important natural and historical resources in Vermont are on private farmland, we often face conflicting objectives on working dairy farms. This requires thinking creatively about techniques beyond fee ownership and conservation easements. Three farmland preservation projects illustrate methods to conserve dairy operations and natural areas. These projects were completed with funding from VHCB and private sources.

Description of Projects and Issues

Whitney/Hospital Creek Project

Through the efforts of the Vermont Department of Fish and Wildlife (VDFW), the Vermont Department of Agriculture, Food and Markets, and The Nature Conservancy

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(TNC), the Whitney/Hospital Creek conservation project protects 822 acres of farmland and wetlands. The Whitney and Hospital Creek Wetland Complexes and adjacent farmland are an outstanding example of a largely undisturbed area rich in agricultural, fish, wildlife and historical resources. The area was very well managed by dairy farmers, who permitted public use for fishing, hunting, trapping, canoeing, and birdwatching. However, the region's character has changed greatly because of demands for seasonal camps and permanent residences, especially near Lake Champlain. The transition from farmland to residential development threatened the area's availability for future public and agricultural use. When three homes were built on a parcel on the southeast side of Hospital Creek, the VDFW became concerned about future development near the creeks. With development limiting public access to Hospital Creek, VDFW was compelled to try to protect this valuable resource when a realtor bought a second property on the northwest end of Whitney Creek, the Grace parcel, in 1989.

The objective was to conserve the farmland and wetlands surrounding Whitney and Hospital Creeks to protect their natural areas and provide access for hunting, fishing and recreation. At the same time, the dairy farms' viability would be enhanced. Currently, almost the entire Whitney Creek shoreline and about 40% of the Hospital Creek shoreline is protected. Future projects will include more of Hospital Creek. The lands between Whitney and Hospital Creeks and the southeast side of Whitney Creek were under imminent threat of development. Development would have caused severe wetland damage and limited farmers' cropland. Public access to the creeks would have been severely restricted. Quick action was needed.

East Creek Project

This project involved the protection of a large marsh adjacent to Lake Champlain. The 800 acres of wetlands harbor a wide variety of wildlife, waterfowl, and plants, including several rare species, such as the blackchin shiner *(Notropis heterodon)*, lake cress *(Armoracia lacustris)*, and falsehop sedge *(Carex lupuliformis)*. The creek through the marsh is used for recreation by local fishermen and occasionally by canoeists. The 4000-acre landscape, including the marsh and land adjacent to it, is broken into 13 different ownerships in 17 large parcels, which include six successful farms.

The project involved several issues. From an environmental perspective, the most important issue was to remove cows that were grazing on marshland edges and wallowing in wetlands and waterways. Second, there was the need to forestall residential development near the marsh when the farms were sold. The third issue was the need to reduce soil erosion and nutrient runoff from adjacent farms and two streams flowing into the marsh.

From a farm perspective, an important issue was the need to aid the farmers with their debt loads and increase the amount of tillable land to insure each farm's viability.

A less important issue was to prevent the loss of affordable housing for farm laborers. Finally, federal money is available to help prevent soil erosion and nutrient runoff, but sometimes the remaining costs are still an obstacle to such projects.

Irasburg Farm

This last project involves a single farm encompassing 659 acres in Irasburg in the Northeast Kingdom region of Vermont. Over a five-year period, this project evolved from a routine Vermont Land Trust conservation effort into an innovative, experimental model to protect 185 acres of wetlands and upland buffers while ensuring the farm's viability. The wetlands are associated with the Black River and two smaller streams that meander through the property, adding to the project's complexity. This well-managed, scenic farm has excellent soils and a historic round barn; located in a strong agricultural region, it is a desirable candidate for VHCB protection. The extra effort to protect the wetlands was made possible by Sweet Water Trust funds. Throughout the negotiations, the challenge was to balance the need for effective, ecologically sensitive wetland protection against the farmer's need for a sound dairy operation with adequate land. Both the farmer and the land trust made concessions to achieve these goals.

Protection Techniques

Various protection techniques were used at the three sites. We describe them in order, from those most commonly used to more unusual and complex arrangements. However, this order does not imply a corresponding order in the benefits for agriculture or natural area protection. The greatest benefits sometimes are gained by simple techniques, such as building a fence or purchasing a natural area. Every problem must be solved individually.

Conservation easements and fee ownership

In the Whitney/Hospital Creek project, a strong proactive approach was used to interest landowners in participating. With access to Hospital Creek already reduced, development of the Grace parcel would have prevented access to both creeks. The Grace parcel was subdivided into two building lots, and aggressive marketing resulted in many potential buyers and an acceptable offer on one lot.

At the same time, a 200-acre portion of the former Guy Smith farm, on the opposite side of Whitney Creek from the Grace parcel, was for sale in 1988-89. This land was originally offered to the VDFW, and an agreement was reached for VDFW to purchase the land. However, no contract was signed, because the owner found a buyer willing to pay far more than TNC or VDFW could afford. Fortunately, the buyer appreciated the area's natural beauty and value and agreed to donate an easement on all but 10 acres. This donation helped leverage a state grant to purchase the entire Grace parcel.

Once the parcels were protected, all landowners surrounding the creeks were approached about selling development rights on their farmland. Two farmers ultimately participated in the program. Charles Veysey, who owned most of the land between the creeks, also had been approached by developers. He preferred to sell his land to Bob Smith, a neighboring dairy farmer who was leasing the land for cropland. Mr. Smith wanted to acquire the land because it was critical to support his farm, but he couldn't pay development prices. Fortunately, Mr. Smith realized that the program would enable him to buy the farm at agricultural value and that Mr. Veysey, who was 82 years old at the time, would receive the full market value, enough for his comfortable retirement. The difference was covered by a VHCB grant. Protection of the Veysey tract stopped inevitable development up the peninsula between the Whitney and Hospital Creek wetlands. The transaction included VDFW's fee simple purchase of buffers along both creeks, providing public access. Mr. Smith owns the intermediate cropland, subject to an easement preventing future development.

The most recent phase of this project resulted in the protection of 204 acres of the Correia farm. That land easement was similar to Mr. Smith's, but included provisions establishing an undisturbed 75-foot buffer and public access along the creeks. Affirmative public access was not included in the farm easements because it was viewed as detrimental to farming. The conservation easements on both farms, however, included provisions prohibiting owners from selling private hunting rights. Except for areas specifically designated for public access, the landowners reserved the right to post farmland against hunting or trespassing.

Sale with leaseback

The Peck Farm in the East Creek project was similar to the Hospital Creek project in that the primary protection tools were a purchase of the natural area in fee and a conservation easement over the farm. However, a lease was used to balance environmental protection with continued farm use. In addition, the easement provided for a future farm-labor housing site because the existing farmstead lacked space for another dwelling.

The Peck farm had hay fields and pastures along the wetlands of East Creek. Besides wetlands, it included several steep hemlock drainages. Although both the wetlands and forested drainages had very low value for feeding cows, there was potential for heavy grazing. Also, one small pasture on a narrow peninsula extended well into the wetlands. This field had been tilled in the past, and although it did not erode when pastured, there was concern about its steeper slopes being tilled for corn.

TNC wanted to purchase the woodland, peninsula field and wetlands as part of its East Creek preserve so that they could provide improved natural habitat by fencing cows out of these areas. However, the farmer wanted to retain the rights to cut firewood for heating his home and to convert the flat peninsula sections back to a hay field. Both parties' goals were met through an arrangement in which TNC purchased the land and then leased to the farmer, for a nominal fee, the right to cut firewood and to use the peninsula field for hay production. The farmer thus retained the farm's productive land base, while the Conservancy could protect the important natural area.

Land exchange with conservation buyer

The Bertrand/Audet East Creek project involved a combination of conservation buyer, agricultural easements, real estate purchase and like-kind exchange of land in transactions over several years. The Bertrand farm had been listed for sale after participation in the whole dairy herd buyout in 1985. However, its lakefront location and development potential made it too expensive for the Conservancy to purchase outright, because only a small, inexpensive portion contained important marsh and buffer areas. Also, the Conservancy did not want to assume the risk of reselling the farm because the condition of its facilities made it unlikely that the farm would ever be an independent farm again. In fact, that consolidation process had begun because the adjacent Audet farm was already leasing the fields, and crop production from the leased fields was critical for that farm's future success. However, the land's high development value also prevented the Audet farm from purchasing the Bertrand land outright. Mr. Bertrand was determined to sell the entire farm as one unit, because he correctly understood that once the property was divided he was likely to be left with only the farmstead, which would be very hard to sell without its lake frontage or surrounding fields.

The first step was to complete an agreement-in-principal with the Audet farm in which TNC, if it could acquire the leased tilled fields, would exchange them, with agricultural easements, for a parcel of equal value (from the Audet farm) of wetlands and their steep, bordering slopes. Once that agreement was made, TNC notified the farm's seller that it would work with any potential buyer who was interested in purchasing a lakefront house and protected land but who did not intend to use the excess land, some of which had development value, and therefore was unwilling to pay for it,

Surprisingly, this type of conservation buyer soon appeared, and the broker involved was knowledgeable and very supportive of such arrangements. TNC negotiated directly with the potential buyer on the portion of the purchase price the Conservancy would pay for the tilled fields and the wetlands with their buffering steep old pasture slopes. Also, TNC conveyed to the home buyer a separate protective easement on the fields directly across the road from the house, in case the agricultural easement was ever dissolved or changed by the governmental and non-profit entities involved. In addition, TNC signed an agreement to convey to the conservation buyer a similar protective easement on a nearby parcel if TNC ever acquired title to it in a future transaction.

More than two years later, the exchange was made with the Audet farm. Part of that time was spent in negotiations about equivalent exchange value and part included the time the farmer took to accept the new arrangement, because the overall the farm would get smaller. Also, it was agreed that TNC would purchase additional buffer land at market value. This was an advantage to the Audet farm because the land in question was used only for grazing, and a change in farm practices decreased the need for pasture. More importantly, this land was accessible for grazing only by trucking the heifers, and this inefficiency had to be eliminated. The agreement to purchase additional land gave the impetus needed to close the deal because the farm partnership needed to extract cash value from the farm without affecting the basic farm operation or increasing its debt.

Fencing

Sometimes there is no need to change any aspect of real estate ownership or even to remove a development threat through agricultural easements. A simple change in farming practice may greatly benefit a natural area. On the McCray farm project at East Creek, TNC worked with the farm lessee and an institutional owner that had previously donated an agricultural easement on the farm, thereby allowing construction of a fence to keep cows and heifers from the East Creek wetlands and a 100-foot buffer.

Although wetland fencing normally has little effect on farm grazing practices, it is rarely done because of its cost. In this case, TNC and a federal program called Partners for Wildlife built more than a mile of fence on the farm and another mile of fence on the Peck farm mentioned above. In both cases, the farmers' only costs will be for maintaining the fence; to keep those costs low, a high-quality, high-tension fence was built.

One complication in fencing cattle from streams and wetlands is finding other reliable water sources. This was not possible on the McCray farm, so a short wetland section was left accessible to cattle. The project in Irasburg also involved fencing cows from riparian areas. There, a well was drilled to supply a watering trough in the pasture, with the costs shared by the Sweet Water Trust and the Vermont Land Trust.

Constructing fences to change agricultural practices is not usually as easy as in these two projects. To change farm grazing practices along wetlands often is difficult because harm from grazing is not usually obvious, so that the farmer sees no reason to change. However, many farmers will consider changing their practices if they understand the harm caused by grazing, if little pasture is lost, and if someone else pays for the fencing. Also, although fencing and wells help correct detrimental agricultural practices, they involve maintenance costs. Usually such costs are low, but whether a farmer perceives them as low may determine whether the techniques succeed.

Management easement

TNC originally purchased the Robie farm several years ago, intending simply to use a VHCB grant to place an agricultural easement on it, retain most the wetlands and a simple 50- to 75-foot buffer as part of the East Creek preserve, and then resell the farm to a young lessee ready to own a farm. In theory, the agricultural easement would make the farm affordable for a young farmer and would provide enough facilities and land for the farm to be viable.

However, actual events were different, allowing TNC to experiment with new techniques to protect a natural area next to a large, successful farm. A suitable buyer could not be found to purchase the farm immediately, so TNC settled for a lease-sale arrangement rather than allowing the fields to go untended through the summer. Unfortunately, that operator could not maintain the facilities and eventually went bankrupt. TNC got back a farm that still had large, excellent fields and three usable houses. However, the main dairy barn was at the end of its useful life unless it received costly repairs. TNC decided to offer the farm for sale again, but looked for a qualified buyer with the resources to insure the farm's viability. Dairy farming had changed, and TNC hoped to find someone who would do another type of farming.

Familiarity with the farm's characteristics was one advantage of having owned it for some time. Early in the project, during the first lease-purchase negotiations, TNC was concerned that the previous owner had tilled slopes that were too steep. This was confirmed during the spring melt in the year the farm reverted to TNC, when every corn field eroded heavily into East Creek. Buffers would have to be adjusted so that they reflected the actual topography to minimize erosion and provide adequate nutrient uptake. However, to redivide the farm into natural area and tillable land would have removed far too much tillable land from the farm. After much discussion with the new potential buyer, the solution was to create a new "management" easement.

The easement focusing on land management had the same legal basis as a traditional easement. However, it was added as an overlay zone on the farm, after the traditional agricultural easement removing development rights had been placed on the entire farm. This arrangement was done because the "management" easement was written knowing that it may change; in fact, it included incentives encouraging the best farming practices possible to eliminate soil erosion and nutrient runoff. Normally, permanent easements are designed to remain largely unchanged (except within farmstead areas), so it was important not to set a precedent that implied they could be changed easily. Also, the agricultural easement is jointly held by the VHCB, the Vermont Department of Agriculture and TNC to ensure stability and permanence; the actual management practices were to be an arrangement between TNC and the farm owner.

This new easement has three unique features. First, a section is aimed at pasture management, without requiring any particular type of pasture management or livestock. A finger of wetland extends deep into the farm's agricultural land. To separate this land would have been difficult, so an easement was crafted to protect the wetland from excessive erosion and nutrient loss while allowing grazing on the abutting pasture. The easement prohibits any grazing that is so intensive that gullies start forming. It also requires the pasture to include a sizable section that is not part of the steep slope, so that grazing is not concentrated on the slope. Also, if flatter portions of the pasture are tilled, the sloped fields will revert to ungrazed buffer.

The second feature creates a hay buffer on the tilled fields' slopes. Instead of losing agricultural land by stopping production on the slopes, a zone on the slopes (except the steepest parts and the waterways) was created that could be used for hay. Theoretically, this strip is wide enough to be properly and economically managed for hay, instead of just being lost to production or requiring continual brushcutting. This arrangement allows effective erosion control while providing a crop, but only experience will show whether the more complicated field arrangement impedes hay production.

The third and most innovative feature is a mechanism to reduce the hay buffer if the field management techniques or the choice of row crops causes less erosion than a normal corn rotation combined with a hay buffer. The long-term goal is no net soil loss. Thus, if soil is retained through techniques such as organic farming or different tillage methods, the buffer could be reduced. Intercropping also might reduce erosion. Again, no attempt was made to require any one management technique or one crop. Rather, the easement defined a minimum standard for erosion control and nutrient uptake levels provided by a hay buffer and included incentives to increase protection levels over time. Thus, we expect the easement to change with changed circumstances.

Ecological Protection Zone

On the Irasburg farm the original goal of the Vermont Land Trust was to conserve a good farm resource. At the time, only a few farmers in the area had sold development rights, and area farmers were suspicious of conservation easements. This certainly was true of the Irasburg farmer. As negotiations progressed, he appeared concerned only with the financial outcome, but was willing to make accommodations to reach his goal. However, after some appraisal issues were finally settled and several different land-use configurations tried, including an affordable housing component on 30 acres of the farm near town, the frustrating negotiations were inconclusive. As a new strategy, the regional director working on the project, Cheryl Fischer, contacted the Sweet Water Trust to discuss model wetland protection on the farm. She was able to get funds from this trust for the necessary scientific identification of the wetland's importance and dimensions, and to contribute the additional funding needed to purchase conservation restrictions.

The conservation easement on this farm is not the standard document used in Vermont. It includes provisions regarding an Ecological Protection Zone (EPZ) that requires additional protection of the 185 acres of riparian lands, wetlands and buffers along the Black River and its two tributaries. Jeffrey Parsons, a wetlands ecologist, prepared a report on the scientific basis for the additional protection; this information is referenced in the easement. There are three areas in the EPZ: the water courses; the undisturbed vegetation areas (all the designated wetlands and most of the buffer zones); and the no-till areas, where some agricultural activities are allowed (forage crops may be cut, but the land may not be tilled). In certain areas where revegetation was needed, fiberglass stakes were driven into the ground to mark the EPZ boundary. Shade trees were planted in the pasture because cows were fenced out of shady areas now included in the EPZ. Walking, hunting, canoeing, fishing, primitive camping in two locations and similar passive recreation is allowed within the zone. Also, beaver dams may be removed if they pose a threat to the agricultural operation.

The farmer already was not farming 125 of the 185 acres because they were too wet. However, fearing impending restrictions and seeking to replace some of the lost tillage, the farmer clear-cut 20 acres just before the easement was placed on the farm. According to Jeffrey Parsons' report, the ecologically optimal size for this zone would have been 220 acres, but balancing that goal with the farmer's agricultural needs required compromise.

Discussion

These three projects provide a broad range of methods, from simple to complex, to conserve both farmland and natural areas on the same property. The focus of the Whitney/Hospital Creek project was to prevent development without imposing management regimes. For the East Creek farmland, management to enhance water quality was introduced. At the Irasburg farm, an intensive study was conducted to determine the needed resource-protecting measures. In all cases, it was necessary to balance the farmers' need for a viable, profitable business against the need to protect special natural resources. Changes, compromise and considerable creativity resulted in projects that adequately met both needs.

The Whitney/Hospital Creek project goal was to protect the wetland without unduly restricting the surrounding operating farms. Although the two interests are often thought to conflict, agriculture supported some wildlife and recreational values in this case. Public access to the wetlands has been very important to local residents. Not only is farmland with access the best way to provide such benefits, but cropland also is important for migrating waterfowl, thus enhancing fall hunting. Increasingly, farmers were selling exclusive hunting rights to individuals, thereby limiting local residents' hunting opportunities. Wetland protection and public access were achieved, to the extent possible, through public ownership of nonagricultural land. (In one case, however, the town opposed additional state ownership of land because it would reduce the town's taxable land base.) The Whitney/Hospital Creek easement prohibited sales of exclusive hunting rights and provided public access to areas along the creeks. Also, the easement was designed not to interfere with farm management decisions.

TNC used several methods to conserve properties surrounding East Creek. They recognized the need to keep existing farmland productive and viable; this recognition led to creative changes in the standard conservation easement that controlled some management practices. With the Peck farm, TNC leased land back to the farmer for haying and cutting firewood, with provisions to ensure wetland protection. This arrangement met both the farmer's needs and those of TNC.

In a second transaction, the use of a conservation buyer and a land exchange achieved all parties' goals. Though this transaction took a long time, it was probably the most important addition to the East Creek natural area and provided the greatest long-term benefit to a successful farm. The project increased the tillable land without any cash outlay by the farmer and decreased the cost of carrying land not needed for the farm operation. Allowance for future housing for farm labor anticipates the possibility of a larger farm (though the farmer decided to till it for the foreseeable future). The project provided badly needed cash through a sale that did not entail house lots, the usual way that farmers meet their cash needs. Changes in farming (larger herds and more efficient operation) were driven by outside forces; TNC was able to combine the pieces into a strong partnership.

An easement to control farm management in a buffer zone was used on a farm that first was purchased in fee by TNC. It is unclear whether TNC would have succeeded in placing such a comprehensive easement on this farm without first owning it. Although the details were carefully negotiated with the new owner, the balance of power in the negotiation was not the same as if TNC were trying to persuade a farm owner to modify land use voluntarily. Dictating management is a sensitive matter because farmers are rightfully proud of the ways they decide to manage their farms.

Complicated projects may not always be the best way to meet the need for resource protection and farm viability. At Hospital/Whitney Creek, fee purchase of the wetland buffer protected the resource. At East Creek and the Irasburg farm, simply fencing cows out of fragile areas effectively protected wetlands. TNC tapped resources from Partners for Wildlife to share fence construction costs. The Vermont Land Trust used funds from the Sweet Water Trust and another private foundation to provide shade for cows fenced out of wooded areas. Finally, the complicated EPZ on the Irasburg farm provided protection levels for the farm's riparian area based on a sound scientific study. The project's complexity, however, created a threatening atmosphere for the farmer, making negotiations difficult. Keeping solutions simple is the best place to start, but competing interests often require the flexibility to use more complicated arrangements.

Empirical Evidence of Public Preferences for Farmland Preservation

Jeffrey Kline and Dennis Wichelns[1]

Introduction

The environmental amenities provided by farmland are receiving increased attention among policymakers in the United States and Europe. Historically, farmland has been valued primarily for its productive capability. In Europe, intensification of agricultural land use has led to increased agricultural production and a decline in landscapes associated with more traditional, extensive farming activities (Slangen, 1992; Pruckner, 1995; Hackl and Pruckner, 1996). In the United States, increased competition for environmental amenities generates conflicts between farm and nonfarm activities near urbanized areas (Gardner, 1994). As amenities such as wildlife habitat, scenic vistas and cultural values have become scarcer relative to food and fiber in developed countries, public concern has shifted from increasing agricultural production toward protecting and enhancing the quality of the rural environment (Bromley and Hodge, 1990).

Environmental amenity values may be characterized as nonmarket values, because residents and farmers usually cannot purchase or sell amenities in market transactions. Some farmers in France offer farm workshops and operate bed-and-breakfast inns, but farm tourism is not yet widespread (Cavailhes et al., 1994). Some amenities, such as wildlife habitat and scenic vistas, also can be described as public goods because they are not diminished by the number of residents "consuming" them. Conflicts can arise between private and public interests when the decisions of landowners fail to provide socially optimal amounts of environmental amenities (Slangen, 1992). Public policies can mitigate these conflicts by encouraging landowners to manage farmland in a socially desired manner.

Many state and local governments in the U.S. protect farmland by purchasing development rights or by providing tax breaks that encourage farmers to continue farming the land. National governments encourage the provision of environmental amenities by modifying price support programs to require compliance with environmental objectives,

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or directly subsidizing the provision of specific amenities (Russel, 1993). For example, under the Sodbuster and Swampbuster provisions of the Food Security Act of 1985, U.S. farmers receiving federal payments must reduce soil erosion and protect wetlands (Glaser, 1986). The Food, Agriculture, Conservation and Trade Act of 1990 introduced the Agricultural Water Quality Protection Program to subsidize agricultural practices that protect water quality (Osborn, 1991). In the Netherlands, farmers receive compensation from the Dutch government when they voluntarily cultivate farmland according to management agreements that recognize natural and landscape values (Slangen, 1992; Bekkers and Verschuuren, 1996).

Choosing appropriate policies requires accurate information describing public preferences for the environmental amenities provided by farmland. Contingent valuation studies have measured the public's willingness to pay to protect agricultural lands in the U.S. (Halstead, 1984; Bergstrom et al., 1985; Beasley et al., 1986) and in Austria (Pruckner, 1995; Hackl and Pruckner, 1996). These studies confirm that residents of developed countries wish to preserve farmland, but they do not describe preferences for specific amenities associated with farmland.

This paper identifies and measures public preferences for the environmental amenities provided by farmland. This information can assist policymakers in developing efficient policies to achieve the benefits most desired by the public. We use qualitative information provided by focus groups and data from a survey of Rhode Island residents to identify and compare socially valued environmental amenities associated with farmland and other open space.

Focus Groups and Survey of Residents

Rhode Island is a small state with a population density of 958 persons/mi^2 (second highest in the U.S.). In 1945, 39% of the land was in farms, but the figure declined to 15% in 1964 and 9% in 1987. Today, farmland constitutes just 7% of all land in the state (U.S. Department of Commerce, 1994). In 1968, the Rhode Island state legislature passed a law assessing land at its use value. Rhode Island began purchasing development rights in 1981. The development rights program has been supported by six separate public referenda that have provided a total of $14 million in funding.

We assembled six focus groups, each involving two to eight members, throughout Rhode Island during the spring of 1994. We led the focus groups in discussions of preservation, current land use issues, and land use changes. The focus group participants generally were supportive of preserving farmland and open space and believed that preservation slows the rate of development in Rhode Island. They felt that development diminishes the quality of life and rural character of the state. Participants described *rural character* generally as the land use and cultural patterns that prevailed in Rhode Island when they were growing up. *Quality of life* involved access to land, clean water, and abundant wildlife, which were perceived to epitomize environmental quality.

The primary concern expressed by focus group participants regarding farmland had more to do with rural character and quality of life than with agricultural production. Though some participants expressed an interest in buying local produce, none felt that Rhode Island's agricultural production is of national importance. Preserving farmland was perceived as beneficial, but not to insure local or national food supplies. Rather, it insures the continuation of rural character and quality of life in the state. In fact, some participants suggested that preserved farmland provides a public benefit even if it is left idle.

The principal tasks of the focus groups were to develop a list of reasons that preserving farmland and open space is important, and to identify lands and land attributes most valued by the public. We used this information to develop a survey of Rhode Island residents interviewed at motor vehicle registration sites throughout the state during February and March 1995. The survey instrument provided a brief description of Rhode Island's farmland and open space preservation programs, and asked respondents their opinions and preferences regarding farmland and open space preservation.

Environmental Amenities Provided by Farmland

Focus group participants commonly listed several reasons for preserving farmland and open space. The survey presented respondents with this list (Table 1) and asked them to indicate how important each reason should be when deciding what farmland or open space to preserve (on a scale from 1 to 10, with 1=not important, 10=most important).

Most mean ratings of the importance of each reason are significantly different from each other at $p < .01$ (Table 1). Survey respondents believed that protecting groundwater should be the most important consideration in farmland preservation decisions, followed by protecting wildlife habitat and preserving natural places. Slowing development and providing public access were rated as least important. Providing local food and maintaining farming as a way of life were ranked in the middle, along with preserving rural character and preserving scenic quality. The ranks of reasons for open space preservation were similar.

The ratings assigned to various reasons for preserving farmland show that the public associates farmland with environmental amenities such as clean groundwater, wildlife habitat, and natural lands. The respondents believe that protecting these amenities should have priority over more traditional agricultural policy objectives, such as insuring a local or national food supply. The importance of preserving farming as a way of life is not significantly different from the importance of protecting aesthetic amenities associated with farmland, such as scenery and rural character.

Table 1. Respondents' ratings of the importance of various reasons for preserving farmland and open space.

Reason	Mean Rating of Importance: Farmland Preservation	Open Space Preservation
Protecting groundwater	9.34*	9.37*
Protecting wildlife habitat	9.02*	9.11*
Preserving natural places	8.85*	8.93*
Providing local food	8.25*	—
Keep farming a way of life	7.80	—
Preserving rural character	7.66	7.83*
Preserving scenic quality	7.62	8.19*
Slowing development	7.20*	7.46
Providing public access	6.70*	7.33

* denotes a mean that differs significantly from other means in column ($p < .01$), based on Student's t-test ($n = 525$). Ratings range from 1 (not important) to 10 (most important).

Preferences for Farmland Relative to Other Lands

Focus group participants listed nine types of land that they believe should be preserved. These included beaches, rocky shoreline, ponds, rivers, wetlands, woodlands, and three types of farmland: crops and pasture, turf (sod) farms, and fruit and vegetable farms. Most farms in Rhode Island can be placed in one of these categories. In addition to these nine land types, the focus group participants expressed the need to preserve specific land attributes, including public access, endangered species habitat, and important groundwater resources.

The nine land types were used with different combinations of the other land attributes to describe hypothetical land parcels. A section of the survey presented respondents with descriptions of two hypothetical parcels and asked them which the state should preserve, if they had to choose between the two. For example, a woodland parcel with public access might be paired with a farmland parcel that overlies an important groundwater aquifer. The pairings were based on a factorial design (Addelman and Kempthorne, 1961). Each of the 583 respondents was presented with five pairs, yielding 2,915 observations of their choices.

The choice between different land parcels is similar to votes on policy alternatives during public referenda. We assume that respondents choose between different parcels according to their perception of the benefits derived from the preservation of each parcel compared with the costs of preservation. Some may base their perceptions on what they feel is best for society, others on their personal welfare. Still others may base their perceptions on some combination of both social and personal welfare. In either case, we assume that a respondent's utility $u_i(x_i,c_i)$ for any parcel i, is a function of a vector of parcel attributes x_i and the scalar parcel cost c_i. This utility index includes a measurable component $v_i(x_i,c_i)$ and a random component e_i, which is unobservable. For any pair of parcels 1 and 2, parcel 1 will be chosen for preservation by a respondent who believes that

$$v_1(x_1,c_1)+e_1 > v_2(x_2,c_2)+e_2.$$

A logit model of the difference between the two functions gives the probability of a respondent choosing parcel 1 as

$$P_1 = \frac{1}{1+\exp\{-[v_1(x_1,c_1)-v_2(x_2,c_2)]\}}$$

We estimated it using the maximum likelihood procedure (Ben-Akiva and Lerman, 1991).

We specified the functional form for the utility index describing parcel i as

$$v_i = \beta_0 x_{i1}^{(\beta_1+1)} c_i^{\alpha} \exp\left[+\sum_{j=2}^{n} \beta_j x_{ij}\right]$$

where x_{i1} is parcel size, and the x_{ij} are measures of land type and other parcel attributes j (j=2 to n), and the β_j and α terms are coefficients to be estimated. The functional form is consistent with conceptual models that describe land value per acre as a function of parcel characteristics (Chicoine, 1981; Shonkwiler and Reynolds, 1986).

The model was estimated by taking the natural logarithm of both sides as

$$\ln(v_i) = \ln(\beta_0)+(\beta_1+1)\ln(x_{i1})+\alpha\ln(c_i)+\sum_{j=2}^{n} \beta_j x_{ij}.$$

Because discrete choice estimation uses the utility difference between two parcels, the parameter $\ln(\beta_0)$ drops out of the analysis. The scalar impact of this unknown parameter does not affect the estimated coefficient values for parcel size, cost, and other attributes. The estimated model includes dummy variables describing land type and the interactions between land type and other parcel attributes: public access, endangered species habitat, and important groundwater resources. Many of the estimated coefficients describing land type and parcel attributes are significant at $p<.01$ (Table 2). Because the dummy variable for turf farmland is omitted for model estimation, the signs and values of the land type coefficients are interpreted relative to turf farmland. All land type coefficients are positive, showing that turf farmland is the least preferred land type.

The coefficient for parcel cost (α) is -0.207 ($t=-1.83$; $p<.07$), indicating a negative relationship between the utility index and the expenditure of public funds. The coefficient value for parcel size (β_1+1) is 0.225 ($t=3.05$; $p<.01$), indicating a positive relationship between parcel size and the utility index. Converting the coefficient for parcel size to utility per acre results in a negative coefficient of -0.775 ($\beta_1=0.225-1$), which implies diminishing marginal utility as parcel size increases.

The coefficients representing public access to preserved land are positive for all land types except beaches and crop and pasture farmland. The coefficients for rocky shoreline, ponds, and rivers, have the greatest magnitudes and are significant at $p<.01$, $p<.06$ and $p<.08$. Respondents may desire greater access to lands that have rocky shoreline, ponds, and rivers, but feel that existing access to other lands is sufficient. All coefficients representing lands described as including endangered species habitat or important groundwater resources are positive and nearly all are significant at $p<.01$. Survey respondents have strong preferences for lands with these specific environmental attributes.

Table 2. Estimated coefficients of the preference model.[1]

	Land Type	Public Access	Endangered Species Habitat	Important Groundwater Resource
Beach	1.594*	-0.266	0.927*	—
Rocky shoreline	0.758*	0.557*	0.493*	—
Pond	0.688*	0.358	0.754*	0.819*
River	0.828*	0.335	0.683*	0.768*
Wetland	0.363	0.081	0.464*	0.932*
Woodlands	0.610	0.287	0.827*	0.383
Crops/pasture	1.240*	-0.295	—	1.378*
Turf	—	0.234	—	1.407*
Fruit/vegetable	1.505*	-0.174	—	0.734*

[1]Estimated using 2,915 observations. Value of the log likelihood function is -1,829.
* denotes statistical significance ($p<.05$).

Calculating Utility Indexes

The estimated model coefficients (Table 2) can be used to calculate utility indexes for actual parcels of land. Utility indexes are calculated for each land type using mean sizes and preservation costs per acre for actual parcels preserved by the State of Rhode Island (Table 3). The indexes represent survey respondents' preference ratings for preserving different parcels whose sizes and costs are typical of past preservation efforts. These indexes are presented for generic parcels that do not have special attributes, and for parcels that have endangered species habitat or important groundwater resources. Indexes for open space land types are calculated with public access, because state open space acquisitions provide public access. Farmland indexes are calculated without public access, because state purchases of farmland development rights do not provide it.

Fruit and vegetable farmland has the highest utility index of all generic parcels (11.5), followed by woodlands (9.4) and crop and pasture farmland (8.8) (Table 3). The index for turf farmland (2.6) is lowest. The indexes for other open space lands range from 5.1 for wetlands to 7.7 for rivers. Except for turf production, public preferences for preserving generic farmland compare favorably with preferences for preserving other open space lands. Preferences for farmland reveal a high marginal disutility associated with losing additional farmland amenities.

Table 3. Estimated preference indexes of farmland and open space parcels with mean size and cost.

			Generic Parcel		Special Attributes	
Parcel	Mean Size[1] (acres)	Mean Cost[1] ($)	No Public Access	With Public Access	Endangered Species Habitat	Important Groundwater Resource
Beach	10	2,029,330	—	5.1	13.8	—
Rocky Shoreline	35	2,174,515	—	7.1	11.6	—
Pond	32	530,912	—	7.1	15.0	16.1
River	8	136,088	—	7.7	15.3	16.6
Wetland	46	214,728	—	5.1	8.1	12.9
Woodlands	240	584,400	—	9.4	21.5	13.8
Crops/Pasture[2]	70	1,094,310	8.8	—	—	26.1
Turf[2]	70	1,094,310	2.6	—	—	13.2
Fruit/Vegetable[2]	70	1,094,310	11.5	—	—	20.1

[1]Based on a sample of state open space acquisitions from 1967 to 1990, R.I. Dept. of Environmental Management, and farmland appraisals, R.I. Agricultural Land Preservation Commission.
[2]Mean parcel size and cost per acre are unavailable for different farmland types.

Utility indexes for parcels with endangered species habitat range from 8.1 for wetlands to 21.5 for woodlands, and are higher for many open space land types than the indexes for generic farmland. Similarly, many open space parcels located above important groundwater resources have higher indexes, ranging from 12.9 for wetlands to 16.6 for rivers. Open space parcels that include special environmental attributes, such as endangered species habitat or important groundwater resources, are more valued by the public than farmland. Farmland above important groundwater resources has very high utility indexes: 26.1 for crops and pasture, 20.1 for fruits and vegetables, and 13.2 for turf. The importance placed by the public on protecting groundwater motivates policies that reduce negative agricultural impacts on water quality.

Conclusions

These results are empirical evidence that the Rhode Island public perceives farmland to have significant environmental amenities. The importance of protecting these amenities outweighs the importance of protecting local agricultural production or maintaining farming as a way of life. Focus group discussions revealed that interest in local agricultural production may have more to do with insuring opportunities to visit farm stands than with safeguarding local or national food supplies. Except for turf production, public preferences for preserving farmland compare favorably with preferences for preserving other types of open space. Agricultural policy can play a significant role in preventing environmental degradation and enhancing the amenities the public desires.

The emerging scarcity of the environmental amenities associated with traditional agricultural landscapes in developed countries inevitably erodes the distinction between agricultural and environmental policy. Agricultural production as a primary policy goal is not appropriate in places where farmland is no longer viewed by the public solely as a production input. Providing incentives to farmers to keep farmland in production may be unnecessary or detrimental in some locations. Commodity price support payments, if they are to continue, could be made contingent on farmers meeting criteria that address environmental amenities such as wildlife habitat and groundwater quality, similar to existing Sodbuster and Swampbuster provisions in current U.S. legislation. Such environmental cross-compliance policies would exploit potential complementarity between agricultural and environmental policy goals (Russel, 1993). However, environmental cross-compliance does not insure that agricultural policies are efficient. Discontinuing commodity price support payments altogether might force marginally productive land out of production but result in greater net welfare gains because many environmental amenities desired by the public are not directly related to agricultural production.

In addition to environmental cross-compliance, agricultural policy can encourage landowners to manage agricultural lands in socially desired ways through subsidies that compensate them for providing specific amenities, such as the management and maintenance agreements used in the Netherlands (Slangen, 1992; Bekkers and Verschuuren, 1996). On some lands, environmental amenity values may be so great that long-term agricultural production is socially suboptimal. Governments could purchase such lands to remove them from production permanently, provide incentives to landowners to idle land temporarily, or encourage less intensive forms of agricultural production. An alternative system of land use policy could mandate societal standards of land use, taxing landowners for agricultural activities that deviate from the standard (Bromley and Hodge, 1990). However, mandating socially acceptable land use in the U.S. could face significant opposition from property rights advocates.

This study shows that the public is interested and willing to provide input into agricultural policies. Policymakers can make better use of public input in developing policies that simultaneously address agriculture and the environment. Surveys could be designed with greater detail to address the relevant issues in specific countries, states, and localities.

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The Living Countryside: Maintaining Sweden's Agrarian Landscape

David Vail[1]

Öppen natur kräver bönder och djur[2]

A Swedish Tradition: Farmland as a Public Good

Sweden, like its northwest European neighbors, has a long tradition of land use policies intended to maintain cultivated land and an open and varied agrarian landscape. Such policies have multiple official motives, most of all national food security. They also aim to preserve cultural-historical values, scenic and recreational amenities, and biological diversity. The subtext for such policies has been the objective of maintaining farmers' land asset values and income streams. In the past, the rationale for Sweden's food security objective derived from the nation's diplomatic and military neutrality. Cultural and historical values were particularly attached to working landscapes that had been used since the Iron Age and Viking times, and to farm structures predating this century. Recreational value derived from the tradition of *allemansrätt*, the right of common access to private property. The biodiversity goal stemmed from the fact that agrarian landscapes are habitat for a rich flora and fauna, including many beloved wildflowers and three-fourths of Sweden's threatened or endangered vascular plant species.

As one would expect, Swedish farmers, through their national federation (the LRF), have consistently supported an interventionist agricultural policy regime. However, until recently they vehemently resisted becoming "park workers," compensated for maintaining landscape values. Farm organizations, seeking to maintain incomes and land values in a neoliberal policy environment, have only reluctantly come to embrace an explicit farmland preservation policy. Farm interest organizations are not alone in this effort: prominent Swedish environmental organizations have made common cause with the LRF on farmland protection, and public opinion strongly supports the effort. Several surveys assessing citizens' valuation of the farm landscape (Drake, 1988; Hasund, 1990) show

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[1]Economics Department, Bowdoin College, Brunswick, ME 04011. This essay is drawn largely from *The Greening of Agricultural Policy in Industrial Societies* (Vail et al., 1994). I thank my coauthors, Lars Drake and Knut Per Hasund, without implicating them in this essay's errors or omissions.

[2]"Open nature demands farmers and animals" (slogan painted on the side of a hay barn in Värmland). The rhyme and meter are lost in translation.

that they are willing to pay a substantial amount to maintain open farmland. They especially prize *hagmark*—ancient, beautiful, and biologically rich natural pastures, about which the novelist and playwright August Strindberg rhapsodized: "I know nothing so enthralling, and in the same way so genuinely Swedish, yes perhaps the only thing genuinely Swedish, as the *hage*" (Edman, 1990).

In this essay I assess the complex and contradictory land use impacts of Sweden's core agricultural policies. I then trace the evolution of farmland protection measures in the 1970s and 1980s, and speculate about the impact of two momentous changes in the policy regime: a market-oriented food policy reform in 1990 and Swedish membership in the European Union, beginning in January 1995.

The Problems: Afforestation, Development Pressure, and Agricultural Rationalization

As in other industrial societies, Sweden's "farmland problem" has two main symptoms: loss of farmland and transformation of the farm landscape. In the thirty years

A birch and juniper *hage* (photo by Bengt Hedberg, courtesy of *Naturbild*; from Vail et al., 1994, p. 13).

between 1950 and 1980, land in agricultural uses declined by nearly one-third, from 4.5 million to just over 3 million hectares. More than four-fifths of the loss was through afforestation of economically submarginal land, especially in the north and the uplands of southern and central Sweden. Most urban and suburban encroachment occurred in southern Sweden, on productive lands with high fertility and a comparatively long growing season.

Since World War II, "rationalization" of land use has been driven by technological developments and competitive pressures. Field elements like stone walls, hedgerows, tree islands, and drainage ditches were removed to facilitate efficient mechanization. Wetlands were converted to arable fields, following a long tradition, and crop rotations were simplified, evolving toward monoculture. Agricultural policy was deeply implicated in these processes. Selective commodity price supports reinforced tendencies toward specialization and rotational simplification. An array of "rationalization measures," including agro-scientific research, extension advice, and capital investment subsidies, accelerated three key trends: mechanization, specialization, and enlarged farms and fields. In all these tendencies, Sweden differed from other advanced industrial nations only in the details.

Measures promoting agricultural productivity growth were motivated by the Social Democratic government's desire to find the least expensive ways to meet the consensus goals of national food security and farm income parity. In Sweden's fast growing post-War economy, an even more important objective was to push young people from farm-related occupations into the tight urban-industrial labor market.

Land Use Policy: From Reaction to Proaction

In 1979 a land care law was enacted to keep the remaining three million hectares of arable land in farming, primarily for national security and regional development purposes rather than to preserve biodiversity or other landscape values. A core regional development goal was expressed in the slogan "a living countryside" *(en levande landsbygd)*. The problem of urban-suburban encroachment was dealt with fairly successfully through zoning restrictions on farmland conversion. These were backed-up by price supports and rationalization measures that kept farming profitable (that is, that kept implicit land rents positive) in the more populous and agriculturally productive southern third of Sweden.

The most serious concern, as mentioned, was loss of economically submarginal farmland to forest. The afforestation problem was handled in an innovative but not fully successful way by requiring County Agricultural Boards to act as buyers of last resort when retiring farmers had no heirs or buyers to take up their land. The Boards' task was to find prospective buyers and arrange long-term financing (typically at a subsidized interest rate). But the ever-increasing competitive disadvantage of marginal land in economically marginal farming regions meant that subsidized land costs and farm price supports were not always enough to ensure a positive return on farm investments in colder, less fertile regions. Thus, by small increments, land continued to be lost to "dark spruce forest."

A "green" farmland policy—one focussing on the land's nonmarket values—did not take shape until the mid-1980s. A prime catalyst was a Ministry of Environment report cataloging industrial agriculture's negative environmental impacts. Nitrogen leaching topped the list. Sweden's largest environmental organization, the Society for Nature Conservation, used the report to touch off a media blitz criticizing agriculture's creeping industrialization. (Sweden's major environmental organizations had taken a growing interest in agricultural policy since the "world food crisis" of the 1970s.)

As I have suggested, a focal problem was loss of *hagmark*, nonarable pastureland with little commercial production value but great value as a public good. The *Riksdag* (parliament) responded in 1986 with a program called Nature Conservation Efforts in the Agrarian Landscape (Swedish acronym: NOLA). NOLA was a voluntary program under which owners of highly valued natural pastures and meadowlands could receive yearly "rental" payments of about $50 to $100 per hectare in return for maintaining traditional uses under a multiyear contract. By 1990, NOLA's yearly budget was nearly $5 million, and about 7% of the remaining natural pastures and meadowlands were protected.

Surveys estimating citizens' willingness to pay for farmland preservation suggest that this program had a highly favorable benefit/cost ratio. However, voluntary enrollment was less cost-effective than a program targeted precisely to the most highly valued land parcels. Nonetheless, even a lower bound estimate of *hagmark's* combined "use value" as a visual and recreational amenity, "existence value" as a source of biological diversity and cultural history, and "bequest value" as a legacy to future generations suggests that much more money should have been earmarked to protect it. Farmland preservation expenditure was in fact increased six-fold as part of the 1990 food policy reform, discussed below (Drake, 1988; Hasund, 1990).

Another initiative had the aim of reversing the history of landscape rationalization in fertile grain-producing plains regions. NYLA (New Features in the Landscape) was budgeted at $5 million for three years. It compensated farmers up to $3,300 per project to re-create wetlands, establish hedgerows, plant small groves of trees on cultivated land and create other elements that enhanced visual and biological variety. It is noteworthy that the subsidizable costs included not only direct capital outlays but also forgone crop revenue and higher operating costs from irregular field layouts. At the actual compensation levels, however, the budget only covered one to two thousand projects per year.

NYLA's small budget and its high cost per project meant that the initiative had a negligible impact on overall visual and biological diversity in the southern plains.

Considering the broad extent of landscape rationalization over the previous half century, NYLA's cost-effectiveness is dubious. Further, if Sweden had had an economically sensible grain pricing policy, NYLA's prime political motivation—reducing grain surpluses and the cost of export subsidies—would have been eliminated (Hasund, 1990).

While NOLA and NYLA were explicitly intended respectively to preserve and enhance the farm landscape, a series of other piecemeal initiatives in the late 1980s influenced landscape qualities indirectly, mainly for the better. All these measures were prompted by their "win-win" implications for politicians: they were inexpensive but symbolically potent ways to display environmental friendliness to a demanding "green" electorate, while reducing costly grain and milk surpluses. (Commodity surpluses, and with them the fiscal costs of price supports and export subsidies, escalated in the late 1980s. This resulted from a combination of price support stimulus, long-term productivity growth, and excellent short-term growing conditions.)

Four policy-induced changes in land use enhanced visual amenities or biological richness. First, new legislation on farm animal rights mandated a longer grazing season for dairy cows. (Swedes place the highest value on landscapes associated with grazing animals.) Second, row crop producers in regions with sandy soils were required to plant a larger proportion of bare fallow land in cover crops (up to 60% in some coastal areas). Third, Sweden's grain set-aside program included an option loosely comparable to the Conservation Reserve Program in the United States, under which farmers could receive payment to reconvert arable fields to wetlands. Expenditures were several times larger than for the NYLA wetlands restoration program described above. Fourth, and perhaps most striking to non-Swedes, the government paid growers up to $1500 per hectare to convert from conventional to chemical-free farming. Enrolled land was required to remain chemical-free for six years. By 1990, about 1.5% of Sweden's arable land was farmed organically, the largest proportion in any advanced industrial society (Haxsen, 1990).

The prime environmental objective of the cover crop requirement and the organic conversion subsidy was to reduce nitrogen leaching rather than to enhance the landscape. According to our assessment, these measures had positive net social benefits, but primarily because of the avoided cost of subsidies on grain and milk exports and the reduction of nitrogen leaching in sandy soil regions. Enhanced landscape qualities were less significant (Vail et al., 1994, Chapter 7).

One contemporaneous policy measure had a contradictory effect on the rural landscape: under one grain set-aside option, land owners were paid up to $1,000 per hectare to plant trees on excess cropland. Typically, this consisted of spruce monoculture, the type of forest stand with the highest expected return on investment. Much of Sweden is already covered by conifer plantations, so this measure prompted a public outcry. In response, the afforestation program was abruptly curtailed and its emphasis shifted from spruce plantations to diversified deciduous-conifer stands.

The 1990s: Farmland in the Snares of a Neoliberal Policy Regime

In 1990, following five years of debate, reports by blue ribbon commissions, and protracted resistance by the LRF and its Center Party allies, the *Riksdag* enacted a sweeping food policy reform. Its core was elimination of internal market regulations, including negotiated commodity pricing. In addition, import protection was reduced and export subsidies terminated. Both the reform as such and the five-year transitional plan to bring it into effect would have major effects on the extent and character of the farm landscape. It is impossible to summarize these complex and contradictory effects briefly, and in any event some of them were obviated by Sweden's subsequent decision to join the European Union. EU membership brings Sweden under the EU's Common Agricultural Policy (CAP), environmental measures, and regional development programs.

In brief, agricultural deregulation together with the transitional measures would accelerate aggregate farmland loss. Most importantly, more than half of economically marginal land with high biological, cultural-historical and recreational value would be lost to forests in the long run. In the short run—that is, while the present generation of farmers remain active—existing capital stocks plus a sixfold increase in the NOLA budget have kept much of this land in use. The revamped and expanded NOLA program (advised by my Swedish co-authors) adopted a land rating system based on systematic evaluation of particular parcels' various nonmarket values. Public officials made the dubious claim that old laws requiring advance notice of proposed land use conversion would alert County Agriculture Boards so they could intervene and protect land with a high rating. In theory, at least, declining land prices also would enable tenant operators or new entrants to make a go of farming such land. It was expected that many farms in all regions would gradually shift from dairying to extensive, part-time beef operations, which would maintain landscape values.

In the southern plains, market deregulation and transitional subsidies strengthened owners' incentives to convert land from intensive grain-oilseed production to more extensive uses, such as ley and pasture, with higher public goods values. However, the overall landscape impact in grain-producing regions is unclear, since transitional subsidies for tree planting—now expanded to include short rotation "energy forests" for thermal power—point to a less socially desirable outcome.

In sum, the 1990 agricultural policy reform had no consistent approach to maintaining and improving the landscape. Economic objectives, especially reduction of governmental costs and retail food price inflation, outweighed agriculture's public goods contributions.

Likely Land Use Trends Under the Common Agricultural Policy

Sweden's membership in the European Union will affect agrarian landscapes in several ways. It was widely predicted that Swedish farmers' exposure to competition from large, efficient, counterparts in France, Denmark and the Netherlands would drive many of them out of business and reinforce the long-term trend toward increased scale and specialization. Both of these consequences would erode landscape qualities. In reality, there are several countervailing forces, and farms on the fertile southern plains, near large population centers, and in the North now seem well positioned to survive. First, many of the least efficient grain and dairy producers were weeded out by the 1990 food policy reform. Perhaps more important, Sweden's quota for fluid milk production under the CAP, plus the high cost of handling and transporting fresh milk, protects most of the dairy sector and thereby most fodder-producing land from serious external competition.

More speculatively, the LRF has joined forces with the Swedish Organic Farmers' Association under the banner "On the road to the world's cleanest agriculture." With state support, they have launched an export offensive on the European continent. On the whole, Swedish agriculture is significantly less chemical-intensive than the rival Dutch and Danish farming systems. Further, Sweden can trade on its reputation for stringent food safety standards and humane treatment of farm animals. The strict "salmonella free" standard for livestock products has already shaped a lucrative export niche. To the extent that Swedish producers succeed in establishing Swedish farm products' "clean and green" image among the EU's millions of health- and environment-conscious consumers, more land will remain in agriculture. Indeed, a growing Continental demand for "green" food exports should also shift land toward pastoral and rotational systems that enhance landscape values.

This prognosis holds primarily for the fertile southern regions with relatively long growing seasons. The future of farming and farmland protection in forested and mixed farm-forest regions is less promising. On the positive side, northern Sweden qualifies for the EU's heavy agricultural subsidies to "disadvantaged regions." The existing program of long-term contracts to maintain meadows and *hagmark* has also been ruled consistent with the CAP's "structural directives" regarding environmental protection and "extensification" (Johansson, 1995). Indeed, in aggregate, Swedish agriculture is budgeted for $220 million per year in EU "Environmental Support to Agriculture." (Extrapolated to the scale of the United States, this would come to $4.5 billion.) Still, under long-term economic pressures, much of the open land in economically disadvantaged regions will almost certainly revert to forest. Sadly, this includes many tracts where the agrarian landscape's "social benefits" for recreation and biological diversity are greatest.

What Can We Learn?

At the most general level, Sweden's recent experience is a reminder: as we slash federal farm spending and talk about weaning ourselves from crop price supports in the U.S., it is crucial to promote a dialogue about agriculture's "public goods" contributions, especially the maintenance of open, varied, and biologically rich landscapes. Likewise, it is important to devise carefully targeted and economically efficient policy instruments to sustain the land uses that "produce" these public goods.

Of all U.S. regions, the Northeast most closely resembles Sweden in its geoclimatic features and demographic patterns, as well as the economic marginalization of its farm sector in a globally competitive market environment and a neoliberal political environment. The Northeast probably also is most analogous to Sweden in the mix of cultural-historical, scenic, recreational, and biological values that make our little remaining farmland qualify as a "public good"—in my view, a public treasure. On the basis of these loose analogies, I urge sustainable agriculture advocates in the Northeast to consider variations on two policy initiatives that have proven effective in Sweden.

The first initiative is to strengthen existing research, extension and marketing measures encouraging the transition to reduced-chemical and organic farming. Besides its widely publicized health and environmental protection benefits, such a transition would contribute to a more varied and biologically rich agrarian landscape.

The second initiative has multiple components. The first crucial task is to get more serious and more clever in educating the region's urban-suburban majority about the public goods provided by an open and varied agrarian landscape. Concerted state-level projects might be led, for example, by the state Farm Bureaus, the Northeast Organic Farming Association, and The Nature Conservancy and other mainstream environmental organizations. Such projects could be effective, especially if the local propaganda effort is vested in grassroots groups such as land trusts and farmers' market associations.

The next task is to devise a multiple-criterion framework like Sweden's and use it to inventory and evaluate the remaining farmland. Developing such a framework is a great opportunity to debate and publicize core values. A pilot project could be used to test the idea of multiyear "rental" contracts targeted to the most highly valued land in the project area. Funding for a pilot project might be a joint state-local venture, ideally with some financial commitment from nongovernment organizations and taxpayers.

The umbrella alliance I have proposed, joining mainstream farm organizations with organic producers and environmentalists, may seem naively "un-American." Obviously, it is a difficult task. Even in Sweden, good will and years of persistent effort were required for similar groups to break down their mutual suspicions and discover their common ground. Still, this uneasy alliance has been decisive in moving Swedish politics toward support for long-term farmland preservation.

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The Provision of Countryside Amenities: External Benefits of Agricultural Production in Mountainous Regions

Franz Hackl and Gerald J. Pruckner[1]

Introduction: Externalities in Agriculture

Economists have dealt with externalities—how the activity of an individual affects the technology, the consumption set or the preferences of other agents—since the early 1930s. The most prominent research on externalities has been about environmental pollution from industrial production. Another important area has been agriculture. Environmental degradation from high pesticide and fertilizer applications and from concentrated livestock production without sufficient pastureland are typical examples of the external costs of agriculture.

On the other hand, economics textbooks and scientific articles only occasionally highlight external *benefits* of agriculture, such as the increased productivity of an orchard caused by the activities of a nearby beekeeper. There exist other external benefits from agriculture, and their importance is growing over time. Some forms of agricultural production, such as the cultivation of mountainous regions by farmers in Austria, Switzerland, northern Italy, Norway, and Sweden, may contribute to the pleasure of the whole population, both the residents of those regions and the tourists who vacation there.

This paper deals with nonmarket activities by farmers who take care of the countryside for residential and recreational purposes, with an empirical focus on Austrian agriculture. There have been a few studies that measured the value of landscape-enhancing activities, but most do not allow discussion of politically feasible models of direct compensation of farmers, as we do here.

External Benefits of Agriculture

Besides producing food, feed and other goods sold in private markets, the agricultural sector of many countries provides nonmarket goods—both positive and negative externalities. External benefits of agricultural production consist primarily of its recre-

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ational and protective functions. In several European countries, agricultural production areas also are residential areas or recreation sites. Thus, obvious interdependencies exist between the agricultural sector and the rest of society. For example, Austrian agriculture (including forestry) accounts for over 80% of all land in the country, and therefore is responsible for creating an appropriate landscape nationwide. Farmer activities relevant to recreation include mowing alpine grasslands, tending the network of rural trails and roads, preserving the woods along rivers and brooks, and caring for alpine pastures. Moreover, maintaining a diversified arrangement of groups of trees, hedgerows and brushwood contributes to the preservation of wildlife and plant species. People who spend their leisure time in these regions value these activities but do not pay any financial compensation in return.

Since environmental amenities are essential for the prosperity of tourism, the agricultural sector provides a valuable service for the tourism sector for which it is not necessarily being compensated. The relevance of these activities for tourism is acknowledged. There is empirical evidence that a well-kept countryside is essential for getting tourists to spend their vacation in some central European countries. Several European countries already pay mountain farmers to continue their landscape-enhancing services, which are primarily for the benefit of the tourist industry.

These recreation-related agricultural activities and protective benefits are not included in either internal farm accounting or national accounts. Agricultural cultivation, in particular forestry activities, protect people, animals, and the material infrastructure from avalanches, landslides, erosion, and rockslides. Besides the maintenance of "disaster-averting forests," another external benefit of agricultural production is the preservation of the water-holding capacity of soil as a protection against floods and water pollution. The protective functions occur mainly in mountainous regions, but the recreation-related externalities apply to lowland areas also.

With a general equilibrium model for positive externalities, we can derive the following conditions for economically efficient provision of recreation-related agricultural activities and protective benefits:

1. A tax tied to consumers' demand for goods such as vacations causes a loss of efficiency. Thus, direct subsidies should be financed by lump-sum taxes, i.e., taxes that are independent of the behavior of any individual. This seems intuitive for negative externalities; Cropper and Oates (1992, p. 681) argue that victims should not be compensated, because they then no longer will have the incentive to undertake efficient levels of defensive measures. However, the corresponding result is not immediately obvious for the provision of agricultural landscape-enhancing activities.

2. A second and more important condition concerns the amount by which farmers should be compensated for providing recreation-related services: the subsidy should equal the total of consumers' marginal utilities resulting from those services. This

result relates to a very important political issue. From an efficiency point of view, farmers should be directly subsidized if and only if a positive value is attached to the increase in nonmarket agricultural services. Obviously, the subsidies may vary among regions, depending on aggregate marginal utility. However, an additional restriction is that the subsidies should be independent of farmers' production of private goods like food, feed or raw materials. Thus, one firm cannot receive higher subsidies by switching to a more intensive mode that produces more of private goods and less of external benefits. This is the decoupling argument, which stresses the notion of production-independent direct subsidies.

Environmentally Based Subsidies for Agriculture in Europe

A few programs for compensating agricultural landscape-enhancing activities are already in place in Europe. It seems obvious, given the discussions on European integration, that decisions on such programs cannot be made purely on a national basis. To prevent putting themselves at a competitive disadvantage because of their ecologically oriented treatment of the countryside, the various nations must coordinate their subsidies. For this reason, the European Union (EU) passed regulations that take account of environmental aspects of agricultural production. The EU established additional supporting measures for environmentally friendly agricultural production within the scope of the Common Agricultural Policy (EU regulation no. 2078/92). This was the first official EU-level acknowledgement of the role of farmers as conservers of the landscape and protectors of natural resources. These resolutions enable member states to subsidize reductions in environmental degradation by agriculture and to compensate agricultural functions that serve the public interest.

Within this framework, which may be adapted to regional specifications, EU member states are authorized to work out national compensation models in line with local environmental requirements. In this connection, there are three examples in Germany and Austria: The Market-Relief and Landscape-Compensation Programme in Baden-Württemberg (MLCP); the Bavarian Landscape Program (BLP); and the Austrian Environmental Program for Agriculture (AEPA).

The MLCP of 1992 assigns per-hectare subsidies to farmers who apply measures to preserve an agricultural landscape, achieve more extensive production, or protect biodiversity. Farmers decide whether and to what extent they would like to participate in this program for five years. From a comprehensive list of landscape-enhancing activities they choose the ones they believe fit best with their production structure. Each activity gets a score, the total of which determines the compensation payments. The upper bound is 550 DM (293 ECU) per hectare of agricultural land. (In November 1995, 1 ECU = US$1.31.) Because this program has been widely accepted by the farmers, it is supposed to be continued in the future. The province of Baden-Württemberg allocated a total of 75 million ECU to continue the program in 1993 and 1994. A similar model with an aggregate subsidy level of 175 million ECU per year was passed in Bavaria in 1988 (BLP).

The Austrian variant (AEPA), passed in 1995, is another interesting example. It pays farmers for cultivating mountainous regions, for example by mowing the alpine grassland or tending alpine pastures and areas set aside from forestry. The catalogue of measures promoted in this program is more comprehensive than in any other comparable EU program. Austrian farmers receive 400 million ECU from the European Union, the Austrian government, and the nine provinces. Farmers in less productive mountainous regions are expected to benefit more from this program than their counterparts in productive lowlands. Besides this national program, there are local voluntary compensation payments to farmers for providing countryside amenities, which we discuss below.

The design of these subsidy programs does not reflect the economic efficiency conditions mentioned above. The payments are based on ecological considerations, such as biodiversity, rather than attempting to reflect marginal benefits. Several constraints, such as distributional issues and the need to keep administrative costs low, mean that actual compensation models in general represent a second- or even a third-best solution. Despite these political restrictions, we argue for an increased consideration of the efficiency conditions discussed earlier.

The Measurement of External Agricultural Benefits

It often is feasible to determine a (marginal) cost curve for providing landscape-enhancing services, but measuring marginal benefits has many problems. As was already pointed out, the public good characteristic makes private markets fail, with consumers' preferences not revealed directly. There are well-known methods to reveal people's preference. These may be based either on related private goods (indirect measures) or, by application of survey techniques, on respondents' stated willingness to pay (direct methods) (Mitchell and Carson, 1989; Braden and Kolstad, 1991; Arrow et al., 1993; Diamond and Hausman, 1994; Hanemann, 1994). Many studies recently have applied both direct and indirect methods to measure the value of different national parks or regionally specific recreation areas. Navrud (1992) provides a comprehensive review of studies of the valuation of countryside-related benefits in Europe. Studies of outdoor recreation were done recently in Denmark (Dubgaard, 1994) and Italy (Merlo and Della Puppa, 1994). However, only a few studies deal with cultivating the agricultural landscape for recreational and residential purposes. Empirical results from an Austrian study are presented below.

A contingent valuation of recreation benefits in Austria

In a study using the Contingent Valuation Method, in summer 1991 more than 4000 tourists were asked about their willingness to pay (WTP) for agricultural landscape-enhancing activities in Austria (Pruckner, 1995). The vacationers were given a verbal description of these services, and their familiarity with them was checked. In an open-ended format, they were asked to state the maximum amount they would pay for these services into an appropriate fund. The average WTP per person per day of vacation was 9.20 Austrian schillings (ATS), or 0.70 ECU, with a standard deviation of 15.95. The median was 3.5 ATS. About 40% of those asked this question did not answer. A comparison of the means for the vacationers of different nationalities (Table 1) shows that Austrian tourists were significantly higher in WTP than those from other countries.

Applying the distribution of individual WTP to all summer vacationers in Austria results in a total of 720 million ATS (54.5 million ECU) if we calculate it using the mean, or 280 million ATS (21.2 million ECU) if we use the median (with nonrespondents not included in computing the mean and median). The largest portion of this total is for the province of Tyrol, followed by Carinthia and Salzburg. If the calculation is extended to include winter tourists, the total (computed using the mean) becomes 1.2 billion ATS.

These numbers do not include Austrian non-tourists' aggregate WTP for the provision of these agricultural services for recreational purposes or for the protection of their living space. This was studied by Drake (1992), who elicited Swedish residents' WTP for preserving agricultural land that otherwise would be brought out of production.

Actual versus hypothetical payments

Looking at the compensation models already developed, and recalling the results from the empirical measurement of benefits, one might ask whether CVM results are reliable estimates of recreation values and therefore contribute to establishing workable

Table 1. Willingness of tourists to pay for agricultural landscape-enhancing services in Austria (ATS per day per person) (Pruckner, 1995).

Tourists' Nationality	Mean	Median	Std. Dev.
Austria (without Vienna)	11.40	5.00	18.38
Vienna	8.90	5.00	12.32
Great Britain	8.50	1.75	15.97
Netherlands	6.40	2.00	13.48
Switzerland	9.80	5.00	14.30
Germany	9.00	3.50	15.95
USA	11.50	3.10	20.55
All	9.20	3.50	15.95

models in practice. The existence of discrepancies between hypothetical CVM bids and actual payments was raised in several empirical studies. For example, Seip and Strand (1992) compared CVM outcomes with responses to an actual solicitation for membership in a Norwegian environmental protection organization. Of those whose stated WTP was greater than the membership fee, only about 10% accepted an offer to become a member and actually paid the fee. The study was criticized on the grounds that the respondents might not have been evaluating the same good in both cases. In response to the survey, people could have been expressing their WTP for a somewhat vague set of environmental goods related to the organization, whereas in becoming members, they were revealing their WTP for the well-defined private good of membership. Fisher (1994) argues that strategic incentives to answer untruthfully may account for the discrepancy. Only a few empirical studies deal with this question. Thus, Fisher (1994) recommends further experiments in which people use real money and face the actual consequences of their decisions. When they used this approach, Cummings et al. (1995) and Neill et al. (1994) found significant differences between hypothetical and actual WTP in experiments with various private goods.

Our approach is not based on this kind of experimental design. Rather, we compare hypothetical CVM bids with subsidies actually paid to farmers by local tourist associations (consisting of hotel owners) and communities in three heavily touristed Austrian provinces: Salzburg, Tyrol, and Vorarlberg. These subsidies are the outcomes of bargaining processes. We argue that these compensation payments at the community level represent a lower bound for the unobserved true recreation value, for reasons that follow.

Whenever tourists are willing to pay for countryside amenities, hotel owners may be able to capture part of this consumer surplus by charging higher prices for private goods. The degree to which they succeed depends on their market power in the community. It will not be possible under competitive conditions, but a hotel owner can retain a considerable portion of the consumer surplus when the local tourist industry has less than full competition. In that case, it may be profitable for a few hotel owners or a small community to agree to pay compensation to farmers. This happens whenever their expected increase in profit (from tourists' willingness to pay more because of landscape-enhancing services) is greater than the voluntary payments to the farmers. In most alpine tourism communities, the hotel owners are confronted with an "all or nothing" situation: the relevant question is whether to keep the mountainous farmers in alpine regions at all (and have them provide landscape-enhancing services). Because of the precarious income situation of Austrian mountain farmers, the leeway for marginal considerations is lost.

The additional profits to hotel owners are the maximum subsidy that can be offered to farmers for providing landscape-enhancing services. The minimum amount the farmers will accept is the marginal cost of providing the services. At what point between these two limits the actual local compensation payments will fall depends on the parties' negotiating skills. Thus, we interpret local compensation payments as the lower bound for tourists' (unobserved) recreational values and compare these subsidies with hypothetical WTP figures. The weakness of this comparison results from our inability to know exactly how much additional profit was diverted to hotel owners from recreational consumer surplus. However, tourists' true WTP for countryside amenities clearly is higher than local subsidy payments. Therefore, even if hypothetical WTP from a CVM study equals true WTP, on theoretical grounds we expect the CVM results to be higher than actual payments.

We have data from 48 tourism communities that voluntarily subsidize farmers for their landscape-enhancing activities. These payments show that the tourist market is imperfect, so that hotel owners can retain part of the recreational consumer surplus. We divided these subsidy payments at the community level by the number of summer vacation days in each community. Comparing the hypothetical WTP figures with the subsidy payments per summer tourist at the community level shows various results. Several tourist sites have hypothetical values (both mean and median) that exceed the subsidies, but the opposite is true in others. In still others, the hypothetical and actual payments are in good agreement (the subsidies lie between the median and mean of the survey). However, community-level comparisons between these figures and the hypothetical WTP obtained from the CVM study are not sufficiently reliable, because in several communities the CVM study sample was small. Thus, we aggregated the local data for groups of tourism communities located near each other that provide similar landscape-related services. The mean of those figures was calculated across all the communities in a specified region. This yields a regional per capita subsidy payment that is directly comparable to the regional WTP. The regional hypothetical values are from the respondents who were interviewed in that region.

Because the outcome of the bargaining is determined by the median voter, we argue that the median WTP reflects the appropriate comparison measure. Table 2 shows that the hypothetical payments in Salzburg exceed the subsidy values. Except for Salzburg southwest, even the median WTP is twice the per capita local payments in these areas. The biggest difference can be observed in Western Tyrol (east), where the median is more than four times the community payments. On the other hand, the hypothetical medians are similar to the actual values in Vorarlberg, Western Tyrol (west) and Salzburg southwest.

These results confirm our expectation that actual payments would be lower than the hypothetical values. Recalling the weakness of this comparison—that we cannot know by how much the true WTP exceeds the subsidy payments—we cannot say exactly how well the CVM figures coincide with unobserved welfare measures. However, looking at the order of magnitude of the difference between actual and hypothetical payments, we conclude that the CVM results are not unreasonably high as estimates of welfare.

Table 2. Actual subsidy payments and tourists' willingness to pay for agricultural landscape-enhancing services (ATS per person per day).[1]

Region	Regional per Capita Subsidy	Number of Tourism Communities	Regional Willingness to Pay: Mean	Regional Willingness to Pay: Median	CVM Sample Size
Salzburg north	1.20	2	8.14	2.50	146
Salzburg southeast	1.91	11	8.07	3.50	81
Salzburg southwest	1.99	16	8.79	2.50	169
Western Tyrol (east)	1.17	3	9.20	5.00	307
Western Tyrol (west)	3.38	10	6.02	2.50	72
Vorarlberg	3.97	6	9.90	5.00	291

[1]Sources: authors' calculations; Pruckner (1995); community reports.

On the contrary, we argue that the CVM results in this paper represent a valid approximation of the value of these nonmarket services, and might be one basis for establishing compensation models. As an example, these WTP figures might be used within the framework of the Austrian Environmental Program for Agriculture to improve efficiency in the sense of the previous section. Regionally differentiated payments for taking care of the countryside could be granted in accordance with the elicited level of recreation values.

There are only a few options for empirically testing the validity of CVM experiments. Besides experiments that deal with real money and confront participants with real economic consequences, the results can be compared with those of other nonmarket valuation techniques. Another alternative, which was adopted in this paper, is to compare hypothetical WTP figures with voluntary payments that are actually being granted for providing public goods. Even though this approach has several theoretical and empirical problems, we believe it provides helpful insights regarding the usefulness of CVM results.

Policy Conclusions

Continuing and increasing direct compensation payments to the agricultural sector for environmental reasons will have various effects:

- Direct subsidies based solely on ecological grounds, independent of the volume of agricultural production, are another negative production incentive at a time when prices are already being reduced in the European Union. Excessive agricultural production is expected to decrease, thus reducing surpluses in food markets.

- Agricultural nonmarket services are often provided in areas where production is limited by topography and incomes are low ("disadvantaged regions"). Therefore, compensation payments for environmental purposes may reduce agricultural income differentials among regions.
- Besides these income effects, we also might expect a growing dualism of agriculture. Regions where tourists and residents are willing to pay for nonmarket services will concentrate on environmental amenities and on less intensive production because of ecological considerations. On the other hand, the favorable agricultural production areas, which generally are not used for recreation, will focus on efficient production of agricultural commodities. The industrial-style production of food in these regions is accompanied by environmental degradation, which requires another kind of government intervention. Just as we have made a case for compensating the provision of nonmarket agricultural services, an analogous claim can be supported for internalizing the external costs associated with agricultural production.
- Whatever program is chosen to compensate farmers for the provision of nonmarket services, it should be implemented quickly. A lack of appropriate policy decisions today may result in severe and irreversible environmental consequences tomorrow. If, for example, policy fails to keep mountain farmers in alpine regions, a disadvantageous change in the Austrian mountain landscape must be expected. Similar irreversible developments may be occurring in many other countries.

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Integration of Environmental Objectives into Agricultural Policy and Law in the Netherlands

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Introduction: Alternatives in Environmental Policy-Making

Environmental policy can be described as a "mission impossible" because so many policy programs try to solve such complex problems. These problems are complex because environmental issues and problems affect many organizations that have different interests that they try to protect. Because the stakeholders are diverse, the perceptions of an environmental problem, the values and norms that are at stake and the proposed solutions all differ. Therefore, environmental issues involve a wide range of organizational networks. The intriguing question is: Can we solve such problems?

Governmental policy interventions in such problems must respect the varied interests and perceptions at stake, and therefore should be directed at linking these interests and perceptions. For a policy program to be successful it is necessary to generate an early commitment from the relevant stakeholders. Otherwise, implementation of the program will fail, as many studies have shown. In more traditional conceptions of governmental intervention, this observation often is ignored. Implementation is seen just as the mechanical execution of rules in a stable and cooperative environment. The reality is different, however.

In this paper we explore how policy makers in the Netherlands try to link the interests and perceptions of several organizations, both governmental and nongovernmental, to integrate the dominant values underlying agricultural and environmental policies. This integration is not imposed. Policy makers acknowledge that the organizations affected by certain policy programs or involved in implementing them are not cogs in an implementation machine. They are powerful and intelligent organizations that possess self-regulation capacities; that is, they can regulate the behavior of those associated with the organization without governmental action, or with regulatory authorities having only a small role. These capacities should be stimulated and directed in the desired way.

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We start by describing some basic notions about new forms of governmental intervention and self-regulation. In the next section we give some characteristics of environmental policy and law in the Netherlands. These relate to a general framework in which the new forms of intervention are being formulated. We then focus on a case that illustrates the use of self-regulation to integrate agricultural and environmental values. A voluntary contract is made under which farmers are obligated to run their farms in a more ecologically balanced way. Government compensates these farmers if the new ways of farming are less profitable. In the last section, we analyze and interpret the idea of self-regulation as described in this case study.

The Concept of Self-Regulation

New ideas about governmental intervention

By the end of the 1970s it had become clear that we had reached the limits of the welfare state and of the central role of government in shaping that state and solving every kind of social problem. The belief that government can intervene in a complex, differentiated and turbulent society through a wide variety of detailed rules and regulations is being questioned. The legal network of laws, regulations and procedures got entangled, leading to all kinds of problems in implementation and monitoring. Moreover, the idea that a complex society can be managed from one central, fixed point of view located above society (government as the cockpit of society) neglects the fact that society consists of a variety of organizations, institutions and groups. These organizations try to influence the formulation and implementation of policies that affect their interests. Government is just one of these actors. This means that societal or governmental intervention (which we will refer to as *steering* to emphasize that it might only be a very light intervention) must respect the diversity of these actors, their interests and positions, and the resulting conflicts, expectations, opportunities and threats (Den Hoed, 1983; Kickert, 1985).

Consequently, new forms of governmental steering are being formulated that are characterized by the retreat of government. Steering becomes meta-steering, directed at existing self-regulatory capabilities of organizations, institutions, groups and policy sectors, capabilities that must be stimulated and brought together (Bekkers, 1993). The organizations to be steered are free to organize their own processes, according to their own wishes, but must comply with some general input and output parameters, which are laid down in policy programs and in planning and monitoring cycles.

Another instrument that is often used is incentives. Through incentives such as subsidies and fiscal benefits, as well as through disincentives such as penalties and budget cuts, one tries indirectly to influence an organization's decision-making processes by altering the cost-benefit ratio. But the organization is still autonomous in making its own decisions. Another object of intervention can be the interdependencies among organizations. These interdependencies force organizations to communicate and negotiate with each other to reach a shared definition of the problems to be solved and the solutions to be implemented. Governmental interventions can try to create an arena in which relevant stakeholders meet to negotiate. The intervention might involve not only the arena but also the rules by which the game is played.

Forms and conditions of self-regulation

Self-regulation can be described as a way of coordinating a group's behavior in which the participants formulate, implement and monitor the rules. What is the role of government vis-à-vis processes of self-regulation? Four positions can be discerned. First, in the purest form of self-regulation, the initiative to coordinate the behavior of a group is in the hands of the group members themselves, with no role for government. The second form also is voluntary, but the government has urged the members of a group to coordinate their behavior. The third form of coordinating group behavior involves governmental regulation, with the government formulating a legal framework in which self-regulation can develop. The requirements can be directed at the process of formulating, implementing and monitoring rules, but also at the outcomes of the process (Eijlander, 1994). In the last form, the government signs a contract with other (private) organizations specifying rules of behavior, such as the obligation to undertake a particular effort (Geelhoed, 1993). (Whether this should count as self-regulation can be disputed, because the regulatory authorities apply a legal instrument, although not one based on public law.)

The concept of self-regulation raises some questions regarding the conditions for success (Stout and Huls, 1992). The first condition is a clear description of the tasks, responsibilities and authority of the organization that facilitates self-regulation within a group or policy sector. The second deals with establishment of decisionmaking structures and procedures that safeguard a balanced consideration of all interests. The third condition focuses on feedback and monitoring mechanisms. Once established, rules must be implemented by the members of a group, who should then comply with the obligations laid down in those rules. Therefore, a monitoring system with sanctions should be developed. But a monitoring system also is needed for learning whether the intended goals are actually being reached. The last condition deals with norms that refer to the idea of *Rechtsstaat*, like the Rule of Law, legal equality, and legal security.

Some Characteristics of Environmental Policy and Law in the Netherlands

Environmental policy

Responsibility for national environmental policy in the Netherlands rests with three ministers. The first is the Minister of Housing, Planning and Environment. Besides having the main responsibility for environmental policy, she must coordinate environmental policies in several other areas: traffic and water management; pollution, such as by animal manure and pesticides; and preservation of nature, such as protection of landscapes, forests, animals and biological diversity. Traffic and water management are the responsibilities of the Minister of Transport and Water Management; pollution and preservation of nature are responsibilities of the Minister of Agriculture, Nature and Fisheries (hereafter referred to as ANF). Implementation of environmental policies and law takes place at both the provincial and the municipal level.

In the past few years, the environment in the Netherlands has increasingly been regarded as a whole: every aspect of the environment (water, air, land) has its influence on the others. Air pollution, for example, also will pollute the soil, because rain can bring harmful substances from the air to the ground; these substances then get into ground and surface waters. Therefore, it is risky to look at any aspect of the environment by itself. For example, a policy to reduce the amount of waste being dumped on the land or in surface waters might increase air pollution because it causes people to incinerate their wastes instead. To insure that prevention of environmental pollution in one sector does not cause more pollution in another, it is necessary to have an overall policy.

The overall Dutch environmental policy was first published by the three responsible ministers in 1989 in the *National Environmental Policy Plan* (NEPP, 1989). This plan, and its 1994 follow-up, NEPP 2, can be seen as an answer to the scientific report *Concern for Tomorrow* (NIPHEH, 1993). That report described the problems that have arisen and sets out paths for environmental policy from 1990 to 2010. It aimed at reducing all pollution by 75 to 90%. A total of 220 measures were announced, from legislative action to scientific research. The plan also described the annual costs involved in these measures. Annual costs for the necessary environmental protection measures are expected to increase from approximately US$13 million in 1995 to US$20 million. Other important official reports from the government are the Water-Household Plan (issued by the Minister of Transport and Water Management) and the Policy Plan on Nature (issued by the Minister of ANF). These plans are comparable to the NEPP, but are limited to water (quality and quantity) and landscape preservation.

Public and media attention have been focused on several areas: agricultural problems (large quantities of animal manure); acid precipitation (caused by traffic, industry and agriculture); pollution of drinking water (especially by nitrates and pesticides); depletion of groundwater in certain sensitive natural areas; pollution of land on which houses have been constructed; polluted industrial areas; certain extremely polluted river beds; and the problem of wastes. Private environmental organizations, such as the Nature and Environment Foundation, play an important part in stimulating public awareness. They often come up with data on the quality of the environment and thereby can provoke further action by the authorities.

Environmental law

Article 21 of the Dutch Constitution charges the government with the protection and improvement of the environment. The government so far has fulfilled this task mainly through legislation. A package is put together from all available means, such as direct regulations, economic instruments (taxes or subsidies), education, and public information. Each such package takes account of the nature of the group whose behavior is to be influenced. The main idea is to indicate each participant's responsibility toward the environment, although until now the emphasis has been on direct regulation of industries and farmers by national, provincial and municipal authorities. Only recently have self-regulatory instruments been applied, such as creating research duties for industries and agriculture (for example, setting up monitoring systems to monitor an activity's effects on the environment), and imposing a system of environmental care within firms.

For a long time Dutch environmental legislation was dominated by sectoral acts—one for every kind of pollution, i.e., one for noise pollution, one for air pollution by municipal wastes, one for pollution by chemical wastes, and so forth. Since the 1980s, however, legislation also has reflected the strong tendency toward an overall environmental policy. The most important environmental act today is the Environmental Management Act (EMA) (Bulletin of Acts, Orders and Decrees 1992, 551). This act incorporates procedures that formerly were dealt with in separate sectoral acts. It contains rules for license applications and the granting of licenses for plants and installations, including disclosure and public participation, environmental impact assessment, management of wastes, environmental planning and environmental quality standards, general provisions concerning appeal and enforcement of environmental law, and financial provisions.

The EMA offers an elaborate procedure for granting licenses to most industrial and agricultural activities. An important aspect of this procedure is the many possibilities for citizens and organizations to participate in it. They have a right to be heard and to raise objections to draft decisions. Citizens can start proceedings before an administrative court, even citizens with no specific interest at stake. The philosophy behind the liberal rules on admissibility is that whenever environmental interests are at stake, everyone should be able to prevent the environment from being harmed.

The latest trend we observe in Dutch environmental policy and law is the tendency toward sectoral integration. This means that no longer is all environmental policy and law found in one Environmental Policy Plan or one Environmental Management Act. Instead, experience has proven that better results are obtained when environmental objectives (quality goals) are integrated into each sectoral field of policy, such as agriculture. Internalization of environmental interests can only be reached when it is fully supported by the people in the relevant policy field (governmental authorities, farmers' unions and individual farmers). We now review the consequences of this new form of steering: integration of environment into agricultural policy and law, as exemplified by the management contract as an instrument for combining agricultural activities with protection of nature.

Case: Self-Regulation in Agricultural Policy and Law

Agriculture in the Netherlands: A short introduction

Agricultural products are major exports of the Netherlands and therefore are very important to the Dutch economy. Although the Netherlands is among the smallest and most densely populated countries in the world, it is the fourth largest net exporter of agricultural products. Besides milk and cheese, other important products are meat, eggs, vegetables and flowers.

In the Netherlands, agriculture is now seen as one of the most important sources of pollution and environmental degradation. After World War II, agricultural production rose very sharply. For example, from 1950 to 1984 milk production doubled, egg production trebled, pork production quadrupled, and poultry production increased tenfold. At the same time, however, the land area used for agriculture declined by 15% and the input of labor by more than 50% (Baldock and Bennett, 1991). This means that agricultural activities have intensified enormously, making Dutch agriculture the most intensive in Europe.

These results were achieved through substantially greater inputs of nutrients, pesticides, energy, and groundwater, and through development of new techniques of farming and livestock breeding. Agriculture has been industrialized, with all its consequences for the environment. For example, the ratio of production to domestic consumption is now 411% for butter and 233% for pork. To reach these levels in such a small and densely populated area meant great environmental stresses, especially from animal manure.

The problems caused by agricultural activities are enormous, as was shown by the National Institute for Public Health and Environmental Hygiene in its aforementioned study *Concern for Tomorrow*. That report stated that if recent policy is continued, the overall environmental situation will deteriorate drastically within a decade. Looking just at the problems caused by agricultural activities, we can discern several problems: damage from the use of pesticides; acidification by ammonia emissions; discharges of nutrients, especially phosphate and nitrate, from animal manures; and depletion of groundwater by irrigation. Finally, land reform, under which old, small-scale landscape elements were destroyed to make room for large-scale agriculture, has had negative consequences for natural areas and for wild plants and animals and their habitats.

The positive approach: Self-regulation by farmers

So far, the legislature has tried to reach various agricultural policy goals by imposing strict measures on farmers, especially regarding the discharge of animal wastes. This legislation consists of a very complicated set of detailed rules that cover, for instance, the precise amounts of phosphates that can be applied to various soils at various times of the year under various weather conditions. These rules apply on the national, provincial and municipal level. Not surprisingly, this approach has not had great results. Farmers are not very willing, if indeed they are able, to live up to the many complex rules.

Recently, pleas have been heard for a new approach, the first results of which are already visible. Last year the Ministry of ANF published a new policy in their report *Steering to Measure*. This policy will be implemented in different ways, all of which emphasize a joint effort by all involved parties. Social networks of farmers are called upon to take responsibility for improving the environment. Farmers are encouraged to live up to Best Management Practices jointly set up by individual farmers and the government. Farmers' organizations are encouraged to set up systems of eco-labelling of products, intensive livestock breeding systems, and so forth. Another example of the new policy approach and the corresponding new style of regulation concerns protection of nature by farmers, which we now explain.

An example of the self-regulatory approach: Nature management contracts

A good example of how farmers are induced to preserve nature is the *management contract:* instead of imposing obligations and prohibitions by law, responsible authorities can make contracts with individual farmers in which the farmers voluntarily agree to run their farming business in a more ecologically balanced way. The government then compensates farmers for possible losses in profits from this way of farming. This policy was already developed in the 1970s and can be seen as a forerunner of the now widely acknowledged idea of self-regulation.

The *Regulation on Nature Management Contracts 1993* gives the rules that apply to these contracts. Two models can be applied: rules concerning *management areas* (designated by provincial authorities) and rules concerning *reserve areas* (designated by the Minister for ANF). Reserve areas are of extreme ecological importance and therefore need to be acquired by the State for best protection. All agricultural activities are banned in these areas. In management areas, however, agricultural activities and protection of nature are closely interwoven.

A management plan forms the basis for individual contracts. Such a plan has been drawn up by the Provincial Commission for the Management of Farmlands. This commission consists of representatives of farmers' organizations, nature organizations, and the relevant governmental authorities.

Once an area has been designated as a management area, individual farmers in this area can draw up a contract with the Bureau for the Management of Farmlands, an independent organization responsible for making these contracts on behalf of the Minister of ANF. In such a contract, farmers can commit themselves to farm in an ecologically balanced way. A maximum of eight goals can be laid down in the contract, such as: conservation of natural objects like ponds, bushes, etc.; the conservation of natural buffer areas; the conservation of indigenous vegetation; protection of wading birds, such as lapwings; the protection of winter migratory birds; and the maintenance of particular landscapes.

For each goal, a whole package of concrete measures may be agreed upon. These may include such measures as not using pesticides, not cutting meadows during the breeding season of certain species of birds, raising the groundwater level, planting hedges and trees around buildings and meadows, and constructing ponds. As can be seen from these examples, some measures are prohibitions against doing something (passive), some are obligations to act (active).

For each package of measures, farmers receive full compensation from the Ministry of ANF for the loss of income in passive measures and the costs involved in active measures. Depending on the measure, the compensation can vary from US$15 to almost US$1000 per hectare per year.

The European Union strongly supports this policy. Once these management areas are reported to the European Commission, the Commission can put them on the list of sensitive farmlands. For areas on this list, the member state can be reimbursed by the European Union for 25% of the compensation it granted to individual farmers (EC Directive of 28 April 1975, amended 23 March 1985, 85/795/EEC, *OJ* 1985 L93).

Analysis and Interpretation

This case shows that the implementation of a policy program does not imply a brute force command-and-control approach. The central assumption is that the other organizations and individuals have self-regulating capacities. They are intelligent and powerful actors who represent valid interests, which of course can conflict with the interests of environmental agencies. The main challenge is to create a situation in which both government and farmers can win, with each gaining some advantages from the solution and sharing the disadvantages equally.

With nature management contracts, the advantages for the government are mainly in the area of its policies to protect nature. Protection of natural values in rural areas has always proved difficult because of large-scale agricultural activities that do not allow the presence of nature. With the management contracts, however, the government has managed to get farmers to take constant account of nature-related interests. Environmental considerations have become integrated into the economic decision-making process of farmers.

For the farmers, the main advantage is that their natural alliance with nature finally pays off. For a long time they had to disregard their concern for nature because of legitimate economic considerations. With management contracts, however, farmers no longer bear the economic disadvantages of combining agricultural business with caring for nature on their land.

But there are more advantages, especially in the long term. The positive approach that we have sketched not only stimulates farmers to take environmental considerations into account, but also can have positive spin-offs for other areas of agricultural environmental policy. All participants, not only farmers and government, but also environmentalists and others, realize that agriculture and environmental protection are not opposing interests that cannot be balanced.

What are the difficulties with this new approach? We see three main possible problems. First, achievement of policy goals depends on the farmers' voluntary cooperation. The government cannot force farmers into a contract. This is nothing new, however. Neither does direct regulation guarantee that policy goals will be reached. On the contrary, we have seen the command-and-control approach fail in many areas of environmental/agricultural policy because of the great difficulties in getting compliance with such regulations. Through self-regulation, monitoring costs have been partially shifted from the government toward the farmers, in contrast to the old approach. The process of internalization stimulates farmers to do what the government wants them to do, but now in an intelligent way that serves their own interest.

Second, what is the legal status of the contract? What happens if a farmer does not comply with it? In this case, the solution is simple: the government does not pay the compensation. Although this may not be so simple in every form of self-regulation, it always is important to have the option of imposing sanctions. Otherwise, even self-regulation is doomed to fail.

Finally, what is the role of third parties? Third parties like environmentalists have always had an important role in the government's use of command-and-control instruments. They can raise objections and go to court when they do not agree with a government decision. Once farmers and governments make agreements on an equal level, there may be no role for third parties. This problem still has not been solved satisfactorily. Sometimes environmentalists are invited to participate in the self-regulation process, but this does not always work out. Sometimes a third party can moderate a conflict between interests, but sometimes they aggravate it.

The approach we have described has only recently been implemented in the Netherlands. The first results are now apparent and are seen as hopeful. As we have demonstrated, certain risks are involved in the self-regulatory approach. We soon will see whether these risks become real and undermine the road to self-regulation.

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Resource Systems Analysis: Linking Agriculture and Environment in Central Java, Indonesia

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Introduction: The Problem of Soil Erosion

Soil erosion is a major and growing problem worldwide. By the year 2000, an estimated one-third of all global arable land will be lost through soil degradation, the leading cause of which is erosion (Sheng, 1989, pp. 2-3). Although some degree of soil erosion is natural and even beneficial, especially in tropical zones where intense rainfall is the norm, much erosion is caused by human endeavors such as agriculture. Accelerated or human-induced erosion can result in on- and off-site costs, including: losses in agricultural productivity; siltation of irrigation channels, reservoirs and ports; flooding; damage to coastal fisheries; disruption of water supplies; and damage from runoff of pesticides and fertilizers (Magrath and Arens, 1989, pp. 35-51). These do not include the damage inflicted on the ecological functions of the soil, nor the loss of biodiversity.

This paper concentrates on the problem of accelerated soil erosion on Java, Indonesia. I begin with a statement of the extent of the problem and a description and history of the area to be examined, after which I present a theoretical perspective of the problem. The key causal links within a Resource Systems Framework are identified, and necessary changes for sustainable agriculture are postulated. I examine in greater detail the role of a key variable, credit provision, and conclude with an assessment of the prospects for agriculture and environment to coexist in harmony.

Problem Statement

On the island of Java, Indonesia, critical area watersheds cover approximately 1.9 million ha; in 1992, this area had 12 million people. Annual erosion rates were 6 to 12 t (metric tons) per ha on volcanic soils and 20 to 60 t/ha on limestone soils (Ahmed, 1991, p. 4).

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In the Mangunan/Girirejo/Wukirsari area outside Yogyakarta, where the research for this paper was undertaken, soils are mainly limestone-derived. Agriculture in this area tends to be *tegalan:* more or less permanent dryland cultivation of food crops such as dry rice, corn, cassava, chili peppers, groundnuts and vegetables. The cropping system mainly involves annuals or short-term crops raised in monoculture. However, it is not possible to generalize about the uplands because of dramatic variations in altitude, temperature, cloud cover, soils, rainfall, groundwater, topography and the resources of the people. The only common feature of the uplands is their susceptibility to erosion and degradation of fertility (Hefner, 1990, p. 16).

Historically, clearing and settlement of the uplands in the Yogyakarta region began at the end of the eighteenth century because of population pressure and the desire to avoid feudal duties and taxes imposed by the occupying Dutch. A second wave of immigration to the uplands occurred from 1860 to 1925. This was marked by the obliteration of forests to accommodate coffee plantations, leading to massive erosion in the uplands. The last period of upland occupation occurred during the 1940s, when the Japanese replaced the Dutch as colonizers and forced farmers to cut down yet more forest to plant *Ricinus communis* for the production of castor oil. These areas are among the poorest on Java and have the severest environmental problems (Palte, 1989, pp. 40-49).

The Faculty of Forestry of the University of Gadjah Mada (UGM) in Yogyakarta became involved in this situation in the 1960s, setting up a soil conservation program because the area was becoming almost barren. They were granted ownership of an area known as Mangunan/Girirejo in the uplands of central Java, to the east of Yogyakarta. They in turn allowed farmers in the area to continue to work the slopes under their supervision, subject to certain restrictions. They required planting of tree species known to hold soil, intercropping, improved terracing, decreased planting of nutrient-leaching plants such as cassava, and the introduction of livestock. The conservation program is continuing; although great progress has been made, there is still much work to be done to restore cover to the uplands and ensure stable livelihoods in the area.

Theoretical Perspective

Ruddle and Rondinelli (1983, p. 36) define a resource system as "a combination of human, biotic and abiotic elements that provides for human needs. It consists of an entire chain of events through which a component of the general environment is perceived as a resource and passes from its source through processing or technological transformation to the creation and delivery of an end product that satisfies a perceived human need." Supplementary inputs and outputs associated with the primary product also must be taken into account because they interact with and affect the environment.

The main assumptions embedded in this model are that the transformation of resources and consumption are closely related to the available capital, technology and resources. The sociocultural, political and economic environments are also considered main elements, as are the biological and physical environments.

The framework is centered on the Actual Resource System, that is, the transformation of some resource to a product (or products) through the stages of procurement, processing and distribution to the consumer. The inputs that facilitate this occurrence are considered (capital, labor, technology, etc.), as are any wastes or other by-products of the process. Also interacting in this transformation are social organization (including economic and political organization), political economy, demographics, and biological and physical factors. These include ecological functions, which here involve both the functioning of ecosystems and the environmental conditions that affect the human condition.

An important component of this system is credit, the focus of the research reported here. Specifically, I consider how provision of credit provision may affect efforts to halt environmental degradation, especially accelerated soil erosion.

Relationship between Credit and Accelerated Erosion

Rural credit programs are intended to help farm households change their economic activities, specifically their production processes (Von Pischke et al., 1983, p. 101). This is the link between credit and the environmental impact of upland (or any type) of farming. Barbier (1988, p. 3; 1989, pp. 6-11) and Magrath and Doolette (1990) specify this link. Barbier contends that many current upland agricultural practices, for example lack of terracing, cultivation of erosive crops, and lack of vegetative cover, cause accelerated soil erosion and a concomitant decline in productivity and farm incomes. High initial cost is the major obstacle preventing upland farmers from switching to practices that in the long term are not only more environmentally friendly but also more profitable.

Credit can enable small farmers to change their agricultural practices. If this credit is used to finance practices acknowledged to reduce accelerated soil erosion, and if farmers perceive these changes to be beneficial to them (that is, if they believe they will increase their incomes or standard of living), then accelerated soil erosion should decrease and standards of living should rise. This would be a "win/win" situation in a relationship that usually involves trade-offs: environmental quality *versus* livelihoods.

Barbier (1988, p. 15) presents a simple variant of a model attributed to McConnell (1983) that indicates upland farmers' incentives to invest in soil conservation. The model's main assumption is that farmers will work the land in a way that maximizes the present value of the profit stream, implicitly taking into account the risk involved in production. The main factors affecting the profit stream are changes in relative prices of crops and production inputs, farmers' discount rates, soil characteristics, slopes, the cost of production inputs, population, and off-farm employment.

- When the relative prices of crops produced with the traditional input package rise, farmers' profits increase. This increases the opportunity cost of reducing erosion, i.e., the value of what farmers must forgo to reduce erosion; the opposite occurs when the relative prices of the crops produced with a soil-conserving input package rises.
- The discount rate, or the cost of capital invested in a soil-conserving input package, determines whether the farmer can afford to invest in soil conservation. Obviously, a higher discount rate means less investment in conservation.
- The rate of erosion can be as severe on high quality as on poor soils, However, the decrease in production and therefore of profits shows up first on poorer soils.
- The steeper the slope, the more expensive are the runoff control structures needed with the traditional package.
- An increase in the cost of the traditional input package means fewer demands on the soil and therefore less soil degradation. However, this implies less soil erosion only for poor quality soils, because volcanic (good quality) soils can remain somewhat productive despite soil loss.
- Population pressure has a mixed effect on soil erosion; on one hand, lower population reduces the need to engage in subsistence agriculture and open new land to cultivation; on the other hand, with less available labor, the costs of soil conservation may become prohibitive for small farmers.
- Similarly, when income from off-farm employment is a large fraction of total income, the response to reduced profitability on the land may be for farmers to increase their off-farm activities and ignore soil conservation practices.

In long-run equilibrium, if the soil initially is deep, it is economically optimizing for the farmer to deplete the topsoil until the costs of erosion become unacceptable, then switch to a new package of practices. Where the soil initially is shallow, it is optimal to adopt soil-conserving packages. However, even when the value of increased production would exceed the cost of the soil-conserving input package, and even when small farmers are aware of this, they often cannot afford to invest in conservation. The risk involved in changing cropping systems also deters them from switching to the new package.

Only about 15% of the public liquidity credit (readily available loan funds) that upland farmers need is available; a staggering 85% is obtained informally at an interest rate of approximately 60% per year (Barbier, 1989, pp. 174-175). Such a high interest rate is a strong disincentive for farmers in Java to invest in conservation, because it makes conservation more expensive than simply letting the soil erode.

The question then is: How does one obtain credit or capital at an interest rate low enough to encourage soil conservation? Many agricultural practices used in the uplands cause accelerated erosion, such as lack of terracing, the types of crops grown, and the lack of vegetative cover. However, high initial costs may prevent farmers from adapting more conserving practices, such as introducing tree species that take several years to become "productive." In the past, many people have suggested solving such problems through major intervention by state or external funding agencies to provide cheap capital to bypass "exploitative" local informal moneylenders (Lewis, 1955; Leibenstein, 1957; Higgins, 1959). Many supervised credit programs have been put in place in rural Indonesia and Latin America, but for various reasons, most have failed to aid the rural poor (Padmanabhan, 1989, p. 27). The most common reasons are: allocation of credit for a program without the needed complementary inputs and activities; lack of consultation during the design phase with those the program is meant to help; failure to take into account the special needs of very poor or remote borrowers; inadequate training of loan officers in the administration of loans; and the extension of unrealistic borrowing terms. The last of these leads to several problems: dependency on the part of borrowers; borrowing and "relending" at higher rates by the wealthy; and inability to recover the cost of the credit program.

Research Methods

With the help of a translator, I administered questionnaires to 30 upland farming households in six sub-villages or *dusuns* (hamlets) in the Imogiri area. These hamlets had a total of 139 people; approximately 5,000 people in the area were engaged in agriculture (Office of the Village Head, Wukirsari, 1991, and Girirejo Village Development Office, 1992).

The site was in an upland area with medium slopes (>15%), poor soils (mainly limestone), dry climate, and much deforestation. Past agricultural practices were poor. Most farmers held very small, fragmented plots. Their incomes were low compared with lowland farmers, and they had just begun to switch from monocropping of plants such as cassava and maize (the traditional package) to tree crops and silvo-pastoral systems. Half the sample consisted of farmers working in the conservation area, the other half coming from an adjacent village not involved with the UGM project.

Information was collected on household characteristics, household composition, household income and assets, access to credit, and farmers' views concerning soil erosion. The responses showed that credit would allow small farmers in the area to switch to soil-conserving practices. Defining the role of credit in this process was difficult, but the study yielded interesting data that pointed to how any credit system should function to support conservation.

Findings

This study showed that many of the links postulated above exist, and that a suitable program could allow a win/win relationship in the uplands between agriculture and the environment, which are strongly linked. The farmers, especially those on UGM land, faced a dilemma because crop production was becoming less profitable, partly because the newly planted trees were not yet compensating for the loss of the traditional crops they replaced. This shows the important need for credit to carry farmers over until tree crops produce income.

Also, there was a great gap in credit access between the UGM farmers and those not in the project. The UGM farmers had a higher average income and could produce more for own use; therefore they had more resources with which to implement soil conservation measures. Also, they viewed themselves as obliged to do so, partly because it would increase their profits, but also because they felt responsible for the land.

Compared with farmers in the UGM program, non-UGM farmers were more likely to think the productivity of their land was increasing or stable. However, they acknowledged that fertility was declining; that is, more fertilizer was needed to maintain productivity.

Most farmers, when given the option, preferred to be helped with soil conservation through credit and cash inputs rather than more information, seeds, grasses, extra labor, etc. Often, they were not consulted about the kinds of other inputs required, and therefore were given inappropriate "assistance," such as seedlings or plants that could not be grown in the area or that gave them no income.

Overall, upland farmers had little access to credit, with half the sample having no access at all. Very little of whatever credit was available went for soil conservation. Among those farmers who did get credit, most used it for household needs, fertilizer purchase, utilities, or financing small businesses.

Conclusions and Recommendations

Despite the shortage of credit, there was a potential for savings in the area, and a self-administered credit program was within the experience of the people. Small groups that participated in rotating credit schemes were common, but they were largely administered by females for the own households or small businesses. The women had very detailed knowledge of all loans occurring in the household, while the men, who did most of the field work, largely ignored this aspect of household operations.

Several large projects, such as the World Bank-funded Yogyakarta Uplands Development Project, sent money to the villages for critical uplands rehabilitation in the area. However, this money had been diverted to small industries and businesses, with none given to agriculture, let alone soil conservation. Although income diversification is an important part of a development strategy, at least some funding should be going to small farmers.

The area appears to require a kind of credit cooperative of small upland farmers, which would provide loans for improvements to upland agriculture. Providing credit this way has the advantage that it makes the upland farmers responsible for managing the funds, while drawing on local financing and thereby avoiding a dependency problem.

Any agency providing credit should only finance agricultural improvements that will recover the agency's costs, rather than funding any project just because it has a soil conservation element. This would include charging interest to cover costs, but the interest should not be exorbitant.

Various forms of land tenure—sharecropped, borrowed, leased, and rented land—all are important in the area. As a result, most farmers are never entirely sure that land improvements that increase yields or income will actually benefit them. Even UGM farmers do not own their land and therefore are not guaranteed a return from their investment in soil-conserving practices. One can understand UGM's reluctance to allow individual ownership of the land in an area where poor agricultural practices in the past had severely degraded the land. A possible solution would be to allow farmers to work the land in a conserving manner with the promise that they would be given secure tenure once the soil was stabilized. There would be a proviso that if they did not take proper care of the land in a specified period, the land would revert to UGM.

With the credit component of the resource system as a starting point, we can trace a series of events that lead to improved agricultural productivity and environmental quality. When credit is provided in the manner described above, it allows small upland farmers to invest in soil-conserving forms of agriculture: terraces; investment in small ruminants, which would improve incomes and encourage farmers to maintain soil cover; decreased reliance on chemical inputs; and planting of soil-conserving crops and trees. The resulting decline in erosion increases agricultural productivity and incomes and decreases pollution from fertilizer and pesticide runoff. These changes also maintain wildlife habitat, soil fertility, and biodiversity. Other environmental benefits include reductions in siltation, flooding, damage to fisheries, and pollution of the water supply.

The localized, cooperative type of credit system envisioned also has implications for social organization and political economy. It requires that upland small farmers participate heavily in decision making and have a greater command over resources in the villages. Development becomes more of a "bottom-up" process. This type of structure is more conducive to a sustainable system with benefits for both the environment and agriculture.

The case study indicates that credit is important in determining how the upland resource system functions in central Java. Proper credit allocation encourages sound agricultural practices that maintain watersheds. Because the system involves cyclic flows, changes that benefit the environment also benefit agriculture, and vice versa.

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Are Productivity Enhancing, Resource Conserving Technologies a Viable "Win-Win" Approach in the Tropics? The Case of Conservation Tillage in Mexico

Olaf Erenstein[1]

Introduction: Productivity and Sustainability

Agricultural development efforts in the tropics initially focused on raising productivity in traditional agricultural systems. Among other results, this has led to the major productive breakthrough known as the Green Revolution. The initial productivity boost was based on the combined use of high yielding varieties and agrochemicals in more favorable tropical environments. However, recent evidence suggests that the initial productivity boost may not be entirely sustainable because of a variety of resource degradation issues.

Widespread sustainability problems in agricultural systems have recently increased interest in an agriculture more oriented toward resource conservation. This has led to renewed attention to low external input agriculture, and is occasionally taken to the point of avoiding synthetic inputs altogether, as in organic agriculture. Although such systems definitely score high on various sustainability indicators, they tend to have low productive potential.

These experiences suggest there is a trade-off between productivity and sustainability. However, in view of a burgeoning population and finite resources, we need to minimize this trade-off while addressing issues of productivity and sustainability. Productivity-enhancing, resource-conserving technologies seem to hold this promise, simultaneously addressing agricultural and environmental issues to achieve sustainable agricultural development. As such, they have a "win-win" potential (Fig. 1).

Conservation tillage is an example of a productivity-enhancing, resource conserving technology currently being promoted in the tropics. The technology has the potential of simultaneously addressing soil conservation and productivity issues. However, although detailed technical and economic information is available on it in industrialized environments, similar information for the tropics still is scarce. Consequently, we do not know its potential in the Mexican tropics. This paper summarizes some factors affecting the

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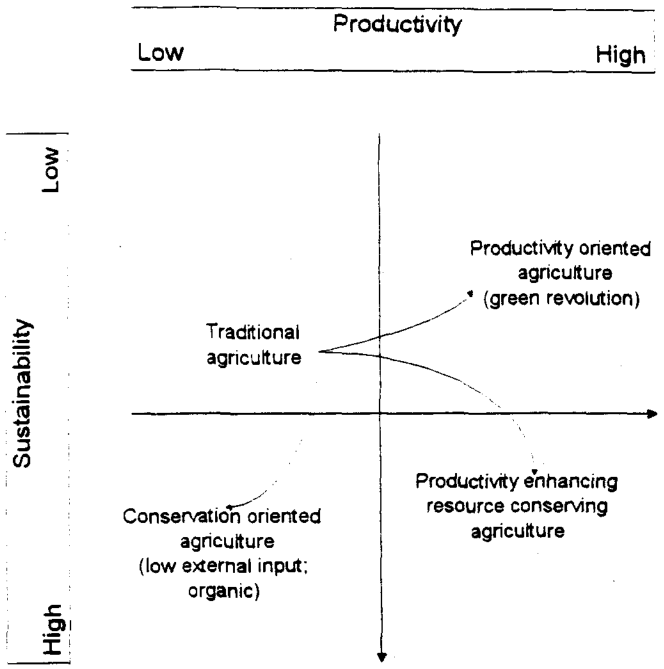

Fig. 1. Relationship between productivity and sustainability in various types of agriculture.

agricultural and environmental potential of conservation tillage in maize-based farming systems in Mexico. However, before doing so, we must look more closely at some implications of soil conservation in the tropics.

Soil Conservation in the Tropics

We can distinguish two viewpoints in relation to soil conservation in the tropics. On one hand, the conservationist emphasizes that soils are being degraded. Although the effects in any one year may be insignificant, they become important as they accumulate over time (Lal, 1987). Therefore, we need to invest now in conservation measures to secure the resource over the longer term. In addition, the conservationist highlights several externalities of soil erosion that harm society at large. Soil conservation can greatly reduce these and thereby generate substantial social gains.

On the other hand, the farmer emphasizes production. Most resource-poor farmers in tropical environments face many uncertainties and short-term needs. As a result, they generally are more concerned with making ends meet today than with securing resources for some distant future. Also, farmers understandably are more interested in the benefits and costs that directly accrue to their farm than in externalities.

In the end, it is the farmer who generally decides land use and therefore the use of soil conservation measures. Thus, for soil conservation measures to be viable and effective, we need to consider the farmer's concerns. That is, we need to alleviate some productivity concerns before, or in addition to, conservation concerns, with the conservation measures themselves imposing only moderate additional costs on the user.

The relative costs of soil conservation measures vary widely, depending on the measure itself and the environment in which it is applied. For example, physical soil conservation structures require substantial initial investments. These investments generally are prohibitive for resource-poor farmers in the tropics and are unlikely to be profitable (Lutz et al., 1994). Productivity-enhancing, resource-conserving technologies such as conservation tillage have the potential to recover part of the conservation costs in the short run through immediate productivity increases, so that the relative conservation costs are low. However, this potential depends on an array of agroecological and socioeconomic factors, most of which are specific to the farming systems and environmental conditions of the tropics.

Conservation Tillage in the Tropics

Conservation tillage is a widely used term that covers many different practices, but generally relates to a reduction in tillage and the conservation of crop residue for erosion control. As a result of its wide use, various definitions abound. Here a system will be classified as conservation tillage if it satisfies the following criteria:

- *The reduced tillage criterion:* tillage excludes any soil inversion, but may vary from zero-tillage to a maximum of two superficial cultivations.
- *The mulch criterion:* at least 30% of the soil surface is covered by crop residues immediately after planting. In Mexico, this translates into a threshold of at least 2 tons of maize residue per hectare.

In general, the adoption of conservation tillage seems to require two major changes. On one hand, tillage/soil movement needs to be reduced to satisfy the reduced tillage criterion, which basically means replacing tillage with herbicides. On the other hand, sufficient crop residues need to be left to satisfy the mulch criterion, so that competitive uses and current practices such as the burning of residues must be restricted.

Both the reduced soil movement and the mulch are soil conservation measures. Their conservation effect is achieved partly by protecting the soil better against the erosive impact of the rain, both through the presence of the mulch as a protective layer and through reduced disturbance of the soil's structure. The mulch also reduces erosion by reducing runoff and increasing infiltration by forming physical barriers and by improving the soil's physical structure and thereby its permeability. Both features are especially relevant in tropical regions with erosive rain storms and with erodible soils cultivated on steep slopes. Conservation tillage also conserves water through reduced runoff, increased infiltration, and reduced evaporation. This increases available soil moisture, which can reduce losses in production during dry spells

Conservation tillage practices have received widespread attention from various agencies throughout Mexico during the past five years. Despite the undoubtedly favorable effect that all the massive attention has had in promoting conservation tillage, the attention also has had its drawbacks. For one, the many different people involved have generated diverse interpretations of what conservation tillage is all about. Some merely interpret it as not burning crop residues, even if they are entirely incorporated or grazed. Others interpret it as any non-inversion tillage. Any subsequent negative experience with such technologies is then erroneously attributed to conservation tillage. However, as discussed previously, conservation tillage must satisfy both the reduced tillage and mulch criteria to achieve its potential benefits.

An additional drawback has been the lack of attention given to assessing the potential of conservation tillage practices in different environments (both agroecological and socioeconomic). Conservation tillage has been promoted as a blanket solution for all Mexican environments. However, it is a complex technology that may not always be appropriate. Its adoption requires changes in several production practices, including field preparation, sowing, mulch management, weed management, and possibly pest and fertilizer management. As a result, it should be promoted carefully, because the required changes could have different implications in different farming systems.

The Agricultural Potential of Conservation Tillage

The agricultural potential of conservation tillage can best be determined by reviewing both its advantages and disadvantages from the farmer's viewpoint and the resulting benefits and costs that farmers face in adopting it. The technology will have little agricultural potential whenever the aggregate on-farm costs exceed or equal the aggregate on-farm benefits. In this section I review some benefits and costs that may influence the agricultural potential of the technology in Mexico.

On-farm benefits of adopting conservation tillage

The benefits of adopting conservation tillage practices generally are twofold: the potential reduction of production costs, and the potential yield increase. The potential reduction of production costs differs between mechanized and manual systems. The reduction in the costs of establishing the crop and controlling weeds can be substantial in mechanized systems. Although herbicide use is increased with conservation tillage, this cost generally is more than offset by the reduced cost of tillage. In manual systems, conservation tillage can save a substantial amount of labor for land preparation and weed control. However, the potential attractiveness to the farmer of replacing labor by herbicides depends on various factors, including the opportunity cost of labor and the cash cost of herbicides. In addition, conservation tillage has major implications for the cost structure of agricultural production, especially for households that rely primarily on family labor, because it replaces a non-cash (in-kind) input with a cash cost. This can be a special problem in (semi)subsistence systems because of their limited sales, although it may be alleviated by other income sources, such as a cash crop (for example, coffee). Family labor freed by the substitution can either be used to expand the area under cultivation or be diverted to other productive activities. The existence of alternative employment opportunities (agricultural or nonagricultural) can therefore be a decisive factor favoring adoption, because it directly affects the opportunity cost of labor.

Adopting conservation tillage potentially increases yields relative to conventional tillage. However, this yield increase is the aggregate effect of three different causal factors: soil conservation, water conservation, and timeliness of crop establishment.

- *Soil conservation* measures such as conservation tillage reduce the rate of soil degradation and thereby the resultant productivity loss. The magnitude of this gain is therefore directly related to the degradation occurring in the first place. Soil degradation is generally less severe in favorable environments, and consequently the yield increase related to soil conservation may become visible only in the long term. However, in marginal environments such as steeply sloping areas (slopes between 40 and 80%), soil degradation is generally more severe, and the yield increase from soil conservation may already become visible in the medium term.
- *Water conservation* can increase yields in areas where water is a limiting factor. In fact, many rainfed areas in Mexico suffer from a water deficit during the growing season, occasionally in the form of a prolonged mid-season dry spell. Conservation tillage can use the available water more efficiently and thereby reduce water stress during these dry spells. This effect potentially translates into higher average yields and lower production risks.
- *More timely crop establishment* also can increase yields. Conservation tillage can reduce the time required for crop establishment. This can be of special interest in areas where the time available for crop establishment is very limited, as in irrigated systems with two crops per year.

On-farm costs of adopting conservation tillage

The costs of adopting conservation are very diverse. First, conservation tillage requires sufficient crop residue to form an adequate mulch. The cost of these residues is very variable throughout Mexico and can be a decisive factor in determining the potential of the technology. The cost of residues is generally an opportunity cost influenced by alternative competing uses for them. The major competing use in Mexico is as fodder during the dry season, especially through stubble grazing. The amount of residues used as fodder is variable, depending on the aggregate supply and demand. The demand for fodder is largely determined by livestock pressure and the availability of alternative fodder sources, both on-farm and off-farm. Off-farm factors are important, especially where exclusion possibilities are still limited: communal grazing after the harvest is a common practice in some areas of Mexico and Central America. Under such circumstances, farmers may need to fence their fields to protect their residues; this may present a substantial entry barrier for would-be adopters. In other areas there is a real market for maize residue. In such cases, the costs of residue conservation are clear (the benefits less so), as would-be adopters must forgo the possibility of selling residues. This is an especially important limitation when sales of residues account for a substantial part of the gross margin of maize production, say more than 10%.

Adoption of conservation tillage also presents learning costs to farmers. These costs may be substantial for resource-poor farmers who have only limited experience with the use of agrochemicals. Also, most such farmers have had little or no schooling, and extension services are especially weak in remote and marginal areas.

The adoption of conservation tillage practices may require access to certain machinery or equipment. The unavailability of such machinery therefore raises the initial costs of adoption. In the Mexican context two specific types can be distinguished:

- *Crop establishment machinery:* Conservation tillage systems in the industrialized world use direct drills to sow through the mulch under zero-till conditions. However, in Mexico these specialized machines are not readily available, a major limitation for the adoption of mechanized conservation tillage practices. This has forced conservation tillage practices toward reduced tillage systems, which have the disadvantage that they incorporate part of the residues. This is especially disadvantageous in Mexico, where the amount of residue available as mulch is already limited.
- *Herbicide application equipment:* Adoption of conservation tillage practices generally involves replacing tillage with herbicides. This requires access to a backpack sprayer. Not owning a backpack sprayer creates an entry barrier, as the farmer would either need to purchase it (a considerable investment for subsistence systems) or hire it (generally at the going rate for a day laborer).

Another major general limitation is the traditional method of residue disposal. In many areas of Mexico it still is common to burn residues to prepare the field. Farmers burn residues for various reasons. Although not all these reasons may be applicable in current systems, farmers will still need to be convinced about doing otherwise. The major reasons for burning involve the following considerations:

- *Pests and diseases:* Many farmers relate the incidence of various pests directly to the presence of the crop residue as mulch. Although conclusive evidence is lacking, the potential for increased pest and disease incidence is certainly present, as many rainfed areas in Mexico have continuous maize cropping with one crop a year. Leaving crop residues under conservation tillage practices probably will either raise the costs of pest and disease control or reduce yield through pest damage. In addition, zero-tillage frequently generates problems in controlling perennial weeds. On the other hand, conservation tillage practices can inhibit weed growth if the mulch layer is adequate.

- *Planting problems:* In manual and even in some mechanized systems, sowing is done manually with a dibble. Farmers occasionally still use animal traction for sowing. With conservation tillage, both practices become a little more cumbersome and time consuming.

A farmer will stop burning only if convinced that the benefits of not burning outweigh the costs. However, it may not be enough that a farmer is convinced of the usefulness of not burning the mulch and therefore would not set fire to it. Whenever a neighboring farmer still relies on burning to prepare the land or regenerate a pasture, there is a risk that the dry, flammable mulch will be ignited accidentally. Therefore, a would-be adopter may need to invest substantial additional time in constructing firebreaks.

The adoption of conservation tillage practices may also be limited by intercropping. Especially in subsistence systems, intercropping maize with beans or pumpkins is common. However, intercrops interfere with the application of herbicides. Furthermore, intercropping generally restricts the possible herbicides to contact herbicides, because the residual effect of some herbicides may harm the intercrop. Conversely, using a wider range of herbicides may limit the possible intercrops.

The Environmental Potential of Conservation Tillage

Technologies that aim to reduce resource degradation seem without question to be environmentally beneficial, with little need for trade-offs among different environmental impacts. Resource-conserving technologies nearly automatically score positively on environmental scorecards.

Similarly, the value of conservation tillage for soil conservation is generally unquestioned, although the size of its conservation benefit depends on the previous level of soil degradation. The soil conservation effect has positive environmental effects both on-site and off-site. On-site, the reduced soil erosion leaves the soil resource less physically, chemically and biologically degraded. Off-site, soil conservation reduces some downstream environmental damage caused by the sediment load in the waterways, such as harm to aquatic life and sedimentation behind dams. In addition, widespread adoption of conservation tillage practices in watersheds has the potential of smoothing the hydrological cycle and reducing flooding.

Less obvious may be the beneficial effects that conservation tillage has on forest resources. A major environmental benefit of conservation tillage is the potential elimination of burning as a land preparation measure. In Chiapas, for example, burning of residues has been identified as the major cause of forest fires. In fact, protecting forest resources was part of the rationale for a recent law that severely restricts burning as a land preparation measure in the state (Sandoval, 1994).

However, conservation tillage practices also can cause environmental harm. They generally increase the use of agrochemicals, especially herbicides, and therefore increase the risk that some chemicals will leave the farm through leaching or surface runoff. Furthermore, although some farmers may have used herbicides in recent years, knowledge of their properties and application requirements generally is still limited (Tasistro, 1994). Many farmers have learned about the use of agrochemicals by doing, thereby creating a hazard not only to the environment, as when they clean backpack sprayers in streams, but also to themselves. By now, many Mexican farmers have experienced intoxication symptoms (for example, up to 45% of farmers in the Fraylesca area of Chiapas, according to Nieuwkoop et al., 1994). Also, the presence of the mulch with conservation tillage practices may further increase ammonia volatilization because the fertilizers, including urea and ammonium sulfate, generally are applied on the surface (Tasistro, 1994).

Conclusion

From the above discussion it should be clear that many factors affect the agricultural potential of conservation tillage in the Mexican tropics. The technology seems viable from the farmer's point of view only in cases where the on-farm benefits outweigh the on-farm costs. On the other hand, resource-conserving technologies as such would generally have overwhelmingly positive environmental effects. However, under certain circumstances the promotion of conservation tillage practices also can have detrimental environmental effects. As a result, we can distinguish different combinations of agricultural and environmental outcomes (Fig. 2):

1. *Agriculture lose - environment lose:* Adopting zero- or reduced tillage practices without adequate residue conservation is harmful both agriculturally and environmentally. Experimental evidence repeatedly has shown that without the protective mulch, reduced tillage actually backfires, causing lower yields because of soil sealing, compaction, runoff and other problems. Furthermore, without the protective mulch, reduced tillage also loses most of its soil conservation effect. There is little point in promoting such practices, and care should be taken so that they are not mistaken for true conservation tillage.

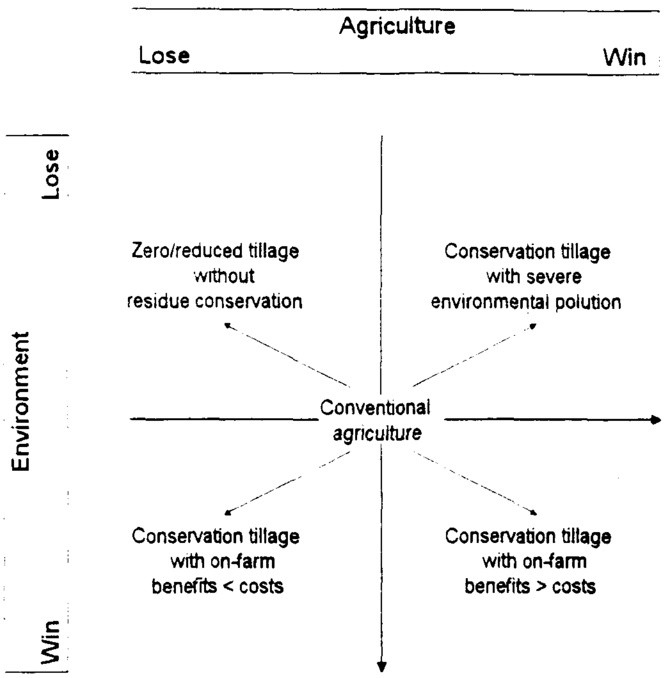

Fig. 2. Potential win-lose relationships between agriculture and environment from adopting conservation tillage.

2. *Agriculture win – environment lose:* Adopting conservation tillage practices under profitable on-farm circumstances would generally lead to a win for agriculture. However, excessive or inappropriate agrochemical use may cause severe environmental pollution, which in extreme cases may offset the soil conservation effects. In such cases, the environmental degradation could be alleviated through corrective measures such as education and price policy.

3. *Agriculture lose – environment win:* Adopting conservation tillage practices would generally reduce the environmental degradation occurring under conventional agricultural practices. However, the on-farm costs of adopting conservation tillage may outweigh the benefits, as in some of Mexico's semiarid regions that have an important livestock sector. In such environments, the opportunity cost of the residues may be so high that it is impossible to offset them through increased productivity. The technology thus offers limited scope unless part of the on-farm costs can be alleviated, such as by better alternative fodder sources and management practices.

4. *Agriculture win – environment win:* Adopting conservation tillage practices is most feasible in areas where the on-farm benefits outweigh the on-farm costs and the environmental benefits outweigh environmental costs. Generalizations of this win-win potential are dangerous in view of the many factors that contribute to the benefits and costs. However, the technology especially seems to have potential where the opportunity cost of residues is low, such as in humid areas where there are abundant and better supplies of fodder. Also, the productivity-enhancing feature of the technology becomes especially obvious in areas with a water deficit during the growing season or in areas that are particularly prone to severe soil degradation, such as steep hillsides. Only in such win-win cases does the technology seem to offer a viable productivity-enhancing, resource-conserving alternative.

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Index