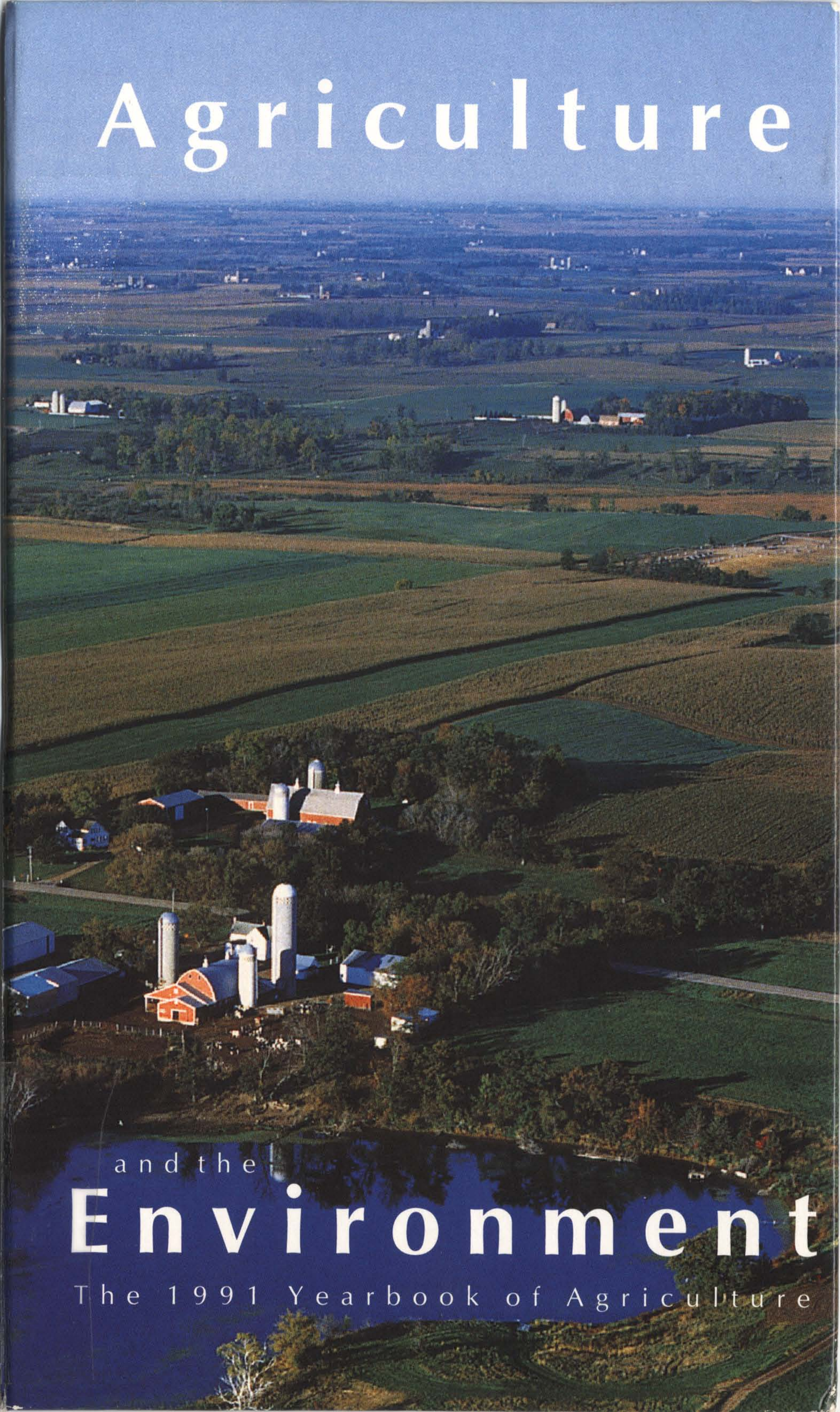
Agriculture



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Environment

The 1991 Yearbook of Agriculture

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and the Environment

The 1991 Yearbook of Agriculture

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Introduction

by Edward Madigan, Secretary of Agriculture

Prospects for protecting the environment have never been greater. As a Nation, we have moved far beyond environmental slogans.

This Yearbook examines environmental concerns facing agriculture, and indicates what USDA is doing to address these concerns. In it, you can learn about our ongoing research efforts to identify environmental risks in agriculture, and about the technical assistance and other programs that are helping to preserve and enhance the quality of our water, land, air, and food.

From the Dust Bowl days of the 1930's to the President's Water Quality Initiative of today, USDA has been charged with taking positive steps to help protect America's lands and improve water quality.

The Search for Balance

Environmental quality and economic growth go together. As we look to the future, we need to continually balance demands on agricultural resources for food production with ecological concerns for surface and ground water quality, wildlife, and wetlands, as well as human health.

U.S. environmental policy is firmly based on the compatibility of environmental quality and economic growth. But the gains in clean air and water, hazardous waste control, and wildlife protection have been costly. National expenditures for pollution control were $115 billion in 1990, a four-fold increase from the amount spent in 1972.

To ensure that Federal funding for environmental quality is spent effectively, we must rely on technical and scientific knowledge, not emotion, to identify our greatest environmental risks and focus attention on our Nation's environmental priorities. Then we must aggressively and systematically work to reduce those risks to acceptable levels.

The challenge facing world agriculture today is to provide food, fiber, and industrial raw materials for billions of people—without jeopardizing the future productivity of our natural resources. Meeting this challenge will require the continued support of science, research, and education programs. To meet environmental and food safety goals, we also need to coordinate international food safety and environmental policies.

The current level of global food production could not have been attained without the use of chemical inputs, mechanical power, and irrigation. The Green Revolution, which resulted in tremendous gains in food production for many countries, relied on high-yielding varieties of wheat and rice that responded to agricultural chemicals.

The United States has long been a leader in responding to rapid growth in global food demand. This country now accounts for about one-half of world soybean production, one-third of world corn production, and about one-tenth of world wheat production. Agriculture contributes an annual surplus of nearly $20 billion to the U.S. trade balance and is also an important source of employment

New technologies, developed through both government and private research, have greatly increased the productivity of our agricultural resources. And new technologies will help us attain environmental as well as agricultural production goals.

Here are some highlights of what we are doing, efforts that you can read about in this Yearbook:

Land

The President's National Tree Planting Initiative, as part of the America the Beautiful program, will result in a billion new seedlings being planted each year for the next 10 years. This book shows you how to plant a tree near your home or in your community.

The Food Security Act of 1985 brought renewed emphasis to soil conservation. By January 1991, about 34 million acres had been enrolled in the Conservation Reserve Program (CRP). As a result, soil erosion has been reduced by an estimated 655 million tons annually. The average soil loss on CRP land has been reduced from an estimated 21 tons/acre/year to about 1.6 tons/acre/year. Pesticide and herbicide use have also been reduced by an estimated 61 million pounds annually and fertilizer use by 2.5 million tons annually. Total water quality benefits resulting from the CRP are estimated at about $4 billion over the life of the program, and fish and wildlife habitats have also been improved.

In the Food, Agriculture, Conservation, and Trade Act of 1990, the Administration and Congress responded to concerns about the adverse environmental impacts of farm commodity programs by giving farmers greater flexibility to plant alternative crops and to use crop rotations. This will reduce soil erosion and the use of agrichemicals.

The "New Perspectives" program of USDA's Forest Service is a means to achieve a balance between the management and use of forest resources.

Water

The wetland reserve program will protect and restore wetlands, and will yield widespread benefits by reducing ground water contamination and nonpoint sources of pollution that adversely affect streams and lakes.

Scientists at USDA and other Federal agencies are studying how agricultural chemicals (especially pesticides and fertilizers) affect ground and surface water quality. This is one of agriculture's most pressing environmental concerns. A few have suggested that such production inputs be banned; others have suggested that farming methods be heavily regulated. Either action would be a disaster for American agriculture and for world food supplies.

The President's Water Quality Initiative, begun in 1990, is a coordinated effort to protect and enhance water quality by USDA, the Environmental Protection Agency (EPA), the Department of Commerce, and the Department of the Interior. The USDA water quality budget for FY 1991 is $206 million, nearly double the amount spent in FY 1989. To start, this effort will develop and test production systems, provide research and education in areas where ground water is highly vulnerable, operate demonstration and ongoing projects in designated areas, and expand data collection. It will encourage voluntary changes in farm production practices by offering producers in critical water quality areas the best technology available.

Air

Ethanol-based fuels, derived from agricultural feedstocks, can play an important role in reducing automobile pollution emissions. The promise of these fuels has given impetus to research that could lead to more efficient feedstock conversion technologies and the development of new types of feeedstocks. Fuels developed from renewable resources have important economic and environmental advantages.

The Clean Air Act of 1990 will reduce sulphur dioxide emissions, the leading cause of acid rain, by 10 million tons. Although air pollution is generally viewed as an urban and industrial issue, improving air quality has an agricultural dimension. For example, acid rain affects crops and forests.

The National Energy Strategy, which requires the use of clean fuels, will reduce air pollution in our cities and, by encouraging the production of alternative fuels, it will lessen our dependence on foreign sources of oil.

Technology

Integrated pest management is just one of many technologies that are helping to realize the promise of sustainable agriculture.

Computers are being used in numerous intriguing ways, for example to study water quality and to plan soil conservation measures.

Photography, videos, airplanes, radios, microwaves, satellites, and other communications tools are being used to monitor the environment.

Researchers are coordinating international efforts to protect forests, and they are striving to offer the techniques of sustainable agriculture for use in developing countries.

To help our Nation's ecosystems maintain biological diversity, wildlife experts are acquiring knowledge on the recovery needs of the northern spotted owl, red-cockaded woodpecker, and grizzly bear habitats.

Advances in biotechnology will speed the development of plants and animals that are resistant to disease and pests, and can thus increase agricultural profitability while protecting the environment.

Food Safety

American agriculture has led the way not only in conserving the Nation's land and water resources, but also in ensuring healthy livestock and poultry. Farmers and animal producers who take steps to improve their crop management practices and protect the health and sanitary conditions of livestock and poultry also protect the health and safety of the public, those who consume the food. This is a win-win situation for everybody.

A significant regulatory and scientific effort is also underway to ensure that unsafe residues and microbial contaminants, such as *Salmonella enteritidis,* do not enter the food supply.

The implementation of the Hazard Analysis and Critical Control Point System—a preventive approach to problems in food production that may occur from farm to table—will also reduce food borne illnesses even more.

USDA also provides leadership through the Food Safety Data Initiative, a comprehensive program that provides reliable pesticide data for developing environmentally sound agricultural policies and practices. USDA is working with EPA and the Food and Drug Administration to collect and analyze pesticide data, link utilization and residue information, and ensure the safety of the food supply. The data will help Federal and State agencies make accurate and responsive regulatory decisions, assist farmers in improving production methods, and enhance the confidence of domestic and foreign consumers in the safety of our food supply.

The Administration has also proposed changes to the regulatory system that will allow faster removal of dangerous substances from the market and speed approval of more environmentally safe pest control alternatives.

What You Can Do

Who is responsible for the Earth's environment? Will regulation and laws ultimately dictate our responsibilities?

Taking care of our environment must be a cooperative effort to conserve the land, water, and air in a way that will best sustain the earth and all its people. The environment is everyone's business.

USDA and other governmental agencies are engaged at the Federal, State, and local levels to enhance environmental awareness and encourage sound conservation practices. USDA offers publications on conservation, as well as technical assistance for landowners and communities.

Farmers are doing a lot to lessen agriculture's impact on the environment, and this book describes but a few examples of these efforts. It also looks at volunteer activities, education and outreach programs, and recycling ideas that people are pursuing across this country.

Farmers and communities are trying new ways to recycle water for agriculture—water used to grow fish in Mississippi, potatoes in Maine, and citrus fruit in Florida.

Teachers, parents, and volunteers are using outdoor classrooms and numerous other techniques to teach young people about the environment they have inherited.

Communities, industries, and individuals are learning more about recycling wood products and other waste materials.

I believe that farmers, landowners, and other Americans will respond to environmental challenges if they understand the problems and see clearly what they can do about them.

We need your ideas, your interest, and your time as a volunteer. If you haven't already done so, you can become actively involved in resource conservation and wildlife enhancement efforts. I hope you find this book useful and informative, and I welcome your involvement in this venture.

Preface

by Deborah Takiff Smith, Yearbook Editor

The 1991 Yearbook of Agriculture explores some ways that agriculture affects and protects our environment.

Farmers work intimately with the earth, water, air, weather, and Sun's energy—all of which sustain plant and animal life. Farming does have an impact on the natural environment, and USDA is working with farmers and others to balance the need for food, fiber, and industrial raw materials with the need to sustain the long-term viability of our productive ecosystems.

The U.S. Department of Agriculture has long been a quiet leader in research, education, and action programs to protect our land, water, air, and food. This Yearbook presents substantive information from USDA experts on such topics as soil conservation, water quality protection, renewable fuels, wildlife preservation, and trash recycling.

It explores up-to-date advances in research and technology that are helping people measure our resources and use them efficiently and wisely.

It gives but a few examples of the thousands of volunteer and community efforts to protect the environment—by farmers, other landowners, ordinary citizens, and government at all levels—and it invites you to join these efforts.

Literally hundreds of people have worked to produce this Yearbook for you. In addition to the authors, these key people planned, recruited, edited, and produced this volume:

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Land

Introduction by
James R. Moseley,
Assistant Secretary, Natural Resources
and Environment

President George Bush said recently that we are not "seeking limits to growth, which are contrary to human nature," but striving for "environmental protection through more informed, more efficient, and cleaner growth." Such growth can be achieved only if each one of us contributes what we can toward the enhancement of our natural resources. In that light, USDA is committed to acting responsibly toward our land through partnerships between landowners and operators and Federal, State, and local technical experts. Together we strive to manage natural resources and enhance the land's productivity.

We have entered a new age of environmental awareness and technology. Over the past two decades, public opinion polls have increasingly identified the environment as a major public concern. The conservation provisions of the 1985 and 1990 farm legislation reflect this concern. At the same time, recent advances in environmental technology have enabled USDA technical experts, using vast computerized information resources, to provide farmers, ranchers, and loggers with the sound conservation planning information they need to both manage their resources and maintain their productivity. It is imperative that we combine our increased awareness and advanced technology to balance the need to feed, clothe, and house our growing population with our desire to protect the environment.

Within the 48 contiguous States, we have almost 2 billion acres of land, about 300 million of which are used for crop production. Each time farmers plant, water, fertilize, or harvest a crop, they work in partnership with the environment. By working with USDA's Soil Conservation Service, today's farmers are increasingly using conservation tillage, among other conservation practices, to enhance farm productivity while reducing erosion and water quality degradation.

In 1891, the public's desire to preserve our natural resources was reflected in the establishment of the National Forest System. This effort to protect the watersheds and timber supplies of our Nation received strong support from President Benjamin Harrison, who set aside the first 1 million acres of the National Forest System. Later, the National Forest System was expanded to 191 million acres—lands that continue to benefit Americans through multiple usage carried out under guidelines implemented by USDA's Forest Service. Besides humans, the beneficiaries include many species of plants and animals that balance the entire forest ecosystem. Today new challenges face the National Forest System, but none is more crucial than balancing plant and animal habitats against the demand for a wide variety of other uses.

A truly successful growth strategy for America's cropland and forests requires more than the implementation of Federal, State, and local land policies. Essential to any successful growth strategy are the important partnerships forged with landowners and operators who are also keenly concerned with fostering the growth of agriculture, keeping in mind the best interests of the environment. Such partnerships enable us to use our wealth of environmental research information in an integrated approach to resolve the complex resource management issues we face.

Our partners realize that as American agriculture continues to grow, so do our environmental challenges. As caring citizens, who are committed to ensuring that our natural resources continue to be productive for generations to come, we can meet the challenges we now face and those to come.

America's Cropland: Where Does It Come From?

1

by Ralph E. Heimlich and Arthur B. Daugherty, Agricultural Economists, Economic Research Service, USDA, Washington, DC

Our cropland was originally wrested from forestland or native grassland. Early in our history, almost all forest and grassland near settlements was converted to crop use. As the population moved West, pioneers converted new cropland from native land cover.

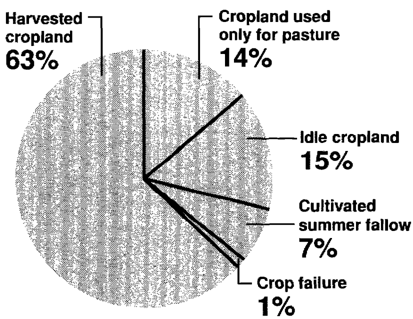
Over time, much of the land in the East that had been cleared and cropped or pastured reverted to forest. For example, in the 19th century, an estimated 85 percent of the land in Vermont had been cleared for agricultural purposes. As of 1987, nearly 85 percent of Vermont's land area was again forested.

As farmers expanded the cropland base, more environmentally fragile land began to be used for crop production. Steeper slopes and land with more highly erodible soils were cleared and used for cropland, increasing soil erosion contributing to sediment damage in downstream rivers and reservoirs. Ecologically valuable wetlands were drained, destroying important wildlife habitat, reducing the ability of the land to retain rainfall, and thus contributing to increased flood damage. In the Great Plains, farmers plowed native grassland, increasing wind erosion. The effects of this conversion peaked during the Dust Bowl of the 1930's, but similar conversions occurred on a smaller scale during the 1970's and early 1980's.

What Is Cropland?

Cropland is land used for the production of adapted crops, like corn, soybeans, wheat, hay, and horticultural crops. As such, it is a landscape created by humans and is no longer part of the natural ecology. The land may be

Figure 1. Harvested cropland accounted for nearly two-thirds of our cropland base in 1987



used continuously for these crops or crops may be grown over a period of years in rotation with grasses and legumes. "Cropland used for crops" includes cropland from which crops are harvested (cropland harvested), land on which crops failed (crop failure), and "cultivated summer fallow." Cropland used only for pasture makes up the remainder of the Nation's cropland resources (see fig. 1).

Not all cropland is used for crops in any given year. Idle cropland includes land in cover and soil improvement crops as well as completely idle cropland. Some cropland may be left idle for physical and economic reasons. However, since farm programs were instituted in the 1930's, much of the idle cropland has been land diverted from crop production into soil-conserving uses by Federal commodity programs.

Crop failure occurs primarily due to weather, insects, or diseases, but crops also may not be harvested—and thus considered failed—due to lack of labor, low market prices, or other factors. Cultivated summer fallow is cropland left unplanted, but cultivated, as a way of accumulating moisture for the next year's crop. Although optional in many

Figure 2. Cropland used for crops is relatively constant over time, but highly variable year-to-year

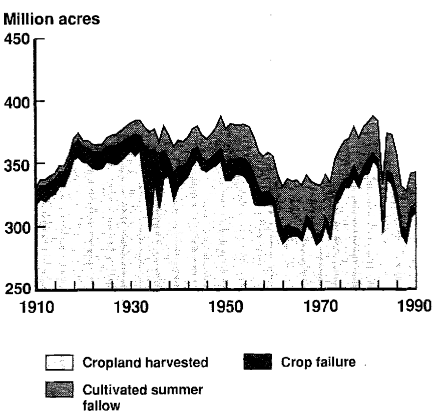
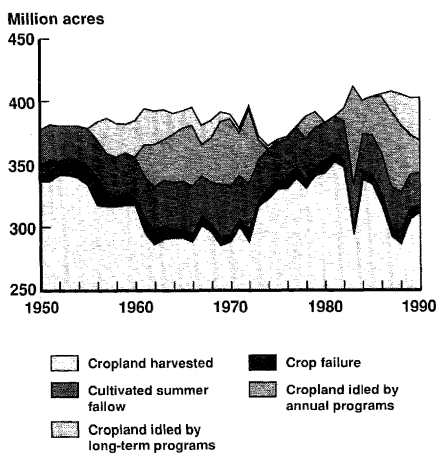


Figure 3. Federal programs idled up to 78 million acres in some years since 1950



important grain-producing areas, cultivated summer fallow is required in some of the drier cropland areas of the West.

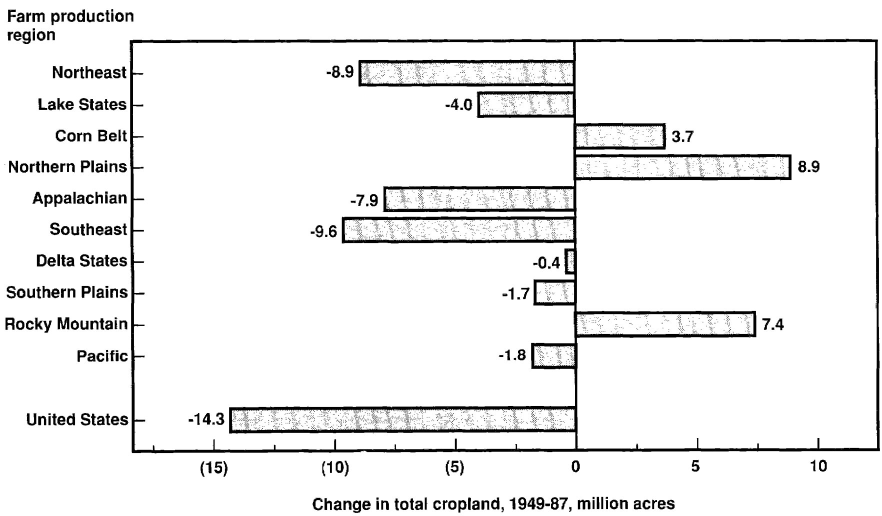
Cropland Trends

The amount of cropland used for crops has been relatively constant in this century (see fig. 2). In 1910, about 330 million acres were used for cropland. During World War I, farmers expanded cropland to almost 375 million acres in order to compensate for the loss of European production. The U.S. cropland base remained at about 375 million acres from then until after World War II. The export boom of the 1970's caused farmers to once again expand crop acreage to more than 380 million acres. After the downturn in farm exports in the mid-1980's, U.S. cropland returned to about 330 million acres, the same amount as in 1910.

In recent years, the major factor changing the amount of cropland used was diversions from production by Federal farm programs (fig. 3). Cropland diverted under both annual and long-term programs accounted for as much as 20 percent of the U.S. cropland base since the 1950's. The peak acreage idled by Federal programs occurred in 1988 when 78 million acres were diverted from crop production. Of these, nearly 25 million acres were contracted into the 10-year Conservation Reserve Program (CRP), which had environmental improvement as a primary objective.

Underlying the relatively stable trend in total cropland are striking regional changes in the location of our cropland resources (see fig. 4).

Figure 4. Northern Plains, Rocky Mountain, and Corn Belt regions gained cropland from 1949 to 1987, while other regions lost.



The Corn Belt, Northern Plains, and Mountain farm production regions together gained 20 million acres of cropland while all other regions combined lost 34.3 million acres. Once again, cropland idled under Government farm programs has had an effect, since the regions that gained cropland are also the regions where the most cropland had previously been idled by Federal programs. In 1990, the Corn Belt, Northern Plains, and Mountain regions accounted for more than 60 percent of the acreage contracted into the CRP and over 50 percent of cropland idled by annual Federal crop programs.

Cropland and the Environment

At the margin, loss of cropland to urban development and other uses and development of "new" cropland from less intensive uses such as pasture, range, or woodland combine in a continuous process. During the export boom of the 1970's and early 1980's, however, development of new cropland from natural lands accelerated and became a focus of public concern. Concerns included direct loss of fragile grassland and wetland ecosystems and indirect effects, such as increased soil erosion and degraded water quality that resulted from farming these vulnerable lands.

Estimates from USDA's 1978 Landownership Survey showed that 9.1 million acres were converted to cropland during 1975 to 1977, of which 38 percent was in the Northern Plains, Southern Plains, and Mountain regions. Analysis of USDA's 1982 National Resources Inventory showed 11.1 million acres were converted to cropland during 1979-81, 37 percent of which were in the Plains and Mountain regions. Much of the land converted to cropland in the Plains and Mountain regions came from pasture and range, leading to the term "sodbusting" to describe this type of conversion.

Wetlands have been converted into cropland from the beginning of European settlement. Wetland drainage caused little concern in the past because of the vast extent of natural wetlands and the perception that drainage was "reclaiming" wastelands for productive uses. However, increased public awareness of the environmental value of wetlands prompted growing interest in preserving the wetlands that remained.

Inventories by the Fish and Wildlife Service in the U.S. Department of the Interior show that 13.8 million wetland acres were converted to other uses between 1954 and 1975, a rate of 458,000 acres per year. About 12 million acres (87 percent) were converted to agricultural uses, mostly cropland. Paralleling "sodbusting" in the Great Plains, wetland conversion for crop production was called "swampbusting."

As farm exports dropped off in the1980's and crop surpluses developed, Federal income tax incentives, farm commodity program benefits, and prospective land value increases began to provide greater impetus to land conversion than did market-driven demand. These Federal Government incentives appeared to be contributing to conversion of fragile grasslands and wetlands, creating economic and environmental problems that other Federal programs were designed to correct. Concerns about land use conversion ultimately led to policies aimed at greater consistency among Federal programs.

By the mid-1980's, Congress was ready to reduce Federal incentives for sodbusting and swampbusting. Most of these policy changes were included in omnibus farm legislation, the Food Security Act of 1985 (FSA), but other incentives were eliminated or reduced in the Tax Reform Act of 1986.

Conservation Provisions in 1985 and 1990 Farm Bills

The 1985 FSA's provisions concerning highly erodible land include the so-called "sodbuster" provision restricting farm program benefits for operators who converted highly erodible grassland to crop production after 1985, as well as conservation compliance provisions requiring conservation practices on highly erodible land converted to cropping before 1985. Both provisions prohibit receipt of USDA farm program benefits by any person who is producing an agricultural commodity on highly erodible land without following an approved conservation plan. Prohibited Government benefits include any type of price support, farm storage facility loans, Federal crop insurance, disaster payments, loans authorized by the Farmers Home Administration, and storage payments from the Commodity Credit Corporation. The main difference between sodbuster and conservation compliance is that producers converting fragile grasslands for production must meet more stringent erosion control goals than those farming land converted before 1985.

The 1985 FSA swampbuster provision prohibited many USDA program benefits for farmers who planted an agricultural commodity on wetlands converted to cropland after 1985. Recent changes enacted in the Food, Agriculture, Conservation, and Trade Act of 1990 closed a perceived loophole in swampbuster provisions by withholding benefits when wetlands are drained, whether a commodity is planted or not. In return, farmers are assessed smaller penalties for minor wetland conversions and have more flexibility to drain some land in return for restoring other wetlands.

The Conservation Reserve Program (CRP) offered positive incentives to landowners for voluntarily retiring highly erodible and environmentally sensitive cropland for 10 years. Farmers received annual rental payments and assistance with the costs of establishing permanent vegetation to protect the land. Almost 34 million acres were enrolled in CRP contracts by 1990. Most of the CRP land was planted to native or improved grasses, but nearly 2 million acres were planted to trees and over 400,000 acres of farmed wetlands were protected.

The Tax Reform Act of 1986, while not focused on environmental problems from land conversion, eliminated or reduced indirect incentives for conversion contained in the Internal Revenue Code. Preferential tax rates for capital gains were eliminated on all classes of property, including capital gains obtained by selling cropland developed from lower valued pasture, range, or forestland. Deductions for land improvement costs, including clearing and drainage, were eliminated. Deductions for soil and water conservation expenses were restricted to those approved in a Soil Conservation Service plan, eliminating many deductions for drainage and irrigation development costs for new cropland. Rules for tax treatment of passive investments were tightened, reducing opportunities to shelter nonfarm income through investments in cropland development.

Recent Trends in Land Conversion

Reduced market incentives and restrictions in farm and tax policy apparently resulted in less conversion of natural lands to cropland in the late 1980's. National Resources Inventory (NRI) data show that cropland increased by only 1.4 million acres between 1982 and 1987, down considerably from the 8.1 million acres gained between 1977 and 1982. Highly erodible cropland increased only 70,000 acres between 1982 and 1987, even before most of the cropland eventually enrolled in CRP was retired from production.

Comparison of 1982 and 1987 NRI data and new data from Fish and Wildlife Service inventories also shows that the rate of wetland loss in the 1980's was 200,000-280,000 acres per year, about half that recorded in 1954-75. As much as half of the loss in the 1980's was probably due to lake water level changes and loss of wetlands in coastal Louisiana, which are not due to cropland conversion.

The apparent success of programs designed to reduce artificial incentives for creating cropland from environmentally sensitive or valuable lands, coupled with reduced market incentives for conversion, is encouraging. We need to ensure that adequate amounts of cropland are available to meet domestic and world needs for food and fiber, while minimizing the sacrifice of important natural lands. ■

Agriculture That Fits the Environment: A Look Backward and Forward

2

by J. Douglas Helms, National Historian; Karl H. Reinhardt, Conservation Planning & Application Leader; and Gary A. Margheim, Deputy Chief, Programs, Soil Conservation Service, USDA, Washington, DC

The search continues for an agriculture that fits the land as well as maintains it. Public opinion polls increasingly identify the environment as a major public concern.

Through legislation passed by Congress and signed by the President, this concern has been translated into action affecting numerous aspects of life in the United States—including life on the farm. Within the past decade, laws such as the Food Security Act of 1985, the Clean Water Act amendments of 1987, and the Conservation Program Improvements Act of 1990 (part of the 1990 farm bill) called for modifications in programs and development of new ones in USDA. The intent of the new laws is to ensure that USDA's programs are compatible with our environmental objectives.

But, if we are to maintain environmental quality, we must have a mechanism and a source of knowledge to turn legislative intent into action on the land. Fortunately for the American public and American farmers, earlier concerns over soil and water conservation led to a system that helps producers farm efficiently while still meeting environmental objectives. Without the scientific research, the practical experience, and the development of institutions at the local, State, and Federal level, public concerns about the environment would be far more difficult to translate into action at the farm level.

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Looking Backward

New crops, new climates, virgin soils, and new social and governmental systems influenced agriculture. Conversely, agriculture influenced the environment. It was not long before perceptive people could recognize that the meshing of agriculture with the environment of North America was not completely harmonious.

During the 18th and 19th centuries, Americans borrowed and developed methods for soil conservation. Growing concerns in the 20th century led to the development of Government programs to help farmers use the soil while at the same time reducing erosion. Starting in 1929, USDA focused on research, setting up experiment stations to test methods of soil conservation.

The Soil Conservation Act of 1935 established the Soil Conservation Service (SCS) to work with farmers. With the encouragement of President Franklin D. Roosevelt and USDA, States passed laws to allow farmers to create conservation districts. Since 1937, farmers, ranchers, and other landowners have created nearly 3,000 conservation districts and, all along, the SCS has had trained soil conservationists working with these local conservation districts and the farmers. It is this system—the experience, knowledge of land and resources, familiarity with the local landowners, and governmental institutions—that makes it possible to shape on-farm management to meet national goals.

At the same time SCS was developing expertise in soil conservation, some developments in agriculture did not bode well for conservation. Part of the problem was the increasing specialization of agriculture. The mixture of cropland and livestock had allowed for many conservation techniques, such as using the steeper lands for pasture and hay, rotating crops, and interspersing close-growing crops into strip-cropping to retard runoff. But increasingly, American farms specialized in a few crops or in livestock.

USDA's commodity price support programs also affected soil erosion. For some time, people believed that some USDA programs had encouraged poor land use. In the 1930's, during a time of low prices for agricultural commodities, laws such as the Agricultural Adjustment Act of 1933 set up a system of price support payments to farmers. The payments were supposed to help maintain supplies and prices, thereby leveling out the peaks and valleys of prices and supplies of agricultural commodities. Fifty years later, critics of USDA programs held that these programs, including crop insurance, encouraged farmers to keep very erodible land in production. A larger issue involved fairness, and the feeling on the part of many that farmers should use methods that conserved resources if they were to receive financial assistance.

Recent Legislation

The National Environmental Policy Act of 1970 addressed some USDA programs, but by no means all of them. Partly impelled by concern over agriculture's impact on the environment, Congress passed the Soil and Water Resources Conservation Act of 1977 (RCA). The act mandated a continuing appraisal of the Nation's soil, water, and related resources. From this information, USDA was to develop a long-term National Resources Program.

The second National Conservation Program was issued in 1988 and set priorities through 1997. It calls for reduced erosion and improved water quality, and encourages State and local governments to assume additional responsibility in soil and water conservation. The results from the studies, debates, and pilot projects started under RCA found their way into national farm legislation, first in the 1981 farm bill, and to a much greater extent in the Food Security Act of 1985.

The Conservation Reserve Program is intended to remove highly erodible land from production by paying farmers an annual rental for 10 years under a contract. The conservation provisions of the 1985 farm bill required that farmers comply with these environmental objectives if they wished to continue to participate in certain other agricultural programs, such as commodity price supports, crop insurance, loans, and farm storage facility loans. Under the "Highly Erodible Land" provision, farmers had until 1990 to develop a conservation plan, approved by USDA and local conservation districts, and until 1995 to complete the implementation of the conservation plan.

Sodbuster, another part of the Highly Erodible Lands provision, was designed to discourage erodible land from being brought into production. If land had not been used for an annual crop during 1981-85, it could not be used for crop production unless acceptable conservation methods were used. The Swampbuster provision, officially titled "Wetland Conservation," was included to slow the conversion of wetlands to cropland. Farmers who converted wetland and produced agricultural commodities on it after December 23, 1985, the date of the act's passage, would be ineligible for certain USDA program benefits.

The Task of Making Laws Work

Within USDA, SCS has generally provided the technical assistance and advice while the Agricultural Stabilization and Conservation

Service (ASCS) has handled financial assistance.

Bringing the intent of the conservation provisions of the Food Security Act of 1985 from the halls of Congress to farm operations has required substantial work. This includes writing definitions, establishing rules and procedures, and giving the public time to offer opinions and suggestions.

The field staff in about 2,800 field offices has dealt directly with conservation districts and farmers. That work has kept SCS and ASCS busy during the past 5 years and will require most of the time of the SCS staff for the coming 4 years. After developing the criteria for defining highly erodible lands, SCS field staff identified the highly erodible land with soil surveys and field examinations. The agency accelerated soil surveys to areas not already covered by the published soil surveys.

SCS and other Federal agencies, especially the U.S. Fish and Wildlife Service of the Department of the Interior, took the definition of wetlands in the farm bill and developed criteria for identification in the field. In 1988, SCS started making inventories of wetlands. In some areas where wetland inventorying has progressed, especially in the pothole region of the North-Central States, many farmers have appealed the designation of some of their lands

An Oklahoma family running for shelter during a storm in the 1930's. The Dust Bowl is an example of how America's agriculture practices have not always been harmonious with the environment. *Arthur Rothstein/USDA CEN-170* as wetlands for purposes of the Food Security Act, and local SCS employees in those areas must review these appeals.

The 1985 law required that farmers have a conservation plan by January 1, 1990, and that they fully implement it by January 1, 1995, in order to stay eligible for a variety of USDA programs. The task for SCS field staff was to formulate 1.3 million plans covering 135 million acres. Farmers and SCS now face a greater task than writing plans—designing and installing, by 1995, all of the conservation practices that have been agreed to in the plans.

New Role for SCS

The work associated with the Food Security Act of 1985 created a new, unaccustomed role for the agency and the field staff. Previously, SCS worked strictly on a voluntary basis. Now SCS must make decisions about whether farmers are complying with the law. A vast majority of farmers participate in farm programs to some extent and are affected by the law.

One method used to reduce erosion has been to take erodible land out of production. As a requirement for participating in Government price support programs started in the 1930's, farmers often had to set aside lands on an annual basis. The Soil

Diversified land use provides for conservation in many ways. Stripcropping, crop rotation, and pastures on steep slopes retard runoff and erosion on this farm in Carroll County, MD.
Tim McCabe/USDA 0981X1234-32

Bank of the late 1950's and early 1960's promoted a longer term shifting of cropland to trees or grass through contracts. The general criticism of these programs has been that the purpose of the price support programs was to reduce crop acreage rather than to conserve soil. In the case of the Soil Bank, the program was not aimed at the most erodible land; farmers could sign contracts and enroll any land they chose.

Under the Conservation Reserve Program (CRP), only land determined to be highly erodible was eligible. From the time of the sixth signup under the CRP in 1988, the criteria have been changed at intervals to allow the entrance of filter strips, floodplain scour lands, and finally wetlands into the program. These lands, however, constitute only a very small fraction of the acres allowed. As of 1990, landowners have enrolled 34 million acres in the CRP. SCS also gives advice on planting methods used to establish grasses and then checks to ensure that the work has been done properly.

Impact on Water Quality

Another concern related to agriculture has been the impact of agriculture on water quality. Part of the concern involves the sediment in water caused by erosion. The use of irrigation can lead to salinity problems. Dairying or raising livestock in a small space, with many such operations concentrated within a watershed, can also cause water quality problems. One of the most complicated problems is determining the exact effect of agricultural chemicals such as nutrients and pesticides. While the first task is understanding the nature and the extent of the problem, there is then the challenge of devising practical remedial measures and getting landowners to use them.

One of the earliest efforts to understand the water quality problem came out of the Great Lakes Water Quality Agreement with Canada in 1972. In that agreement, USDA and the Canadians defined the problem and developed solutions.

During the 1970's USDA learned a great deal from the Rural Clean Water Program (RCWP), which included a number of pilot and demonstration projects. The projects tested the value of various methods as well as the feasibility of getting farmers to use them.

President George Bush's State of the Union message on February 9, 1989, included a major water quality initiative that pertained to the work of several agencies (see Chapter 12).

One of the most promising recent developments in water quality has been greater cooperation within USDA to give farmers advice on the use of agricultural chemicals at the same time that they receive advice on soil and water conservation measures.

Since the 1960's, entomologists in the Extension Service, State experiment stations, and Agricultural Research Service have worked on integrated pest management systems. One of the objectives of these systems is to reduce the amount of chemicals used in insect control. At the same time, agronomists in these agencies have developed ways to use chemical nutrients so that there will be little runoff into surface water or seepage into the ground water.

SCS has worked with the Extension Service to develop recommendations in SCS's technical guides, usually one for each county, that will include information about where and when these chemicals can be used effectively, but in a manner that keeps movement to ground and surface waters to a minimum. These same technical guides also provide the basic information on soil and water conservation measures. The promise is for a better environment through greater cooperation within USDA and, hence, greater service to farmers.

Looking Forward

Concern over the environment seems to be a constant and prominent feature on the political landscapes of both the recent past and the near future. Farmers and the State and Federal agencies with which they work will live in this climate of concern. But in a larger sense the recent legislation is part of a longer quest for agriculture that fits the environment, in which the impetus for adaptation is not a response to legislation but an acknowledgment of the forces of nature. ■

Conservation Tillage and Environmental Issues

3

by David L. Schertz, National Agronomist, Soil Conservation Service, USDA, Washington, DC

The research and development of conservation tillage began in the early 1930's in the United States but did not gain popularity until the mid-1960's. Land users began accepting this practice in order to reduce soil erosion and to save fuel, time, and money, and by they receive advice on soil and water conservation measures.

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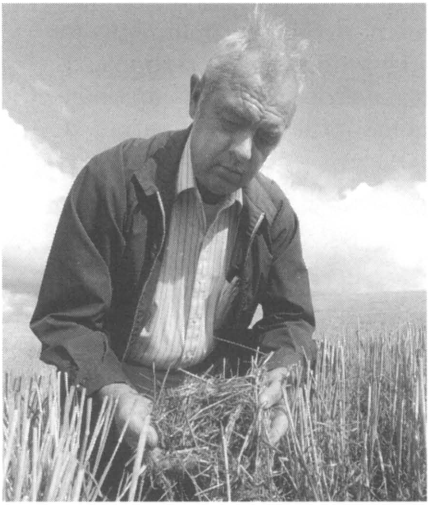
1990, 26 percent of U.S. crop acres used some form of conservation tillage. The farm bills of 1985 and 1990 are expected to increase the 73 million acres currently in conservation tillage to 140 million acres by 1995.

What Is Conservation Tillage?

The basic principal of conservation tillage is to leave sufficient crop residue on the soil surface to significantly reduce soil erosion. More specifically, where water erosion is the primary concern, a farmer can meet the minimum requirement of conservation tillage by leaving 30 percent or more of the soil surface covered by crop residue.

Where wind erosion is the primary concern, conservation tillage requires that approximately 1,000 pounds of small grain residue equivalent be left on the soil surface during the critical wind erosion period. Leaving residue cover after harvest is the beginning of conservation tillage, but tillage operations in the spring often reduce residue to less than the amount required.



Soil Scientist Robert Papendick inspects straw from the previous wheat crop near Pullman, WA. The straw acts as mulch to hold soil in place and retain moisture.
Tim McCabe/USDA 1085X1186-2A

Conservation tillage includes no-till, ridge-till, and mulch-till. "No-till" means planting a crop in the undisturbed residue of an old crop; "ridge-till" means planting a crop in ridges that were developed during the growing season by cultivation and left undisturbed since harvest; and "mulch-till" is planting a crop where the total surface has been disturbed but at least the minimum required residue remains after planting. Also, where conservation tillage is used, many fields will have more than the minimum residue requirement—reducing erosion even more.

Conservation Tillage Concerns

Conservation tillage has not been without its critics. Some assume that additional pesticides, especially herbicides, must be used in order to obtain weed control similar to that of conventional tillage, resulting in increased surface and ground water contamination. Some believe that weed control is more difficult, crop yields may be reduced, or more expensive equipment will be required with conservation tillage. Researchers have shown that these concerns are basically without merit.

One of the first concerns was that conservation tillage would reduce yields. However, conservation tillage has never been recommended for use on all cropland acres in the United States. By tailoring conservation tillage systems to site-specific conditions, crop yields do not decrease compared to conventional tillage; in fact, they may increase. Even if crop yields are equal, the reduction in tillage trips and savings in time will likely yield a higher net profit.

The concern that conservation tillage requires the use of pesticides, especially herbicides, can be answered by reminding those concerned that pesticides, especially herbicides, are used each year on the vast majority of the planted acres in the United States. Since only 26 percent of U.S. crops are grown under some form of conservation tillage, pesticides clearly are used on tillage systems other than conservation tillage. In fact, the majority of pesticides are applied on conventionally tilled acres.

Another concern is that conservation tillage requires the use of more pesticides than does conventional tillage. Some first-time users of conservation tillage may use more pesticides than they used under conventional tillage, but such a practice is often the result of an unfounded fear of poorer weed control or the use of a chemical burndown–which is not generally used in conventional tillage. When herbicide amounts are increased in the first few years of conservation tillage, they are often reduced as the land user becomes more familiar with the tillage system. Since herbicide incorporation is often limited in certain types of conservation tillage, the most common scenario is that the producer will change the pesticide type or the timing of

Soybeans growing in corn residue in a no-till system of farming on a Jackson County, IA, farm. The residue helps retain water and reduces soil erosion.
Gene Alexander/USDA IA-2853

application, rather than increasing the amount of pesticide.

After experience has been gained with the system, it is not uncommon for those practicing conservation tillage to report using less total pesticides than those practicing conventional tillage. The complexity of site-specific conditions makes it impossible to generalize and say there is "more" or "less" pesticide used with either system. Pesticides are an added expense, so excess applications of them are carefully considered before use in either conservation or conventional tillage systems.

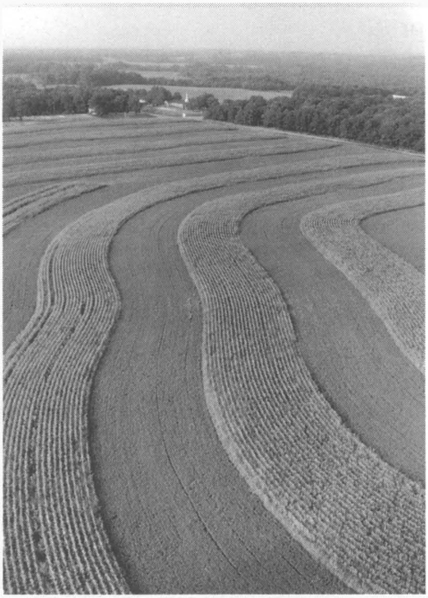
Effects on Water Quality

Many feel that conservation tillage increases the potential for surface and ground water contamination, primarily because of the assumed increase in the use of pesticides and application of pesticides and plant nutrients on the surface without incorporation in the soil, or with very little incorporation.

Incorporating agricultural chemicals reduces the chance of chemical runoff by surface flow. Incorporation requires additional tillage trips and buries more surface residue, thereby increasing the chance of greater soil erosion. If rainfall does not occur immediately following application, the chance for surface runoff of agricultural chemicals applied on the surface is greatly reduced.

Some chemicals applied to the surface, such as paraquat, are immediately tied up with clay and organic soil fractions and move off-site only as soil is eroded. In addition, postemergent herbicides (used in both conventional and conservation tillage) are applied to the plant foliage with very little contacting the soil surface. These types of chemicals pose little threat to surface or ground water.

The effects of macropores on soil-water movement in the soil profile, which develop under no-till, are hard for researchers to describe. The results to date of research related to the effect of



An aerial view of stripcropping in South Carolina. Practices such as contouring, terracing, stripcropping, and use of grassed waterways are often used in combination with conservation tillage. *Tim McCabe/USDA 91BW0333* macropores on ground water contamination are mixed, but work is continuing. Soils farmed with conservation tillage generally have increased soil organic matter in the upper few centimeters of the surface, especially with no-till, which results in increased biological activity that tends to tie up pesticides longer. This generally has the effect of reducing the half-life of pesticides, breaking them down faster than under conventional tillage. Pesticide solubility and soil permeability are very important considerations when planning pesticide application, especially where macropore formation is likely to occur.

In the concern over formation of macropores under no-till and the potential to facilitate the movement of soil water deeper through the profile, the beneficial effect occurring on the soil surface is often overlooked. All types of conservation tillage, especially no-till, leave significant amounts of crop residue on the soil surface after planting. This practice reduces runoff and soil erosion and decreases the potential for surface runoff of agricultural chemicals, compared with conventional tillage. Reduced soil erosion means less sediment entering lakes and streams.

The best way to curb soil erosion is through the use of permanent vegetative cover. Where row crops are grown, however, other conservation measures must be used. Conservation tillage is not a panacea for controlling erosion, but the practice warrants serious consideration when planning erosion control systems because of its effectiveness in reducing erosion. Other practices, such as contouring, terracing, stripcropping, and grassed waterways, are often used in combination with conservation tillage.

Recent advances in herbicides have resulted in dramatically reduced amounts of active ingredients per acre. Improved post-emergent herbicides permit land users to target application only on those areas that are infested, resulting in less total amount applied compared to full-field coverage of a pre-emergent residual herbicide.

Pesticide use will of course vary from year to year depending on factors such as tillage type, crop grown, weather, and the particular pest problem that is present or anticipated. Wherever pesticides are used, however, they should be used judiciously and prudently, regardless of tillage type. Pesticides should always be applied by trained individuals who have a good understanding of the pesticides they are applying and the purpose for which they are being applied.

Conservation tillage technology will endure because it reduces erosion and cuts costs. Technological advances in tillage, planting equipment, and pesticides have been dramatic over the past two decades and should continue into the future. Many believe that growing crops using conservation tillage is more sustainable on sloping cropland than a conventional moldboard plow system that buries the protective crop residue and leaves the soil surface vulnerable to severe soil erosion. ■

How Research Improves Land Management

4

by L.D. Meyer, Agricultural Engineer, National Sedimentation Laboratory, ARS, USDA, Oxford, MS; and K.G. Renard, Hydraulic Engineer, Aridland Watershed Management Research Unit, ARS, USDA, Tucson, AZ

Productive soil is one of our Nation's greatest natural resources, so maintaining land productivity and preventing environmental degradation from soil erosion are high-priority national goals. A century ago, essentially no soil conservation research was conducted in the United States; today America is the world leader. During the same period, American farming methods have changed tremendously, and soil erosion problems have expanded and intensified. The part that research has played in improving management of our billion acres of productive land is an important part of our agricultural history.

Rainfall and Erosion

Another key resource that makes land productive is rainfall. Between 100 million and 1 billion gallons of rain fall annually on each square mile of U.S. land. This water is essential for crop production, but it may also cause problems such as soil erosion and flooding.

Rain falls as drops averaging less than one-eighth inch in diameter, but each drop strikes the land as a tiny bomb. Every year throughout most of the United States, more than a quadrillion (1,000,000,000,000,000) drops strike each square mile of land with the impact energy of thousands of tons of TNT. The impact energy of rain falling on the State of Mississippi, for example, annually equals the energy of a thousand 1-megaton bombs or 1 billion tons of TNT.

When raindrops fall on unprotected soil, they start the erosion ing equipment, and pesticides have been dramatic over the past two decades and should continue into the future. Many believe that growing crops using conservation tillage is more sustainable on sloping cropland than a conventional moldboard plow system that buries the protective crop residue and leaves the soil surface vulnerable to severe soil erosion. ■

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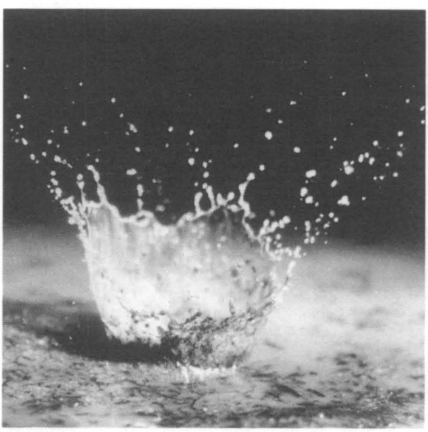
When raindrops fall on unprotected soil, they start the erosion process. These drops detach soil that is then transported downslope by runoff, the rainfall excess that is not absorbed by the soil. Not only does this runoff carry raindrop-detached soil and cause additional erosion itself, but the water is lost to crop production. Runoff from fields and forests to streams and rivers in Mississippi, for instance, averages nearly 20 trillion gallons annually.

Wind Erosion

Although the major erosion problem in most parts of the United States (and the focus of this chapter) is erosion caused by rainstorms, wind erosion is also a serious hazard. Wind erosion results from strong winds blowing across inadequately protected soil, and it usually is worst during droughty conditions. The famous Dust Bowl of the Great Plains during the 1930's was a period of unusually severe wind erosion.



Each drop of rain strikes like a tiny bomb. Every year in the United States, more than a quadrillion raindrops strike each square mile of land with the impact energy of thousands of tons of dynamite. *USDA 91BW0679*

Erosion Research

In the 1930's, the Nation's rapidly deteriorating land resources—and the highly conspicuous Dust Bowl—prompted the Federal Government to launch a major soil conservation research effort. Its purpose was to learn more about how rainfall, runoff, and wind affect erosion in the United States. This research has been largely supported by Federal and State funds through USDA and State agricultural experiment stations.

The primary concern during the early years of research was the consequences of excessive soil erosion on crop yields. By the end of the 1930's, research data plus farmers' experiences showed conclusively that excessive erosion seriously reduces productivity, so researchers proceeded to evaluate erosion rates for typical land use situations and to develop erosion control technology.

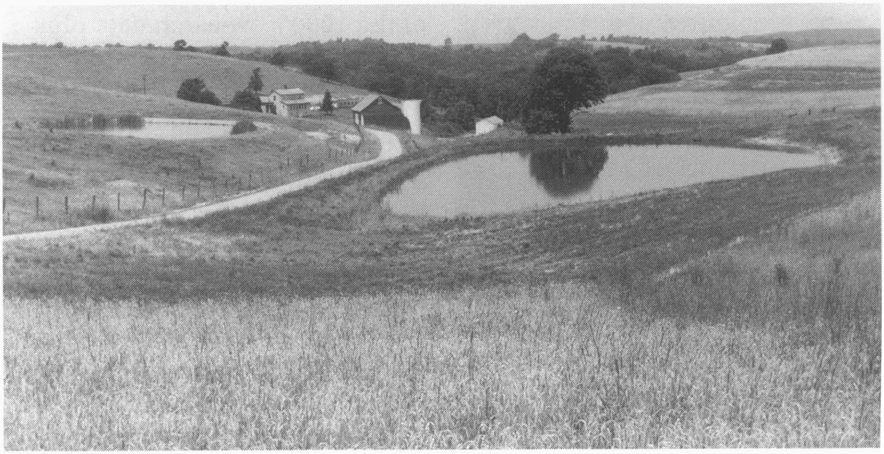
During the 1940's and 1950's, measurements of different agricultural conditions identified those that permitted serious erosion and those that were effective in conserving soil. Erosion-control practices such as terracing, stripcropping, year-round vegetative cover, and windbreaks were developed to fit farming procedures and equipment. Other research was directed toward predicting erosion rates for specific soil, topography, cropping system, and climatic conditions of individual fields. These efforts culminated in development of the USLE (Universal Soil Loss Equation) and the WEE (Wind Erosion Equation). Both were developed by scientists with USDA's Agricultural Research Service (ARS) and Soil Conservation Service (SCS), the USLE in cooperation with Purdue University and the WEE with Kansas State University.

USLE, RUSLE, and WEE

The USLE and its recent revision (RUSLE) quantify annual soil loss as the product of six factors that represent the following:

- Rainfall/runoff erosiveness
- Soil erodibility
- Slope length
- Slope steepness
- Cropping and management practices
- Supporting conservation practices

Generally, USLE values show that a year of rainstorms in the Southeastern United States totals twice the erosiveness of those in the Midwest. High silt soils with low organic matter are 50 percent more erodible than those with high organic matter and twice as erodible as soils with high clay or sand content. Fields of 7-percent slope have twice the erosion of fields with 4-percent slope, and 11-percent slopes have four times



An increased understanding of fundamental soil erosion principles and processes can help in selecting effective soil conservation practices, as on this farm near Philadelphia, OH. The pond catches runoff from the land above and helps protect the land below from serious soil erosion.
Erwin Cole/USDA OH-60961

the erosion of 4-percent slopes. And no-till corn has only half the erosion of no-till soybean and one-fourth that of conventionally tilled corn.

By selecting appropriate USLE/RUSLE values for specific situations, conservation planners can recommend production methods for individual fields that limit soil losses to rates that maintain productive potential of the land indefinitely.

Similarly, the WEE predicts wind erosion rates as the function of five factors that represent the following:

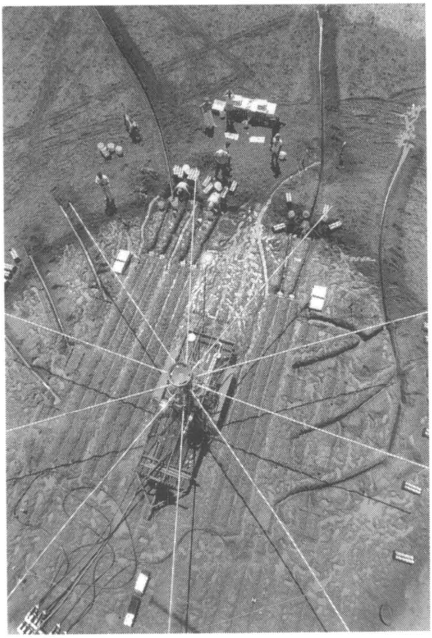
- Soil erodibility
- Soil ridge roughness
- Climate
- Field length
- Vegetative cover

Since the USLE and WEE were first introduced, their systematic approach has had a tremendous effect on erosion technology and conservation planning. Their equations and adaptations of them are used worldwide.

Understanding Erosion

During the 1960's and 1970's, scientists emphasized fundamental research designed to better understand the principles and processes of soil erosion by water and wind. They analyzed and quantified the companion but very different processes of raindrop-caused erosion and runoff-caused erosion. The aerodynamics of wind in relation to soil detachment and transport were defined.

The effects of different types of plant cover, tillage, and cropping systems were evaluated on erosion plots and watersheds, using rainfall simulators and wind tunnels. Various types of conservation tillage were developed, evaluated, and found to greatly reduce both water and wind erosion from land during intensive cropping. Scientists also identified and quantified soil and sediment characteristics that affect erosion rates and sediment pollution potential.



Using a rainfall simulator, ARS scientists conduct erosion research by collecting and analyzing the runoff.
Tim McCabe/USDA 0887X0840-33

Model Development

During the 1980's, the knowledge gained from past experiments and fundamental studies provided the basis for developing mathematical models to describe erosion over a wide range of specific conditions and to improve erosion prediction and control methods. About the same time, the environmental movement gave impetus to an expanded research effort to understand off-site effects of soil erosion and the potential for chemical pollution resulting from it. Models such as CREAMS (Chemicals, Runoff, and Erosion from Agricultural Management Systems) were formulated, which included hydrologic, erosion, pesticide, and nutrient components. Such models incorporated major advances in describing the physical processes involved in soil erosion, sediment transport and deposition, and chemical transport.

Most recently, the WEPP (Water Erosion Prediction Project) model has been developed by ARS, SCS, the FS, the Department of the Interior's Bureau of Land Management, and cooperating universities as the next-generation water-erosion prediction model to replace the USLE/RUSLE. The more versatile WEPP model incorporates many of the scientific advances that have been made since development of the USLE and is based on the principles and processes of soil erosion by water.

A similar effort by ARS, SCS, and university cooperators is underway to improve the predictive capability for wind erosion, culminating in the WEPS (Wind Erosion Prediction System) model. This model is based on the fundamental principles of wind erosion physics associated with climate, soil, topography, and cropping/management systems that affect sediment detachment, transport, and deposition.

Soil Conservation Practices

An increased understanding of fundamental soil erosion principles and processes also helps in selecting effective soil conservation practices for specific land conditions. Effective erosion control involves the following:

- Dissipating raindrop, runoff, and wind-induced erosive forces on nonerodible materials rather than erodible soil
- Reducing the amount of runoff
- Slowing runoff or wind velocities
- Improving soil characteristics that resist the erosive forces
- Preventing massive gully and channel erosion
- Decreasing wind access to barren soil

By identifying the processes that are causing the primary erosion hazards, the best individual management practice or combination of practices (BMP's) may be selected for a particular situation.

Cropland Erosion Control

For conditions where serious erosion is due primarily to raindrop impact or intense winds, protection of the soil surface by plant residue mulches or growing vegetation can be very effective. Keeping the soil covered during periods of critical erosion hazards is especially important, so minimizing tillage and using cropping systems that disturb land only during those times of the year when major rainstorms or windstorms are uncommon should be emphasized. Use of close-growing vegetation or narrower crop rows instead of wide-row crops may also help reduce erosion.

On land where the topography and cropping system are susceptible to serious erosion by concentrated runoff, runoff reduction and management deserve high priority. Practices such as dense vegetation and plant residues that reduce soil surface sealing and increase infiltration will be very effective in reducing runoff. Runoff management can be achieved by routing runoff around the slope at nonerosive velocities using practices such as terraces and row-grade control. When runoff is so great that it cannot be managed in this way, detention structures and/or vegetated waterways are effective.

Erosion from soils that erode as very fine sediment is very difficult to control once the soil is detached. Therefore, vegetation and mulches that provide good soil cover to prevent soil detachment are most effective. In contrast, coarse-textured sediment can be more easily trapped by vegetation, rough-tilled land, contoured rows, terraces, or detention structures. Even with coarse-textured soils, preventing detachment by soil cover is still the most desirable practice, but these sediment-trapping practices will also help prevent major losses.

Soil losses from land with steep or long slopes are difficult to control once the soil has been detached, so maintenance of good soil cover to prevent raindrop and runoff erosion is very important. In contrast, soil losses from land with relatively flat slopes can often be reduced by management practices, such as dense vegetation and graded rows, which slow or store surface runoff.

Effective conservation practices for land subject to wind erosion include vegetative cover (especially stubble from the previous crop), windbreaks and wind barriers, rough and cloddy soil surfaces, and tillage perpendicular to the prevailing wind direction.

Other Erosion Problems

Although reduced productivity is the most widespread consequence of excessive erosion, soil conservation research is not limited to hazards caused by rainstorms or windstorms on cropland. Research is also underway on rangelands, where precipitation is often inadequate for maintaining sufficient vegetation to protect against wind and water erosion losses of the limited soil research sources. Other studies concern erosion from irrigation of sloping fields, on forest lands, and on nonagricultural land such as urban areas, construction sites, highway slopes, and surface-mined land.

Farming Changes and Research on New Problems

Agricultural production methods have changed tremendously since the days of the horse-drawn plow, and many of these changes have increased erosion hazards. Today's heavy mechanized equipment compacts soil and reduces infiltration. Large implements work best on long fields devoid of conservation practices that would hinder their operation, and they operate better when troublesome surface residues have been removed or buried. Absence of horses and other animals on many farms means that hay is no longer needed, so continuous row crops are grown where rotations and pastures once grew. Yet intensive use of agricultural land is necessary because American agriculture is feeding several times more people today than at the beginning of the 20th century.

Research has demonstrated that cropping practices such as conservation tillage (see Chapter 3) can enable farmers to use modern farming methods and still control erosion. However, increased residues and pest accumulations present with conservation tillage require increased use of agricultural pesticides, an environmental tradeoff. Many cropping systems and supporting practices that benefit soil conservation are not considered economically feasible for today's farming situations.

Researchers have shown that crop production can continue without excessive soil losses on much of our Nation's erodible land if farmers adopt conservation cropping systems and properly manage their soil and water resources. However, because of circumstances that are often beyond farmers' control, only small reductions in wind and water erosion have come about in recent decades. Current research is focusing on developing conservation practices that are compatible with current agricultural methods; that enable farmers to make a reasonable profit; and that control soil losses, runoff, and other environmental hazards.

Soil erosion annually produces several billion tons of sediment from U.S. land. Such sediment has always been and continues to be, by volume, our Nation's greatest pollutant. Past erosion has caused major losses of our Nation's soil resources, but consider "what might have been" if we had not developed a land stewardship ethic and embarked on a soil conservation research effort early in this century.

The examples given show that soil conservation research during the past half century has produced a good understanding of the complex soil erosion process and provided effective technology to predict and control soil erosion. These advances were accomplished through the efforts of dedicated Federal and State researchers and action agency specialists. Because of their expertise, the last several generations have experienced remarkable developments in soil conservation technology. Erosion prediction and control methods are now available for most soil, topographic, and rainfall situations, and even better technology promises to emerge from current studies. Certainly, soil and water conservation research must be an important component of all future efforts to conserve our productive soil resources, prevent damage from eroded sediment, and maintain environmental quality. ■

Soil Changes and New Ways To Monitor Them

5

by Richard W. Arnold, Director, Soil Survey Division, Soil Conservation Service, USDA, Washington, DC

What Are Soils?

Thousands of soils join to form the pedosphere, the thin outer covering of the surface of the Earth. Soils share the surface layer of the Earth with plants, animals, and people. Soils are protective living geomembranes through which energy, nutrients, and water pass as they nourish land-based life.

Soils are the product of ecosystems and a recorder of our Earth's history. By monitoring soil processes, we can detect patterns and relationships significant to our understanding of ecosystems and the environments in which they exist.

Soil Processes

Ecosystems can be visualized as dynamic segments of the environment, involving the biology of plants, animals, and microorganisms; the chemistry and has caused major losses of our Nation's soil resources, but consider "what might have been" if we had not developed a land stewardship ethic and embarked on a soil conservation research effort early in this century.

The examples given show that soil conservation research during the past half century has produced a good understanding of the complex soil erosion process and provided effective technology to predict and control soil erosion. These advances were accomplished through the efforts of dedicated Federal and State researchers and action agency specialists. Because of their expertise, the last several generations have experienced remarkable developments in soil conservation technology. Erosion prediction and control methods are now available for most soil, topographic, and rainfall situations, and even better technology promises to emerge from current studies. Certainly, soil and water conservation research must be an important component of all future efforts to conserve our productive soil resources, prevent damage from eroded sediment, and maintain environmental quality. ■

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Soil Processes

Ecosystems can be visualized as dynamic segments of the environment, involving the biology of plants, animals, and microorganisms; the chemistry and physics of moisture, heat, wind, and solar radiation; and the geology and hydrology of surface materials in a landscape.

As time proceeds, orderly changes take place both in the succession of plants and animals and in the flow of energy at relatively undisturbed sites. The exchanges of energy, water, and organic matter in the earthy substrata also produce changes. Many of the subsurface modifications are fairly systematic and the resulting set of properties is recognized as a specific kind of soil.

Climate, parent material, topography, living organisms, and time are the factors of soil formation in soil science. Soils are complex physical, chemical, and biological entities. The biological activities are influenced by climate, and together they interact with earthy materials in a landscape over time. Each factor modifies the processes of the weathering of minerals, of transport and deposition of compounds and particles, and of growth and productivity of plants and animals. Fertility is the most important inherent characteristic of soils.

Soil processes and the properties associated with them have "characteristic response times." The gaseous phase in soils changes fairly quickly, from minutes to weeks; the response times of the liquid phase are from days to months; the changes in living aspects of the soil ecosystem take place over months to centuries; and the characteristic response times to change in the mineral and organic solid phases

The corn in this field demonstrates that soil differences can cause variations in crop quality.
USDA 91BW0655

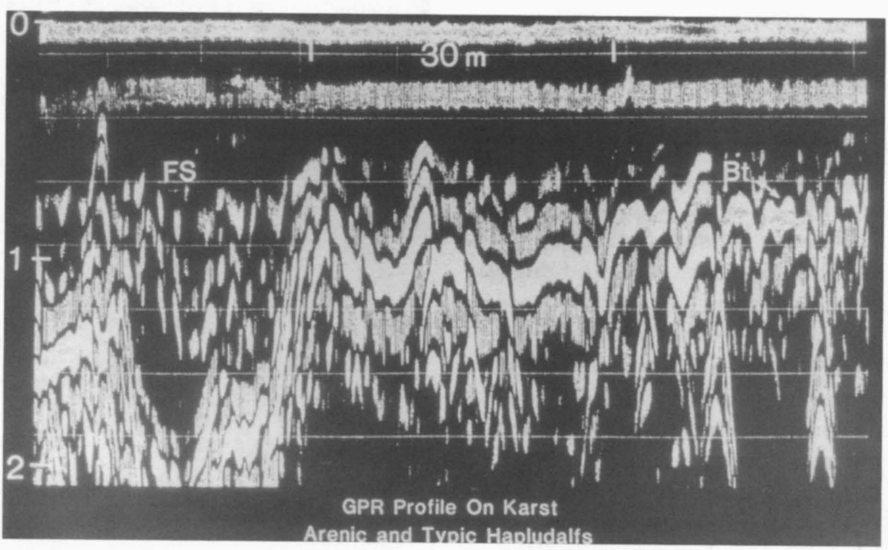
are years to millions of years. The changes of the environment that concern most of us are those that commonly occur in decades or less.

The cultivation of soils for cropping alters many surface features of soils—plowing and disking disturb the soil structure and heavy machinery packs the particles together and reduces the pore space and the infiltration rates.

Throughout a growing season, microbial populations respond to changes of soil temperature and moisture. As fertilizers and manures are added, changes in soil chemistry cause fluctuations in acidity, nutrient status, and the composition of soil solutions. Both time and space influence the soil processes, thus producing soil variability that is observable on the ground.

Many recurring changes in soils are related to cyclic or seasonal variations of temperature, light, water, and vegetation. The daily fluctuation of soil temperature and seasonal changes in acidity, organic matter, and available nutrients associated with plant growth are well documented.

Trends in soil changes indicate a general direction—accumulation, reduction, or steady state. It is common for short-term fluctuations to be combined with longer



Ground penetrating radar (GPR) is a nondestructive technology that sends passive radar waves into the soil and records their reflections. This type of monitoring produces substrata spacial patterns, which can then be interpreted.
USDA 91BW0657

term trends, making their separation somewhat difficult. Because some periodic and random fluctuations are wider than those of most trends, the determination of trends requires special sampling, accurate trend analyses, and reliable processing techniques.

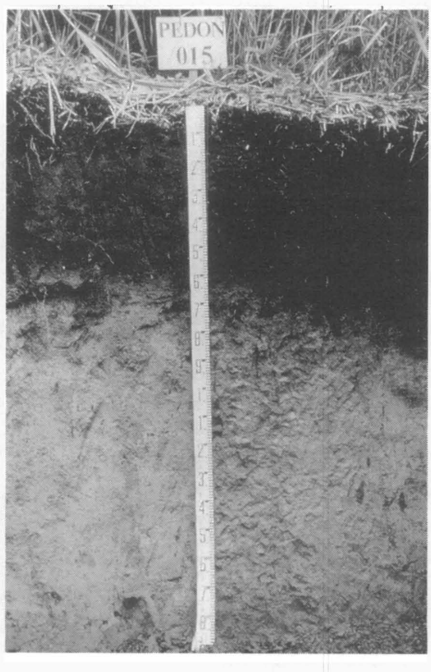
With the accumulation trends of change, the deposition of solid phase material is equal to or greater than the rates of weathering, soil formation, and evolution. Alluvial valleys with frequent floods that deposit sediments and areas of ashfall near active volcanoes are examples of cumulative environments. Degradational trends of soil change erosion occurs faster than weathering and soil formation, and soils cannot attain their most mature stage.

Monitoring the Environment

Technological advances in equipment permit scientists to measure small and large events more quickly.

Remote sensors carried in satellites capture reflected energy from the surface of the Earth. Through innovative interpretation, the signals are associated with patterns of vegetation, water, cities, and other objects. Computers assist in unraveling the confusing noise in the signals so that kinds of vegetation can be identified and measured with acceptable accuracy. Ecosystems, both natural and agricultural, are recognizable and can be mapped as separate entities. This means that changes can also be detected. Degradation and erosion of soils cause reduction of productivity and expose bare soils. Current satellite technology permits drought, floods, and harvesting of crops to be monitored within days of the event.

Ground penetrating radar (GPR) is a nondestructive technology that sends passive radar waves into the soil and records their reflections. GPR has been used to detect solution channels in limestone several meters below the surface. Continuous transects



This soil profile shows the humus and clay subsoil layers.
USDA 91BW0656

of clay-enriched subsoils and the thickness of organic peats have also been recorded. This type of monitoring is interpreted as substrata spatial patterns.

Soil moisture depends on recent events, the weather, the nature of the soil, and the type and physiology of vegetation. Tubes placed in the ground that permit fluctuations of a water table to be observed and measured are called piezometers. Other instruments called tensiometers enable the changes in moisture content to be measured. Neutron access tubes enable emissions from a radioactive source to spread out in a small soil volume; then the attenuation of the rate of movement is recorded and translated into moisture content. Models of crop production and even patterns of global climate change depend on reliable estimates of soil moisture in time and space.

The Soil Conservation Service SNOTEL program monitors snow pack and collects information from remote sites to assist in forecasting water supplies in the Western States. The data are transmitted up to a layer where small meteors break up and the waves bounce back to a receiving station. A new venture will expand the network and collect soil moisture and soil temperature at many remote sites. ■

Marketing Conservation in a Changing Age

6

by Frank B. Clearfield, National Sociologist, Soil Conservation Service, Washington, DC; Louis E. Swanson, Associate Professor, John Hannum, Research Associate, and Kim Fendley, Research Associate, Department of Rural Sociology, University of Kentucky, Lexington, KY

Conservation programs have historically operated on a "first-come, first-served" voluntary basis. However, Federal legislation passed in 1985 and 1990 has changed agricultural conservation programs from voluntary to "quasi-regulatory." This means that farmers can now lose USDA program benefits if they convert wetlands, or if they do not install approved conservation systems on "highly erodible land," regardless of whether those fields had crops grown on them previously.

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Marketing Conservation in a Changing Age

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In order to encourage farmers to implement conservation measures required as a result of these laws, the Soil Conservation Service (SCS) has developed a "marketing manual," called *A Guide for Outreach: Marketing Procedures for Field Offices*, for SCS and Soil and Water Conservation District field office personnel.

SCS will use marketing techniques used by the private sector, such as "market segmentation," or techniques to cater to the specific needs of different groups of clients. For example, SCS advisors will present part-time farmers with information on conservation measures that take a minimal amount of time to manage, and they will provide information on installing low-cost conservation measures to low-income farmers. Some marketing efforts can be as simple as these examples, while others can be more complicated because of multiple ownership, inadequate management skills, and out-of-county absentee owners.

This chapter discusses changes in public attitudes and refinements in science and technology related to conservation; it then describes the research methods and findings on which the marketing effort is based, and offers some general recommendations for working effectively with land users.

Changing Attitudes

During the last two decades, the age of environmental innocence seems to have given way to an era of environmental awareness. Agriculture has also become environmental news due to such issues as chemical residue in apples, ground water and surface water problems, and fish kills. The links between agriculture and the environment have not always been as susceptible to criticism as they are today.

The agricultural industry is now more competitive, more fractured, and more chemically dependent than before. Large agricultural producers rely on state-of-the-art technology and equipment, while most producers use modern agrichemicals. The public now believes agriculture is contributing to pollution. It's not just a matter of losing a few tons of topsoil to a reservoir, it's the possibility of chemical residue in our food and drinking water. The public is also concerned with the loss of wildlife habitat and wetlands due to any reason, including agriculture.

Technologies To Help Our Environment

Science and technology, through their applications, are partly responsible for contributing to environmental problems. They also enable us to understand these problems, and perhaps technology can also help us solve problems. Technology refers to tools we use in our daily activities—such as tractors or chemicals. Decisions to create or use these tools are affected by changing markets as well as social and economic activities or events.

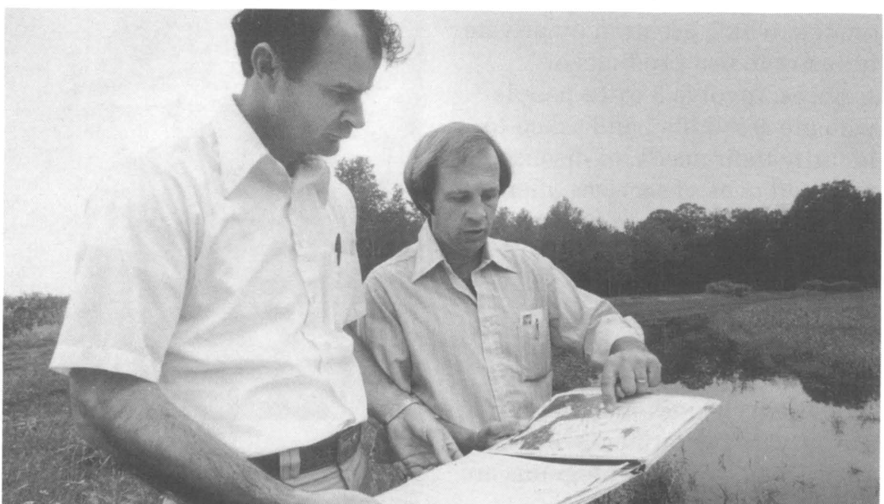
Although there are no universal solutions, some agricultural production systems have positive or neutral environmental effects. Newer technologies—including residue management, Integrated Pest Management, drip irrigation, tail water recycling, laser leveling, snow surveys, computerized weather stations, controlled outlets for drainage systems, and soil moisture meters—can balance environmental protection with economic realities. (See Part IV for more information on new technologies.)

Other conservation measures that have been around for a longer time—such as wind breaks, cover crops, rotations, grass waterways, stripcropping, terraces, and contouring—prevent damage to the environment by controlling soil erosion.

By blending older and newer conservation systems, producers may maintain production without upsetting the ecosystem. Offering producers environmentally safe alternatives, as well as reasonable profit levels, is an overriding challenge for conservation organizations.

Research

SCS is trying to better understand how the 1985 and 1990 farm bills may affect the adoption of conservation systems. To that end, the



District Conservationist Ralph Timmons (right) and Hugh Galbreath, manager of Remington Farms, review a conservation plan for the farm. Remington Farms is a wildlife management demonstration farm in Queen Annes County, MD. SCS district field office personnel provide effective methods to implement conservation programs.
Tim McCabe/USDA MD-30592

agency is working with the University of Kentucky to analyze landowners' responses to proposals for environmentally beneficial farming. The goal of this collaboration is to develop a manual that SCS and conservation district field office personnel can use to provide effective methods to implement the previous two farm bills and to market SCS services to agricultural producers. The idea is simple: Find out what farmers want, and assess the best way of getting it to them.

This study gathered information by conducting focus group meetings with farmers and separate focus group meetings with SCS personnel in six States (New Jersey, Texas, California, Kentucky, Iowa, and Arizona). Focus groups, which are used by private industry to test products or services, involve 8 to 12 people who are assembled and asked to identify their needs, to discuss the pros and cons of services offered, and to suggest how to improve services.

Findings

Findings from the focus groups indicate there have been many wholesale changes in agriculture recently. Many farmers who participate in USDA programs are dissatisfied with the quasi-regulatory situation that has resulted from the 1985 and 1990 farm bills. Some farmers feel they are unfairly being singled out for some of the Nation's environmental problems through these bills.

Agricultural producers observe that the 1985 and 1990 farm bills have changed relationships between agricultural producers and SCS personnel. Both producers and SCS personnel recognize that SCS technical specialists do not have the time to provide one-on-one technical assistance to producers. Producers also feel pressure to implement conservation systems that pose economic risks.

Electronics Engineer James McKinnon (right) and Frank Mitchner, a Mississippi cotton farmer, review information from an automated weather station. The station feeds daily weather information into Mitchner's farm computer to update predictions for cotton yield and harvest dates.
Tim McCabe/USDA 0786X0791-28

Farmers' sense of risk can include both social and economic elements, and both can be extremely important. Farmers may avoid the risk of changing from their traditional farming practices. The *perception* of economic risk can be a huge factor in whether a producer implements conservation compliance plans, regardless of the fact that producers agreed to install these systems prior to January 1, 1990. Upfront costs of installing some practices will undoubtedly increase concern about returns, and potential yield reductions will add further uncertainty to a capricious market.

The focus group meetings with farmers yielded other interesting information. Most farmers now farm part time. Institutional owners, such as banks, are complying with the 1985 farm bill. Urbanization and the loss of prime farm land are becoming more typical, especially on the east and west coasts. Hobby farmers, small ranchers, and specialized fruit and vegetable producers do not participate in USDA farm programs; therefore, the 1985 and 1990 farm bills will not directly affect most of them. However, urban encroachment into farming areas and the awareness of potential environmental damage from agriculture have led urban populations to favor additional environmental legislation. Thus, even if Federal laws do not apply, this small farm segment may soon be affected by State laws.

In addition to agricultural producers and the general public, a number of other client groups—such as developers, town planners, homeowners, government agencies, and "resource poor" and minority farmers—all need technical assistance that ensures that the environment is protected.

Farmers clearly recognize that the old rural power base is eroded and they have less political clout; at the same time, environmental groups are more politically powerful, so more State environmental laws will likely be passed in less populated States, as the population base associated with agriculture decreases.

To ensure compliance with the 1985 and 1990 farm bill provisions, SCS and the conservation districts will provide technical assistance to agricultural producers. In the past, providing technical assistance through a voluntary approach did not depend as heavily on human relations skills; however, since some producers are unhappy with the conservation compliance feature of these farm bills, these human relations and communication skills are essential today.

Recommendations

A general recommendation from the focus groups is that greater flexibility be given to local conservation districts for achieving conservation goals. The groups also agreed that environmental groups and the public are becoming closely involved in agriculture-related environmental decisions. Consequently, new institutional partnerships need to be formed and the public needs to be educated to ensure the passage of reasonable legislation.

In a quasi-regulatory environment, the potential for conflict is greater, overcoming community and social traditions is important, and dealing with perceptions of risk is crucial. Thus, conservationists' human relations skills are more important in implementing new legislative initiatives. Conservation organizations that hired employees based solely on technical capabilities may need to provide guidance and training in human relations skills. Although technology has advanced on many fronts, the art or science of dealing with farmers has not changed a great deal. SCS is working to be responsive to the needs of farmers and to communicate effectively with farmers. The marketing manual, *A Guide for Outreach*, should help SCS and district field office personnel in these efforts. ■

Darren Lemmons, SCS soil conservation technician, inspects a wheat crop planted with no-till drill. No-till planting is an effective method of controlling soil erosion.
Tim McCabe/USDA WA-90548

How USDA Agencies Work Together To Protect U.S. Land Resources

7

by Karl Reinhardt, Conservation Planning and Application Leader; and Earl Terpstra, National Association of Conservation Districts Liaison, Soil Conservation Service, USDA, Washington, DC

USDA programs affect most of the Nation's land area. Soil and water conservation, resource conservation and development, watershed protection, and other related activities are all coordinated to protect and enhance the basic soil and water resources with which the Nation produces large quantities of food and fiber.

When Congress established these programs, it intended that they be carried out effectively and efficiently. Many Federal departments and agencies are charged with aspects of resource conservation. This chapter focuses on how USDA agencies coordinate their work in protecting U.S. land resources.

Federal agencies with resource conservation responsibilities have specific charters and functions for specific activities. The functions of these agencies are contained in the legislation that established each agency.

USDA Agencies Involved

USDA agencies involved in land resource programs are the Agricultural Stabilization and Conservation Service (ASCS), the Extension Service (ES), the Forest Service (FS), the Soil Conservation Service (SCS), and the Farmers Home Administration (FmHA).

The ASCS administers various commodity and land-use programs aimed at supporting farm prices, adjusting farm production, and protecting natural resources. ASCS has responsibility for managing the Agricultural Conservation Program (ACP). The ACP provides cost-sharing with farmers and ranchers to help prevent soil loss from wind and water erosion, solve water conservation and water quality problems, and preserve forest resources. These programs are implemented locally by elected city and county officials.

The ES is USDA's primary educational arm. Federal, State, and local governments share in financing and conducting Cooperative Extension educational programs to help farmers and other land users apply the results of food and agricultural research. Natural resource management is one of the major program areas.

The FS manages 191 million acres of the National Forest System. In addition, it cooperates with State foresters, private forest owners, the wood processing industry, private organizations, and State and Federal public agencies.

The SCS develops and carries out a national soil and water conservation program through 2,955 local conservation districts that involve more than 2.3 million landowners and farm operators. A close partnership with conservation district officials enables the SCS to inventory and assess soil, water, and plant resources. This cooperative effort also enables the agency to plan and apply conservation practices to reduce soil erosion, to improve water quality and quantity, and to maintain the land's productivity.

FmHA administers loans for ownership and operation of family-size farms and ranches when credit is not available from other lending institutions. These loans are intended to provide producers access to agricultural credit necessary to enable them to earn an adequate living from their efforts. Loans are also available for soil and water conservation and pollution abatement.

Each year, the United States Congress enacts legislation to appropriate funds for the USDA agencies, and to stipulate what activities may be conducted using these funds.

Program Components

Most of the programs for protecting land resources have three components. These components consist of an awareness component, an action component, and an incentive component.

The awareness component is needed to enable people to

A sign along an Illinois road promotes "no-till" farming. This project involves cooperation among the Cooperative Extension System, USDA's Soil Conservation Service and its Agricultural Stabilization and Conservation Service, the county, and the local Soil and Water Conservation District.
Tim McCabe/USDA IL-2189

understand the purpose of the program, what is expected to be accomplished, and what actions are needed by the person involved to accomplish the intent of the program.

The action component describes, in general terms, what the people who are affected by the program are to do, and how the goals of the program will be met.

The incentive component describes the method by which the affected people will be encouraged to carry out their requirements under the program. The incentive is usually a financial encouragement to participate in the program and carry out its requirements, or a financial penalty for not carrying out the program requirements.

The awareness component is usually considered to be an educational activity that is in the realm of ES at the national level. The action component is usually in the realm of SCS or FS at national, State, and local levels. The incentive component is usually implemented by the ASCS. Examples of the programs that meet these conditions are the Agricultural Conservation Program (ACP), the conservation title of the Food Security Act of 1985 (FSA), and water quality demonstration projects. Each of these programs has an awareness component, an action component, and an incentive component.

Since no single agency has the authority or funds to carry out all three components of these programs, it is imperative that all the agencies work together to successfully implement the programs. Together, they must ensure that the people affected by the program have a clear understanding of their roles in the program, the benefits they will receive, the public environmental benefits to be accomplished, and the incentives and/or penalties that will result from program participation or nonparticipation. Full cooperation is also necessary to achieve the congressional intent of efficient and effective implementation of each program.

Federal, State, and Local Cooperation

Each of the Federal agencies has corresponding State and local agencies to provide input and guidance to conservation programs. Conservation districts are local units of State government, usually encompassing a county. They function as a liaison between the community and the SCS, which work together to meet local conservation needs. Each district enters into a Memorandum of Understanding with the Secretary of Agriculture, which outlines general arrangements for USDA to furnish assistance. They also enter into a Supplemental Memorandum of Understanding with SCS, which allows for SCS technical assistance to be provided directly to people in the district. Such assistance is provided under terms of a cooperative agreement between the landowner and the district or as a result of a request to ASCS through the ACP or FSA programs. Supplemental Memorandums of Understanding between the district and other USDA agencies permit other specific assistance to the district from those agencies.

In addition to an ASCS State headquarters office in each State, ASCS has established an Agricultural Stabilization and Conservation State Committee in each State, composed of people who provide a State focus to the implementation of ASCS components of programs. A county ASC committee is also established in each county by a local election process. Because the ASC local committee members are elected by their peers, local people have an opportunity to ensure that the program rules can reasonably be met in that county, as well as a local sounding board for people who feel that they have been adversely affected by USDA programs.

ES carries out its information and education program through each State's Land-Grant College or University. The Extension Service

SCS District Conservationist David Steffen (right) meets with Keith Whipple and his son Josh on the Whipple Ranch in Mellette County, SD, to inspect grasses and range conditions.
Tim McCabe/USDA 91BW0334

has established an Extension Advisory Group in each county to provide local input.

FS provides financial assistance to State forestry agencies, which in turn provide technical forestry assistance to private landowners on request.

To assist Federal and State agencies in achieving intergovernmental cooperation, USDA has established a Food and Agricultural Council (FAC) in each State. The purpose of the FAC is to provide a forum for the Federal and State agencies to exchange information, to plan activities in the implementation of land resource programs, and to solve resource problems. Many counties use the State FAC committee as a model for similar local forums. Sometimes, the members of the district board, the ASC county committee, or the Extension Advisory Group are also members of one of the other groups. This allows for added communication among agencies and citizens and helps ensure consistent and efficient implementation of resource programs. ■

Forest Health Monitoring: Taking the Pulse of America's Forests

8

by David Radloff, Research Forester, Forest Service, USDA, Washington, DC; Robert Loomis, Pathologist, Forest Service, USDA, Washington, DC; Joseph Barnard, National Program Manager for Forest Health Monitoring, Southeastern Forest Experiment Station, Research Triangle Park, NC; and Richard Birdsey, Program Manager for Global Change Research, Radnor, PA

Our Nation's forests have been prized not only for their great beauty, but also for the wealth of natural resources they provide. These forests supply us with fuel, a variety of useful paper products, and the wood with which we build our homes and furniture. They also provide a habitat for much of our Nation's wildlife, as well as a scenic environment for family outings and vacations. Throughout the history of the United States, America's dense forests have contributed to our shelter, warmth, convenience, and recreation.

—From Presidential Proclamation, October 1990

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Why Monitor Forest Health?

To effectively protect, manage, and use our precious forest resources, the health (or condition) of the resources must be known. The condition of forest resources is in constant change, so tracking the changes in forest health—that is, monitoring—is a long-term, continuing process.

Some changes are both natural and predictable, such as the growth of trees or some forest pest outbreaks. Other natural changes result from unpredictable events such as fire, flood, and windstorm. Changes caused by humans can result from planned management operations as well as from unforeseen effects such as stress from air pollutants or damage from introduced pests. Whatever the cause, forest ecosystems continually change, and so we must monitor their condition to make possible their protection, management, and planned use.

The term "forest health" denotes the productivity of forest ecosystems and their ability to bounce back following stress. A healthy forest can be defined by different standards, depending on a person's reasons for wanting to use a particular forested area.

The USDA Forest Service, in conjunction with the Environmental Protection Agency (EPA), has developed a Forest Health Monitoring program during the past 5 years. A major reason for this development has been the concern about the effects of air pollutants on forests in North America. Another important factor in shaping the design of Forest Health Monitoring is concern over the condition of forests in response to traditional stresses (such as drought, insects, and diseases) and multiple, interacting stresses. In 1988, the Forest Ecosystems and Atmospheric Pollution Research Act directed the Forest Service to undertake the necessary monitoring to track long-term trends in the health and productivity of forest ecosystems in the United States.

The basic reason for Forest Health Monitoring is that forest managers need to track the health of forests regionally or nationally

At the Boyce Thompson Research Institute for Plant Research in Ithaca, NY, researchers perform controlled atmospheric deposition experiments on trees to get a clearer picture of what is happening to plant life exposed to acid rain. Using data from field researchers as a starting point, the Cornell University research activity provides valuable pieces of information to help solve the forest health monitoring puzzle.
Bernie Yee/USDA 88BW0053-6A

to determine the effects of naturally occurring factors (such as fire, forest pests, forest succession, and drought) and human-caused factors (such as introduced pests, air pollution, and other global changes).

We define monitoring as the repeated recording of pertinent data over time for the purpose of comparison with a reference system, or identified baseline. Monitoring is always concerned with the determination of changes through time or space.

Three Kinds of Monitoring

From a forest resource management perspective, the goals of Forest Health Monitoring are threefold: (1) to detect changes, (2) to evaluate possible causes of change, and (3) to increase our ability to anticipate or predict changes in forest resources.

To achieve these three goals, the Forest Health Monitoring system consists of three interrelated monitoring activities: (1) Detection Monitoring, (2) Evaluation Monitoring, and (3) Intensive-Site, Ecosystem Monitoring. All three are needed to fully understand the nature of the health of forest ecosystems.

Detection Monitoring is the most extensive monitoring activity. It involves a network of permanent plots distributed throughout the forests of the United States, coupled with forest pest surveys and data from other sources. The permanent plots will be selected from existing Forest Service networks of inventory sample locations, augmented with additional sample locations as needed to represent all forest lands in the United States. From this augmented network, a subset of "sentinel plots" will be selected and visited annually. The amount of information collected on sentinel plots will be greater than that collected during regular forest inventories.

Information from the sentinel plots will be coupled with information collected during routine forest pest surveys and other specifically focused monitoring activities. All information will be linked to provide a more complete annual estimate of forest conditions.

Many ecosystem characteristics could be measured for Detection Monitoring. Based on experience with other monitoring programs, we believe that, at a minimum, Detection Monitoring indicators should measure forest growth, forest mortality, forest distribution and structure, canopy condition, root condition, and soil condition. Further development of this list will be based on future research and experience with Detection Monitoring.

Detection Monitoring data are needed to define baseline conditions, which provide a measure of normality for the dynamic forest resource. It is important to understand, however, that Detection Monitoring is not an end in itself. By enabling researchers to observe change, Detection Monitoring begins a process that will lead to understanding the changes and determining the causes.

In many cases, detected changes will be part of the normal progress of an ecosystem over time—that is, normal and healthy. Also in many cases, current knowledge of forest ecosystems coupled with increased information from Detection Monitoring will enable us to understand the changes that are observed. However, Detection Monitoring itself will not necessarily pinpoint the cause of abnormal changes. That is the purpose of Evaluation Monitoring.

Evaluation Monitoring is activated by Detection Monitoring results. When Detection Monitoring reveals changes that represent problems or areas of concern, a specific evaluation will be made to determine necessary followup activities.

Evaluation Monitoring will be implemented where unexplained changes have been detected, and it will be tailored to answer questions about the specific nature of the changes. Activities could include additional targeted surveys, site-specific evaluation visits, more detailed temporary monitoring, and specific research studies. The objectives are to determine the cause of observed changes or to develop hypotheses of the causes that can be tested by further research.

Intensive-site, Ecosystem Monitoring provides the third level of detail by tracking ecosystem health at a small number of intensively studied, intensively instrumented research sites. The goal of Intensive-site, Ecosystem Monitoring is a more complete understanding of the mechanisms of change in forest ecosystems in order to better understand cause-and-effect relationships and to better predict direction and rates of change in forest condition.

Ecosystem Monitoring sites will represent key forest ecosystems throughout the United States. These sites will be the centers for collecting very detailed information on all components of the forest ecosystem. These detailed monitoring sites will supplement Detection Monitoring and Evaluation Monitoring. They will also support research to identify and describe forest processes in ways that (1) increase basic understanding of cause-and-effect relationships, (2) enable explanations or projections of observations in the other levels of the Forest Health Monitoring system, and (3) provide the understanding necessary to develop management responses to unexpected changes.

In some cases, this detailed information might help resolve questions that were raised but not answered by Detection or Evaluation Monitoring. Information from Intensive-Site, Ecosystem Monitoring will contribute to better understanding of the variability within forest ecosystems as well as a better understanding of relationships between Detection Monitoring indicators and other ecosystem characteristics. Intensive-site, Ecosystem Monitoring will also provide long-term data and the sampling infrastructure that will make possible research on the processes that shape forest ecosystems.

Implementing Forest Health Monitoring

Implementation of Detection Monitoring began in 1990 in New England, where the Forest Service and the State forest agencies (Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and Rhode Island) collected the first year's data on approximately 250 Detection Monitoring

Scientist on Whiteface Mountain in New York's Adirondack Mountains collects moisture from passing clouds to measure acid levels. Moisture is gathered by rain or extracting droplets from passing clouds that envelop mountains at higher elevations. The clouds are driven by wind currents from the industrial Ohio Valley.
Bernie Yee/USDA 88BW0052-2

plots. The State foresters provided the field crews for this effort. The long-term familiarity of State personnel with local forest situations can provide consistency and stability to the field observations. Scientists from the Environmental Protection Agency's Environmental Monitoring and Assessment Program collaborated in planning and implementing activities. Also in 1990, Forest Service and EPA conducted a study in New England and Virginia to learn more about additional measurements to incorporate into Detection Monitoring and to involve a wider community of scientists in the development of the program. In 1991, six States—New Jersey, Maryland, Delaware, Virginia, Georgia, and Alabama—are being added to the Detection Monitoring network, and pilot tests will be conducted in the West.

The approach to implementing Evaluation Monitoring builds on existing Forest Service and State cooperative programs. When Detection Monitoring reports identify areas or problems of concern, the need for more detailed evaluation will be determined on a case-by-case basis. This will be done in consultation with State pest specialists and may require formation of a multidisciplinary team to determine specific evaluation responses. Responses could include additional surveys, site- or area-specific evaluations, more detailed monitoring, and specific research studies.

Detailed planning for Intensive-Site, Ecosystem Monitoring is under way in 1991, with plans to implement several prototype sites in 1992. The planning process must address a number of currently unresolved questions: How should regional sites be integrated into a national network? How can the intensive-site network best be integrated with other existing or proposed networks? What forest ecosystems should be represented, and how many sites are required? Should the sites represent average conditions? Should the sites be undisturbed by human activity? What variables should be measured?

The Future

The Forest Service is working with both the National Association of State Foresters and the EPA to develop and implement Forest Health Monitoring on a national scale. States will be encouraged to intensify the regional grid of plots and carry out other related monitoring activities in order to develop more precise State-level information. The Forest Service will continue to coordinate the Detection Monitoring activities with the EPA in order to provide monitoring data for the Environmental Monitoring and Assessment Program. This program, in turn, will provide additional useful information (such as air quality data) to enhance interpretation of Forest Health Monitoring data.

Over the next 5 years, the planning and implementation processes for Forest Health Monitoring will proceed step by step. Specific features of all three levels of monitoring will be selected as they are proved effective in field application. The goal is to have a full program implemented nationally by the mid-1990's. ■

Balancing People's Needs and Resource Quality on the National Forests and Grasslands

9

by Dave Unger, Associate Deputy Chief, National Forest System; and Hal Salwasser, Director, New Perspectives Group, Forest Service, USDA, Washington, DC

Balancing various people's needs while conserving long-term resource quality is basic to managing the national forests and grasslands wisely. This goal—taking care of the health, diversity, and productivity of these lands while allowing wise use by humans—is the star that guides the Forest Service and people in America who are interested in how their natural resources are managed.

In the Forest Service, striving for balance is central to our long-term strategy and programs. In 1990, the Forest Service prepared an assessment of renewable resources on all lands and a strategy recommended for Forest Service activity over the next 5 years. The 1990 Resources Planning Act (RPA) Recommended Program, as this strategy is known, highlighted important areas that needed attention if a better balance in resource use is to be obtained:

- Recreation, wildlife, and fisheries resource enhancement
- Environmentally acceptable commodity production
- Improved scientific knowledge about natural resources
- Response to global resource issues

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- Environmentally acceptable commodity production
- Improved scientific knowledge about natural resources
- Response to global resource issues

These are areas on which the Forest Service is focusing to round out use of the national forests and grasslands and to sustain resource productivity.

Managing Together—An Involved Public

Even before the RPA strategy was completed, the public and forest managers had expressed their concern for wildlife and fisheries, recreation, and the environment. This concern was manifested largely through a forest planning effort that started nearly a decade ago. In planning, new program directions were also being charted, with new emphases in established programs and the creation of other programs.

Programs associated with these changes are now well known among those interested in national forest and grassland management: Change on the Range (a program to improve the quality of rangelands and balance the needs of wildlife and livestock forage), Rise to the Future (which enhances fish stock for anglers), Get Wild (which enhances wildlife management), and the National Recreation Strategy (which aims to provide more and better recreational opportunities, based on user demand).

The planning process and these programs invited people to join the Forest Service in managing the land and opened up opportunities for people to participate as never before. People working together in these programs have already made a difference in helping to manage resources to improve quality and productivity.

New Perspectives

In the winter of 1989–90, the Forest Service initiated New Perspectives, a program to help guide change. Adopted by the Forest Service and its public and private partners, New Perspectives is a fresh way of looking at "multiple use" and "sustained yield." It is aimed at finding a better harmony between people's use of resources and nature's ability to sustain resource health and productivity. The conservationist Aldo Leopold called this harmony a "land ethic." New Perspectives is guided by the following important principles in its effort to improve the harmony between the people and the land:

- Sustainability. Management protects the long-term productivity of the land by applying practices that are correct scientifically, respond to people's needs and desires, and keep ecosystems whole.
- Participation. People can be a part of all decisions, including what kinds and amounts of resources are taken from the land and what remains over long periods of time.
- Integration. Ideas and knowledge about how natural resources can be used and what

purposes they can serve are brought together in planning and managing.
- Collaboration. Scientists, managers, partners, educators, and communicators come together to test new ideas, apply current knowledge and technologies, and learn from what happens to natural resources as people use them.

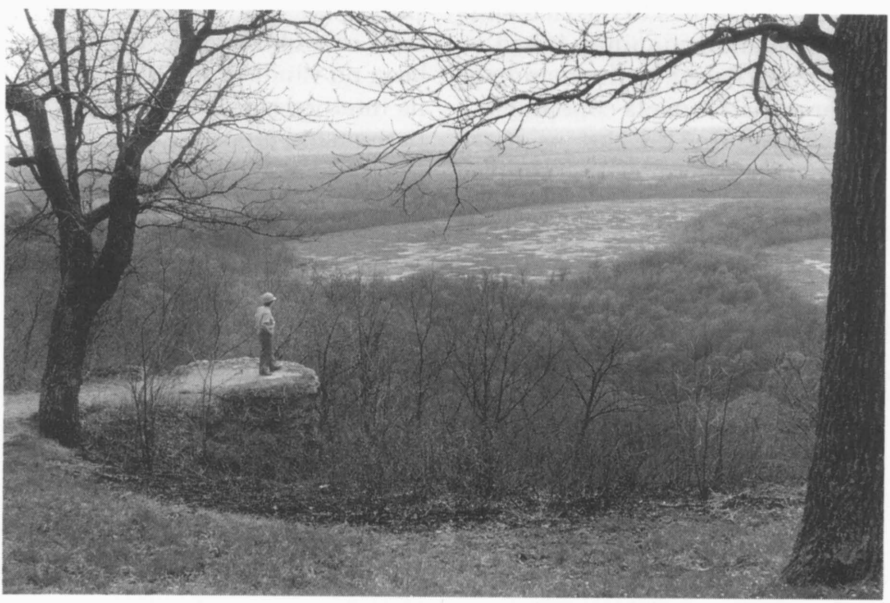
Shawnee National Forest—A Community Story

A specific example can suggest how the Forest Service achieves this elusive balance between use and conservation of a healthy, diverse resource.

The Shawnee National Forest, sandwiched between Missouri and Kentucky in southern Illinois, identified in its forest planning process the Simpson Township Barrens as an ecological area to be managed for its unique resources.

Comparing 1930's aerial photographs of the barrens—a high-quality, dry upland forest and limestone-glade plant and animal community—with the existing resource, forest planners found that the woodland had been more open and the glades more extensive than they were now. Plant life in earlier days was found to have been more diverse.

What had happened at



Tudi Perry, FS geologist, looks out over the valley at the foot of the Larue Pine Hills Ecological Area in the Shawnee National Forest, IL.
Ken Hammond/USDA 91BW0698-20

Simpson Township Barrens to cause this change? When European settlers moved into the area, they brought with them new plants and animals that would compete with native plant and animal species. There was also evidence that in prehistoric times Native Americans had set fires to keep the barrens open and useful to game animals and that lightning and natural fires further opened the area. Fire control in the early 1900's removed this dynamic force, and eventually the forest encroached on open areas.

In 1988, Shawnee National Forest managers and people in the surrounding community started the project of returning Simpson Township Barrens to the rich and diverse plant community it had once been. Based on their study of the area, participants concluded that by restoring the barrens, most of the present human uses could continue and new ones begin. The new uses would include, for example, recreational and viewing opportunities for tourists and visitors.

To restore the barrens, the managers set "prescribed" fires to open the area, removed selected trees and shrubs, and controlled many of the plant species the Europeans introduced. They applied these methods to a 180-acre site.

The diversity of the area has increased greatly since the restoration began. Non-native species such as white sweet clover and black locust were eliminated from the area. Wildflowers and glade plants such as little bluestem, Indian grass, and rattlesnake master were given a chance to thrive. Now visitors can see native grassland with some species standing over 7 feet tall. Over 131 native plants and animals have been identified in a roadside limestone glade and several rare species are now present where they were not known before. Also, over 75 different kinds of butterflies and moths have been identified.

The residents living near Simpson Township Barrens have developed great pride of ownership in the area, symbolized by their care for the area. There has been no vandalism to the site or its interpretive signs. Seven partnership groups, including government agencies and private people, helped restore and interpret the site. Prison crews donated over 200 person-days of labor. Interested people working together with the Forest Service preserved a special ecological area for the community and the Nation and opened the door to new economic opportunities associated with tourism and education.

Besides the recreational opportunities, the barrens enriches the community's life in another important way: It has become a center for education on conservation and the environment. Children from surrounding schools spend time at the site exploring and learning about nature.

Wise Path

In 1976, then-Senator Hubert Humphrey could have been referring to the Shawnee National Forest project when he recognized the importance of balance in managing for a healthy resource and meeting people's needs:

The days have ended when the forest may be viewed only as trees and the trees only as timber. The soil and the water, the grasses and the shrubs, the fish and the wildlife, and the beauty that is the forest must become integral parts of the resource manager's thinking and actions.

The Forest Service is finding new and better ways to balance people's needs and desires with the long-term productivity of the national forests and grasslands. Careful applications of our best scientific knowledge and management methods make projects such as the restoration of the Simpson Township Barrens possible. Such projects ensure the long-term quality of the environment while helping people maintain their local economy. ■

Every Species Counts: Protecting Threatened and Endangered Species and Their Habitats

10

by Kathy Johnson, Endangered Species Program Manager; Russell M. Burns, Principal Research Silviculturist; and Tom Lennon, Special Designations Program Leader, Forest Service, USDA, Washington, DC

Fire-renewed, dense, young jack pine stands grow on Michigan's lower peninsula, home of Kirtland's warbler; dry, steep, grassy slopes of Hell's Canyon in Oregon and Idaho harbor the beautiful wildflower, MacFarlane's four-o'clock; clear, gravel-bedded mountain streams of Tennessee are the home of the elusive little fish, the smokey madtom.

What do these have in common? They are habitats of threatened and endangered species whose survival prospects have been improved through effective recovery plans.

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What Are Threatened, Endangered, and Sensitive Species? Endangered species are those plants or animals in danger of becoming extinct throughout all or a significant portion of their range. Threatened species are those plants and animals likely to become "endangered" in the foreseeable future. These plants and animals are identified and protected by law through the Endangered Species Act of 1973. Sensitive species are those plants and animals that the Forest Service has concluded may become threatened in the future.

habitats increases tremendously. At risk are native, self-maintaining populations of animals and plants, beautiful and inspiring in their own right, but also useful performers in the ecosystems that support life on Earth, including human life. Some may even provide substances for new life-saving medicines, such as that being developed from the Pacific yew, a small tree from the Pacific Northwest that produces taxol, a cancer-inhibiting compound that as yet has not been synsethized in commercial quantities. Preventing species extinction is important to us all.

The National Forests as Habitat

The 191 million acres of national forests and grasslands are home to thousands of species of fish, amphibians, reptiles, birds, mammals, insects, and plants. In the West, half the Nation's spawning and rearing grounds for salmon and steelhead trout, and 3 out of every 4 acres of elk, bighorn sheep, and mountain goat habitat are in national forests and grasslands. This rich variety of habitats—wetlands, meadows, prairies, rangelands, and forests—is critical to the survival of more than 30 percent of the Nation's threatened and endangered plants and animals.

Forest Service and Threatened and Endangered Species

The protection and recovery of threatened and endangered species and environments constitute a significant part of USDA's efforts to conserve the full variety of America's plants and animals. The USDA Forest Service is a leader in this work.

Forest Service activities to conserve and recover threatened and endangered species include:

- Managing habitats, for example with careful, controlled burning to maintain open habitat for mountain golden heather in wilderness areas in North Carolina.
- Inventorying and monitoring their habitats or special environments, such as tracking northern spotted owl nest locations and breeding success in different forest types.
- Protecting or maintaining rare or unique plant and animal communities such as those that inhabit many bogs and wetlands.

- Giving special consideration to sensitive species to prevent decline.
- Researching requirements of individual threatened and endangered species and determining effects of various activities on species or groups of species. New biological knowledge on the red-cockaded woodpecker and Puerto Rican parrot, for instance, indicates what forest conditions are needed for these species to thrive and even what kinds of nesting structures biologists can provide to enhance breeding populations in areas devastated by Hurricane Hugo in 1989.
- Restoring key habitats to conditions suitable for establishing and maintaining populations, such as enhancing the barrens for Mead's milkweed in the Shawnee National Forest in southern Illinois.
- Reestablishing lost populations, such as reintroducing thick-billed parrots from Mexico to the Coronado National Forest in Arizona.
- Reviewing and evaluating Forest Service policies and activities that affect threatened and endangered species.
- Collaborating with other agencies, citizens groups, and individuals to recover species.

Activities such as these are at the forefront of applying new scientific methods and results to solving real-world resource problems. This work is central to the Forest Service mission of "Caring for the Land and Serving People." Foresters and biologists alike work diligently to ensure that managing the national forests and national grasslands never harms but, in fact, restores threatened and endangered plants and animals.

A Recovery Project: The Peregrine Falcon

Protection and recovery of threatened and endangered species and environments are a high Forest Service priority. It is challenging and exciting work for biologists. An example is the work done for the peregrine falcon by biologists from the Rogue River, Klamath, Siskiyou, and Shasta Trinity National Forests in Oregon and California; the States of Oregon and California; and other cooperators.

The work began with the Peregrine Falcon Recovery Plan—a plan for managing either habitat or species population which was agreed to by participants from cooperating agencies. The plan's three main goals are monitoring, inventorying, and augmenting the population.

In March—the beginning of the breeding season—local biologists visit known aeries in predawn hours to determine, from distances sometimes exceeding a mile, whether or not adult falcons are occupying the territory. If occupancy is confirmed, the biologists will return to the nest a second time to find out if the pair is incubating eggs or if there are young in the nest. If young have been identified at any of the aeries, then a helicopter is used to check the nest to determine the number of young. Using the helicopter, suspected new nest sites are checked and additional areas are inventoried.

When the falcons are 6 weeks old or older, intrepid biologists, assisted by ground crews, visit the high, narrow rock ledges—relying on their rock climbing skills and ropes—to weigh, measure, and band each bird; collect prey remains to determine local feeding habits; collect eggshell fragments for laboratory analysis; and assess the condition of the nest for future maintenance projects.

After the breeding season, biologists improve new sites and unsuccessful aeries by modifying ledges and adding pea gravel; then they plan for the next year.

Protecting Habitats

Wilderness and Recovery. Some of the work occurs in the breathtaking Wild Rogue and Trinity Alps Wildernesses and sections of the Rogue and the Trinity Wild and Scenic Rivers. Wilderness and Wild and Scenic Rivers—special area designations, each of which has a unique set of objectives—often complement the protection of threatened and endangered species.

There are almost 34 million acres congressionally designated as "Wilderness" in the national forests and grasslands alone. Wilderness is "an area where the Earth and its community are untrammelled by man and where man himself is a visitor who does not remain," or so it is described in the Wilderness Act of 1964. Wilderness may contain ecological, geological, or other features of scientific, educational, scenic, or historical value. Here is pristine habitat for such species as the grizzly bear and eastern timber wolf, and for many rare plant communities.

Wild and Scenic Rivers. The 3,400 miles of Wild and Scenic Rivers within the national forests also contribute to the protection and recovery of threatened and endangered species. The cliffs along the Rogue and Trinity Rivers are habitat for the peregrine falcon. Other Wild and Scenic Rivers support fish and aquatic organisms in habitats as diverse as bayous, placid pools, streams, and whitewater rapids.

Wild and Scenic Rivers are designated to protect the free-flowing nature of the rivers and their unique or outstanding resource values within the river corridors. Fish and wildlife, particularly threatened or endangered species, along with geologi-

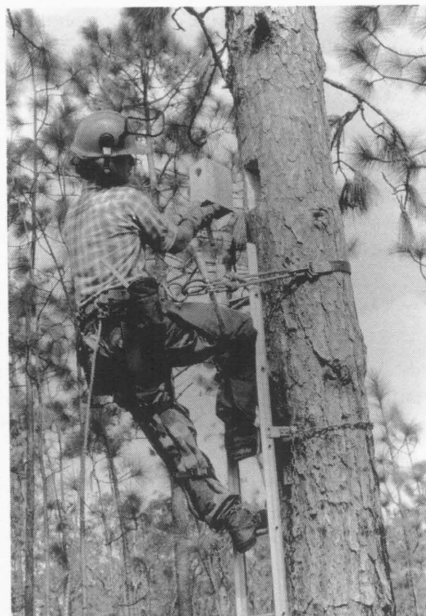
cal features, scenic values, recreation activities, and historical and archeologic sites, are outstanding outdoor resources.
Rivers included in the National Wild and Scenic Rivers system receive special recognition and protection from future developments or use that would jeopardize their outstanding resources. To date, the Forest Service has 70 Wild and Scenic Rivers and is evaluating many more rivers for inclusion in the system.

Forest Service Partners in Recovery and Conservation of Species

It takes teamwork, cooperation, and coordination to ensure the recovery of threatened and endangered species and their environments. Partnerships are a major focus of the Every Species Counts program, announced in 1990, to expand the contribution of the Forest Service in threatened and endangered species conservation. The success of the program depends in part on collaboration with State and Federal agencies, private organizations, and individuals all of whom are stakeholders in the recovery and conservation of threatened and endangered species.

The Shared Investment

Successful collaborations are underway. In 1990, the Forest Service had more than 300 partners working on projects to benefit threatened, endangered, and sensitive species. These partners matched $2 million in Forest Service project funding with more than $2 million of their own funds. Projects such as the peregrine falcon work in Oregon and California and other places, as well as the Mead s milkweed habitat restoration in Illinois, help



An artificial nesting cavity for endangered red-cockaded woodpeckers is installed to help restore populations on the Francis Marion National Forest in South Carolina. In 1989, Hurricane Hugo destroyed 87 percent of the cavity trees and killed 60 percent of the bird population. The new cavities have significantly increased the population since then, and are being considered for installation throughout the woodpecker's habitat range.
Southeast Forest Experiment Station/ USDA 91BW0466

The Grizzly Bear

When Lewis and Clark explored the Louisiana Territory in the early 1800's, they saw an animal unlike any previously experienced in the Eastern United States. The grizzly bear, an animal of great size and courage, as Lewis and Clark discovered, was one to be reckoned with. At that time, about 100,000 grizzly bears roamed western North America from northern Mexico to the Arctic. By 1975, when the grizzly bear was listed as a threatened species, only about 1,000 grizzlies were left in the lower 48 States.

To maintain the remaining grizzly bear population, six grizzly bear recovery areas have been identified in Montana, Wyoming, Idaho, and Washington. These recovery areas range in size from about 1.3 million acres in Idaho's Selkirk Mountains to about 5 million acres each for the Yellowstone and Northern Continental Divide areas in Montana and Wyoming.

Under provisions of the Threatened and Endangered Species Act, Forest Service grizzly bear management focuses on two primary goals—reducing mortality rates and ensuring suitable habitats.

Grizzly bears have low reproductive rates and often live into their twenties. Females do not begin to produce offspring until they are 5 to 6 years old and then only in a 3-year cycle. It may take 12 years or more for adult grizzly bears to replace themselves. This life history reminds us that adult grizzlies, especially females, must be maintained if the species is to survive.

Quality habitat is also important to maintaining the grizzly bear. Grizzly bears sleep from about mid-November to the first of March and may lose 20 to 30 percent of their body weight on an annual basis. Bears must be able to replace this lost weight each year.

Grizzly bears are mainly occupied with reproduction and eating during active periods. These strong needs cause bears to travel widely. An adult female occupies an area of about 100 square miles, while an adult male may have a home range of 500 to 800 square miles. Their space needs are further complicated by their need for habitat at various elevations. Most grizzlies tend to use high elevation areas during denning and summer periods, lower elevations during the spring, and both low and high elevations during the fall. Grizzly bear habitat includes wilderness, timber management areas, livestock grazing lands, and recreational areas.

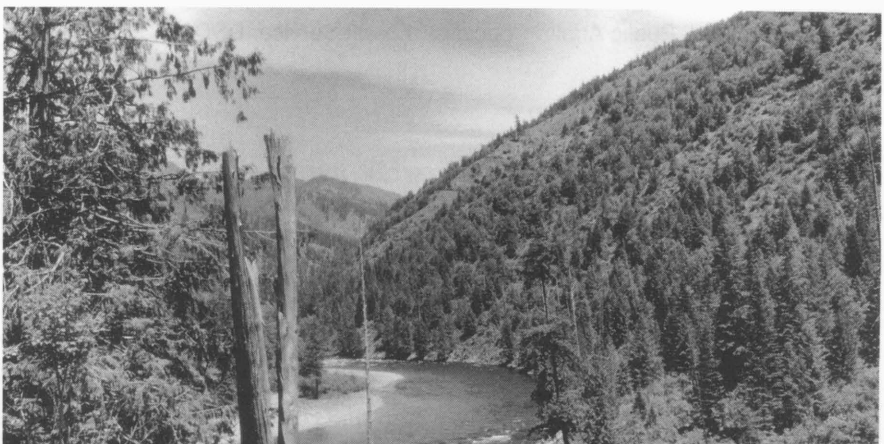
The Forest Service protects and enhances grizzly bear habitat. Avalanche chutes in northwest Montana are burned to retard tree growth and maintain snow movement potential. Big game winter ranges in Montana are also burned to maintain plant productivity and produce elk and deer--important prey. Habitat throughout grizzly range is protected through special management of riparian or streamside areas. Road management and control of bear attractants in camp and at work sites are also important ways of protecting grizzlies and people.

Current and future grizzly bear management activities will be directed at minimizing bear-human conflict and maintaining rich and productive grizzly food through protection and improvement of important habitats.

ensure that these species and their habitats have a chance to flourish.

A key partner with the Forest Service is The Nature Conservancy. The Conservancy is a nonprofit organization that owns and manages its own preserves and maintains extensive scientific expertise in the management of biological diversity. The Conservancy and the network of State-run Natural Heritage Inventory programs have aided in identifying and establishing Research Natural Areas (RNA), and have helped with the inventory, monitoring, research, restoration, and planning needed to maintain and enhance threatened, endangered, and sensitive plant and animal populations.

The establishment of RNA's is an activity that illustrates this teamwork in action. To ensure the validity of its selections, the Forest Service cooperates with and coordinates its RNA activities with universities; State, private, and professional organizations; and other public agencies. These relatively small, pristine areas are part of a national network of natural area preserves designated in perpetuity for research, education, maintaining biological diversity, and measuring long-term ecological change on the national forests and grasslands.



The Selway Wild and Scenic River flows through the Bitterroot Wilderness Area in Idaho. Rafting and other forms of nonmotorized boating are limited through a lottery system in order to protect the area from overuse.
Jill Bauermeister/USDA 91BW0463

So far, 250 RNA's have been created. The Forest Service and its cooperators are evaluating about 450 additional candidate areas that typify important forest, shrubland, grassland, alpine, aquatic, and geologic types as well as other natural situations with special or unique characteristics of scientific interest and importance.

Many of these natural areas provide essential habitat for rare species, some of which were quite abundant before the European settlement of North America, but which now exist only in these remnant sites. Protection and recovery of threatened and endangered species and environments are of importance and of scientific interest to the Forest Service and its partners in the RNA program. ■

America the Beautiful: A Tree Planting Program

11

by Robert Conrad, Public Affairs Specialist, Forest Service, USDA, Washington, DC

From sea to shining sea, Americans are making personal contributions to improving their environment by planting new trees and taking better care of existing ones. They have responded to a call by President George Bush to join the "new greening of America."

In his 1990 State of the Union address, President Bush announced a significant new environmental initiative called "America the Beautiful." A major component of the program, passed by the 101st Congress, is a nationwide, multiyear program of planting, improving, and maintaining trees in all communities and rural areas across the Nation.

The America the Beautiful program—involving the public and private sectors at the national, State, and local levels—should make a major contribution to environmental quality and resource sustainability. Such a program represents an investment in the future, comparable to investments in other national needs such as education, housing, and transportation.

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People and Trees Growing Together

Trees are a remarkably valuable resource. They contribute to the environmental, economic, and social well-being of this country. They enhance biodiversity, wildlife habitats, air and water quality, and recreational opportunities. Trees improve landscape beauty and property value, reduce soil erosion, and provide many valuable wood products. They also contribute to energy efficiency and conservation by shading and cooling buildings and serving as windbreaks. Also, there are those deep emotional ties between people and trees. We like trees and enjoy them in our environment.

The need for America the Beautiful is there. Urban deforestation is occurring all over the United States, not just in large cities but also in our small towns and villages. Only one tree is replaced for every four streetside trees that are removed or die, and in some cities a tree lives only 7 years under current conditions. In addition, over one-half million acres of forest land are lost annually as cities expand. In Atlanta, GA, some 20 percent of the tree cover within the current boundary has been lost in the last 15 years. However, the group "Trees for Atlanta" has embarked on a massive tree planting program to stop this trend.

Community Trees

Trees for Atlanta is just one of many groups all across America that are part of a nationwide volunteer effort to mobilize the corporate and civic sectors to donate funds and labor to help plant trees in the 40,000 cities, towns, and villages of the United States.

National leadership of the America the Beautiful program is shared by USDA's Forest Service and the National Tree Trust, a nonprofit foundation. This foundation promotes the program; motivates the public, corporations, and civic groups to work cooperatively; solicits funds to assist communities; and encourages volunteerism in communities to plant trees. Funds raised by the foundation are used to help communities pay for site preparation and tree selection, planting, and maintenance in communities throughout the country.

The Forest Service provides professional forestry leadership and builds upon its existing system for delivering technical assistance through State foresters and other cooperators. The Forest Service is assisting States and communities to develop, strengthen, and expand the infrastructure of technical expertise needed to coordinate volunteer tree planting efforts.

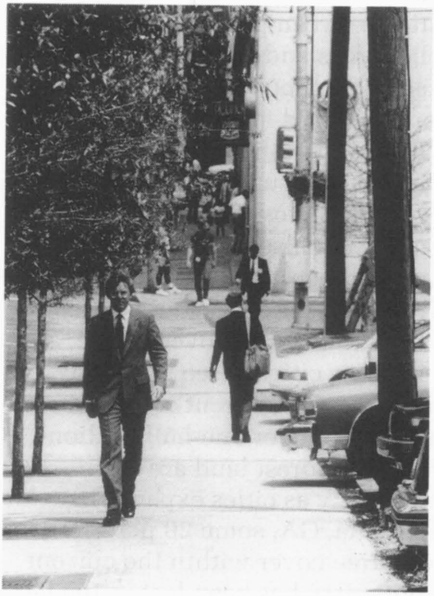
Rural Trees

The rural aspect of America the Beautiful provides for tree planting and forest improvement in the Nation's rural areas through strengthened coordination, technical assistance, and cost-sharing financial incentives for private landowners. Most private landowners neither seek nor receive technical advice concerning timber management or reforestation practices; less than a third of those who actually harvest timber have a management plan before harvest. This program will be accomplished through the new Forest Stewardship and Stewardship Incentive Programs contained in the Forestry title of the 1990 Farm Bill.

The Forest Service estimates that as much as 16 million acres of forest land will be permanently converted to other uses over the next 20 years if present trends continue. At the same time, more than 80 million acres of environmentally sensitive and economically marginal crop and pasture lands are suitable for tree planting. Removing such lands from annual production would provide numerous environmental benefits without significantly reducing food supplies.

About 57 percent of America's commercial forest land is private land that is not used by large enterprises in the forest products industry. This private, nonindustrial forest land, because of low levels of management and investment by owners, tends to be in poor condition. USDA surveys show that up to 80 million acres of private woodlands are in need of conservation treatment. Thus, investments in reforestation and stand improvement on these lands can yield an especially high level of environmental, social, and economic benefits.

The America the Beautiful national tree program is intended primarily to improve the management and encourage the reforestation of these private lands. Specifically, the Government will



Trees help cool "heat islands" in the city. The density of buildings and concrete in the inner city keep temperatures there several degrees higher than in the suburbs, where the buildings are not so close together and there is more greenery.
Trees For Atlanta/91BW0868

provide cost-shared assistance through the Forest Service and State forestry agencies to encourage rural landowners to plant trees and undertake other improvement practices on their lands. The program also provides for grants to State forestry agencies to allow them to provide needed leadership, technical assistance, and forest resource management plans to private landowners, consistent with the landowners' objectives for their land.

The goal of the rural program is to plant trees on about 1.5 million acres of private land annually, and encourage forest improvement and other stewardship activities on another 180,000 acres. Much of the tree planting will take place on economically marginal and environmentally sensitive agricultural crop and pasture land.

Keeping America Cool and Conserving Energy

Forest Service has found that cities create "heat islands." City temperatures are from 3 to 5 degrees higher than those in the surrounding countryside, resulting in increased energy needs to cool urban dwellings. Strategic planting of trees around each house in America would save from 15 to 50 percent on air conditioning bills, or as much as $4 billion annually.

The American Forestry Association (AFA) estimates that there are 100 million available spaces around our homes and businesses, in our towns and cities, in which we could plant trees. Trees planted for shade in those spaces could reduce atmospheric carbon dioxide levels by an estimated 18 million tons per year by reducing energy consumed for cooling. Trees planted as windbreaks could reduce energy consumed for heating by interrupting wind flow to the outside surfaces of homes.

These savings in energy consumption benefit us personally, by reducing our utility bills, and globally, by reducing fossil fuel consumption and the resultant carbon dioxide emissions to the atmosphere. The carbon dioxide emissions prevented by the reduction in fossil fuel consumption from shading and cooling, AFA concludes, actually are 15 times greater than the carbon sequestered by an individual tree.

Tree Planting All Across America

The tree planting program has taken root as more and more people recognize the value and benefits of trees. In all parts of the country, people are joining together to plant and care for trees. Their names are different—Tree People, Tree New Mexico, TREES Forever, Trees for Tomorrow, American Treedition—but their goals are the same. Tree planting is a positive step each individual can take.

Here's how some Americans are getting involved:

- Shannon Ramsay and David Krotz, two Iowans who were alarmed by worldwide environmental degradation, decided to do something about it, something simple and lasting. They focused on planting trees, and their ideas evolved into the group TREES Forever. Hard work and strong organization brought quick success to the group. In cooperation with the Iowa Nurserymen's Association, they planted a grove of 60 trees of native Iowa species on the grounds of the State capitol in Des Moines. In 1990, they planted trees in school yards, parks, and recreation centers. In 1991, they are emphasizing plantings for energy conservation.
- In Texas, the Dallas Parks Foundation has launched a program, Trees for Dallas, with the goal of planting 1 million trees in Dallas County by the year 2000, one tree for every county resident.
- In California, the Sacramento Tree Foundation began 8 years

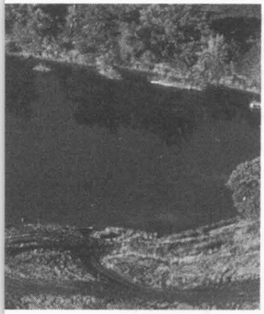
These children from schools around the metropolitan Washington, DC, area are learning about tree planting and care from a Forest Service expert.
Jill Bauermeister/USDA 91BW0821-14

ago—raising money, recruiting volunteer tree planters, and forming alliances with local service organizations such as the Lions Club and the Boy Scouts. Thousands of trees were planted, but the results were not always successful. In the words of the executive director, "In the beginning, we did it wrong. We got the trees in the ground, received terrific media coverage, and congratulated ourselves. But, we forgot to ask ourselves who would water and care for the trees."

Today, the Sacramento Tree Foundation has a tree-care agreement that requires that organizations do not just plant trees, but commit to regular watering of all newly planted trees and all-around care for a minimum of 3 years. Their goal is to plant 1 million trees by the year 2000.

The America the Beautiful tree planting and improvement program provides excellent opportunities for individuals to make a positive contribution to their local environments. Taken together, these individual actions will make a positive contribution to global reforestation and environmental protection. The President's program is providing a meaningful way for individuals to think globally while acting locally. ■

For the first time in their lives, these schoolchildren planted a tree. The America the Beautiful National Tree Planting Program helps children and adults get involved in improving their community's environment.
Jill Bauermeister/USDA 91BW0819-24



Part II Water

Introduction by
Charles E. Hess,
Assistant Secretary,
Science and Education

It is common knowledge that the human body can survive without food longer than it can survive without water. And, of course, water is one of the agricultural producer's most basic tools as well as one of our Earth's most vital natural resources.

President Bush has identified the protection of the Nation's water resources as a high priority for his administration. He has made it clear that farmers need to be involved in a vigorous effort to protect both ground water (beneath the water table) and surface water (lakes, rivers, and streams) from contamination as a result of their land management practices.

As part of this strong Water Quality Initiative, the President has directed USDA to help producers by developing and demonstrating farming practices that would avoid water quality degradation and that are economically viable. Under the Initiative, USDA is committed to three major areas of action: research and development; education, technical, and financial assistance; and database development and evaluation.

The Water Quality Initiative combines the expertise of agencies throughout Federal Government to provide farmers, ranchers, and foresters with the knowledge and technical means to respond independently and *voluntarily* to on-farm environmental concerns and related State water quality requirements. The Department wants to achieve this goal in a way that reduces the need for restrictive regulations, maintains agricultural productivity, avoids economic hardship, and sustains an economical and safe supply of food and fiber.

Let me stress that we are not seeking to eliminate the use of important pesticides and fertilizers. Where feasible, we need to consider reductions in chemical use; yet at the same time, we need to prevent the spread of pests and diseases. We fully appreciate that in many instances, pesticides and fertilizers are absolutely necessary to the farmer. We are, however, seeking ways to reduce their usage and increase their effectiveness in order to improve and maintain environmental economic sustainability.

Research has helped us by developing the broadest selection of production tools ever enjoyed by the agriculture community. Always keeping public and environmental safety in the forefront, it is USDA's responsibility to maintain producer access to that full range of tools. We have provided strong and persuasive science-based arguments to keep an adequate number of necessary and safe pesticides available.

Unfortunately, the balance between risk and safety has sometimes tipped too far in one direction, leading to the belief held by some that *any* risk, no matter how small, is totally unacceptable. We must communicate to the public that we do not live in a totally risk-free environment—and that eating a safe and healthy diet that includes fruit and vegetables can offer major health benefits. We also need to stress the fact that our incredibly low food costs are very dependent on the use of technology—including pesticides and fertilizers.

The use of technology also includes giving increased emphasis to Integrated Pest Management (IPM). This involves developing new systems of control as well as speeding up the adoption of existing programs. These are often under the umbrella of Integrated Resource Management (IRM)—a systems management approach that looks at the farm as a whole. We also want to maximize the potential provided by the new tools of biotechnology to speed the development of genetic resistance to insects and disease. We can both increase efficiency by cutting production costs *and* protect the environment by reducing heavy dependence on chemicals.

Farmers have always tried to take care of our land and water resources, but that effort is now receiving renewed emphasis. The appropriate measure of a system's productivity and efficiency is not how much it produces, but rather the relative value of what it produces compared to what went into producing it. We must now include environmental impacts in the cost/benefit equation. Not only our economic welfare, but also the quality of our lives depends on our ability to develop agricultural systems which produce efficiently while sustaining our natural water resources.

The President's Water Quality Initiative

12

by Harry C. Mussman, Deputy Assistant Secretary for Science and Education, USDA, Washington, DC

No segment of our society has a more direct interest in protecting our environment than do farmers. High-quality water is among their most basic resources. American farmers want to keep good land in business, and they want to keep it good land. Farmers and their families are the first people who suffer from impaired water quality.

But farmers continue to need more information on agricultural practices that will do better to help them protect the environment and make a decent living at the same time. These are compatible goals.

In order to help farmers such as Jeff England (see box) and others achieve the twin goals of agricul-

"Don't let anyone tell you that farmers need to be taught to be conservationists; they already are," said Jeff England, a dairy farmer participating in a water quality initiative demonstration project near Maryland's Monocacy River, a major tributary of the Chesapeake Bay.

"The difference is in how strongly conservationist they are and that depends on how much return they see," England said. "The margin is tough in this business; there's not a whole lot to be made. You can't expect farmers to invest much in a practice, even with cost sharing, unless they see a return. We all want to be good stewards of the land, but there's no better incentive than making money doing it."

England is taking part in the project because he has seen conservation pay for him, through both his eyes and his wallet. He looks at acres of lush green alfalfa striped with rows of corn and knows that contour strip cropping is giving him more profitable harvests as well as keeping soil and farm chemicals in place.

He knows that conservation is crucial in an area like his, where dairy farmers survive by growing as many crops as possible, often two a season, on steep, highly erodible hills. England himself farms a total of 600 acres, growing hay and grain to feed his cows, which are confined to feedlots. He also grows wheat and soybeans as cash crops.

He sees his 200 head of cattle drink heartily from the clean, deep troughs he installed to avoid contaminating springs and creeks, and he is sure that is one reason he gets more milk.

When he is cleaning manure from the milking parlor and feedlots, he knows it will be mixed with water and stored in concrete tanks underground. This way he can spray it on the land when it is least likely to leach nitrogen into streams and ground water.

tural productivity and environmental protection, President George Bush proposed and the Congress adopted an initiative on enhancing water quality that began in 1990. In proposing the initiative, which addresses the issue of agricultural chemicals reaching water resources, the President made it clear that farmers like Mr. England are ultimately responsible for avoiding contamination of water as a result of their farming operations.

Many farmers have long viewed their role toward the natural resources they manage as being one of stewardship. Successful farmers must understand the land and water and the effects that various production methods and farmstead practices have upon them. Therefore, the President directed USDA to accept its traditional responsibility of conducting research and providing education, technical assistance, and financial assistance that helps agricultural producers fulfill their responsibilities. By developing and delivering production methods that are financially profitable and environmentally beneficial, the Federal Government can help equip farmers with the tools they need to act voluntarily.

Agencies consulting or cooperating with USDA on the Presidential initiative include the U.S. Environmental Protection Agency (EPA), the U.S. Geological Survey (USGS), and the National Oceanic and Atmospheric Administration (NOAA). The Tennessee Valley Authority (TVA), the U.S. Army Corps of Engineers, and the U.S. Department of the Interior's Fish and Wildlife Service also contribute to this work. USDA has organized a working group on water quality to coordinate the activities of 11 USDA agencies and the 6 other Federal agencies. A policy advisory committee, consisting of representatives of USDA and each of the six other agencies, provides policy guidance to the working group.

The main objective of this initiative is to provide farmers, ranchers, and foresters with technical means and financial assistance to respond voluntarily to their unique environmental and production situations, so that they can both conform to State water quality requirements and maintain profitable operations.

The working group identified three primary areas of endeavor:

- Research and Development aims to provide scientific understanding of biological, physical, and chemical processes involved in agricultural production based on land and water resources. It also uses such understanding to develop new or improved production systems.
- Education and Technical/Financial Assistance delivers appropriate technology (either new or already known) to pro-

ducers, helps them adapt it to their individual needs, and provides financial assistance.
- The Data and Evaluation component documents fertilizer and pesticide usage by commodity and analyzes and evaluates the impacts of the other two areas of work. It also assesses how well the working group's overall effort is solving the problem of agricultural contamination of water.

Research and Development

The loss by leaching (dissolving and seeping through the soil) or runoff of agricultural chemicals from the sites where they are used often pollutes the environment. The primary goal of research and development is to understand how this chemical movement occurs and to develop farming practices that minimize the potential for such movement.

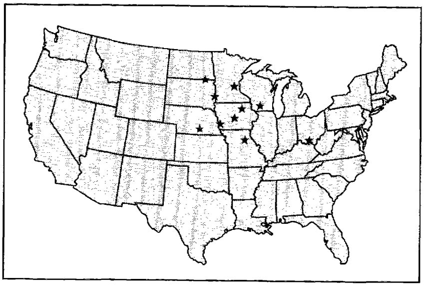
What is already known to science will support the development of new and modified practices that should be improvements over some in current use. Substantial improvement, especially in protecting ground water, will depend on expanded research into the numerous factors that affect losses—factors such as how water moves through and over soil; how plants take up and

Patty Engler, facilitator for the SCS Monocacy River Demonstration Project, and Jeff England inspect plants on the Englands' 209-acre dairy farm in Frederick County, MD. The farm has been selected as one of eight National Water Quality Demonstration Project sites.
Tim McCabe/USDA 91BW1778-29

release nutrients; how pesticides react with plants, insects, and microorganisms; how chemicals are transformed in soil and water; and many others. A new understanding of any one or a combination of these factors could provide the basis for improving production methods.

The research and development contribution to the President's initiative follows a two-pronged approach. The first is to use what is already known to develop and test new equipment and cropping practices. The second is to conduct research on a broad array of specific questions thought to be important to the future development of even better equipment and practices than are possible with present knowledge. Both of these research thrusts are pursued by scientists of the several agencies already mentioned and by scientists at private and State institutions. Many States are cooperating with the Federal Government in supporting both research approaches, particularly through the State Agricultural Experiment Stations and the land-grant universities.

Figure 1. Management systems evaluation areas



Developing and Testing. Corn and soybean production in the Midwestern States involves high inputs of nutrients (fertilizer) and pesticides. Analyses of water samples taken in these States have revealed nutrients or pesticides, or both, in some well waters and streams. Major testing and development projects have been initiated in Ohio, Minnesota, Iowa, Nebraska, and Missouri. The Minnesota project includes study areas in Wisconsin, North Dakota, and South Dakota. Figure 1 shows the location of field sites, called Management Systems Evaluation areas. They include a range of soil, aquifer, and climate conditions.

At each site, several sensitive instruments collect the many samples and observations that are needed to evaluate the performance of various cropping systems and their effects on the loss of chemicals to the environment. The evaluation sites are generally farm fields, and the farmer-owners themselves apply the cropping systems being tested. Farmer participation on full-sized fields, using their own production equipment, ensures that the tested practices are applied in a practical way and that economic information is realistic.

Specific Questions. Over 160 individual projects have been funded at State, private, and Federal research facilities across the Nation. Many are attempting to develop new cropping practices or methods for managing chemicals on the farm and ranch. Others seek fundamental knowledge of physical, chemical, or biological processes that, once obtained, should point the way to new approaches for agricultural chemical management.

As an example, very little is known about the role of macropores, which are large, continuous openings in soil. They may carry water and dissolved chemicals from the soil surface all the way through the root zone and thus be an important chemical movement mechanism. On the other hand, when chemicals have been incorporated into the soil, water must seep through the soil in order to dissolve and carry them away. Thus, macropores may also carry clean water past the root zone, possibly diluting any pollutants that are in water that has seeped through the soil. At least six projects in as many States are studying how macro-pores affect chemical movement.

As a second example, on farms where they are used, sprayers may be a source of chemical loss. Figure

Tim McCabe/USDA 90BW1777-24A

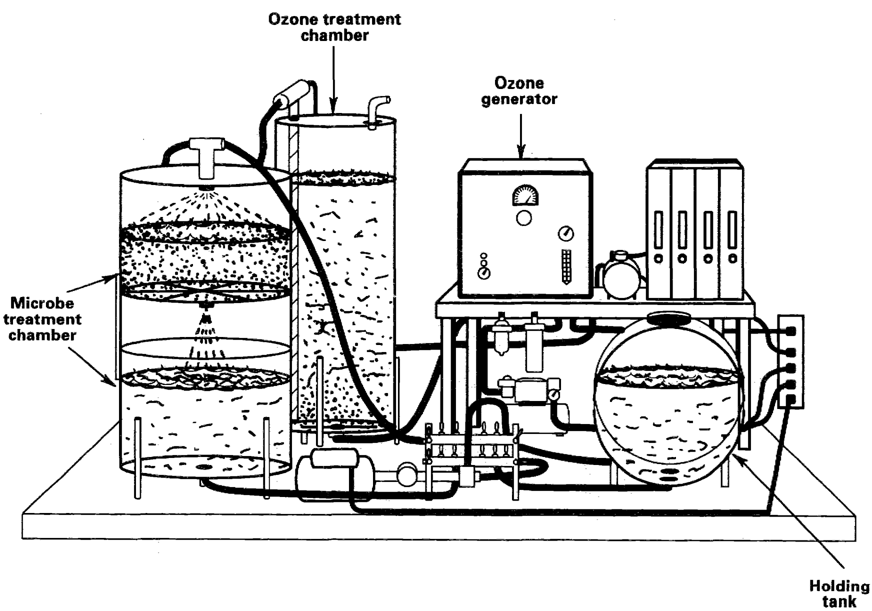
2 shows a schematic of a promising experimental apparatus for removing pesticides from sprayer rinse water. One tank treats the rinse water with ozone. The other contains soil in which heavy concentrations of certain microbes have been incorporated. The ozone partially breaks the chemicals down, and the microbes complete the process by converting the remaining compounds to carbon dioxide and water.

As an example of a federally funded State research program, the University of California is testing a process using soil fungi to hasten cleanup of selenium-contaminated Kesterson National Wildlife Refuge in that State, at a great cost saving over present methods. The fungi convert selenium, which is toxic to wildlife at the concentrations found in the reservoir, to a harmless gas that is dispersed by the wind.

Education and Technical/ Financial Assistance

The primary goal of education and technical/financial assistance is to provide the agricultural community with the necessary educational, financial, and technical assistance needed to restore agriculturally impaired water resources and to minimize the risk of additional future impairment.

Figure 2. Schematic of sprayer rinsate decontamination system



One of the most far-reaching efforts of education and technical/financial assistance is a program to give water quality training to USDA field office personnel in the 3,000 agricultural counties of the Nation. These employees are being provided with updated office guides that contain the latest technical information needed to solve and prevent water quality problems. All farmers, ranchers, and foresters of the Nation have access to these offices.

In addition, three special programs are now operating in 165 watersheds with high-priority water quality problems. These three programs are known as the Nonpoint Source Hydrologic Unit Areas, Water Quality Demonstration Projects, and Water Quality Special Projects. A fourth program having water quality treatment objectives addresses the problems of certain multistate regions, such as the Chesapeake Bay, Gulf of Mexico, and Colorado River.

Nonpoint Source Hydrologic Unit Areas. In selected agricultural watersheds or aquifer-recharge areas, USDA personnel provide conservation planning and technical and financial assistance to help farmers and ranchers meet State water quality goals

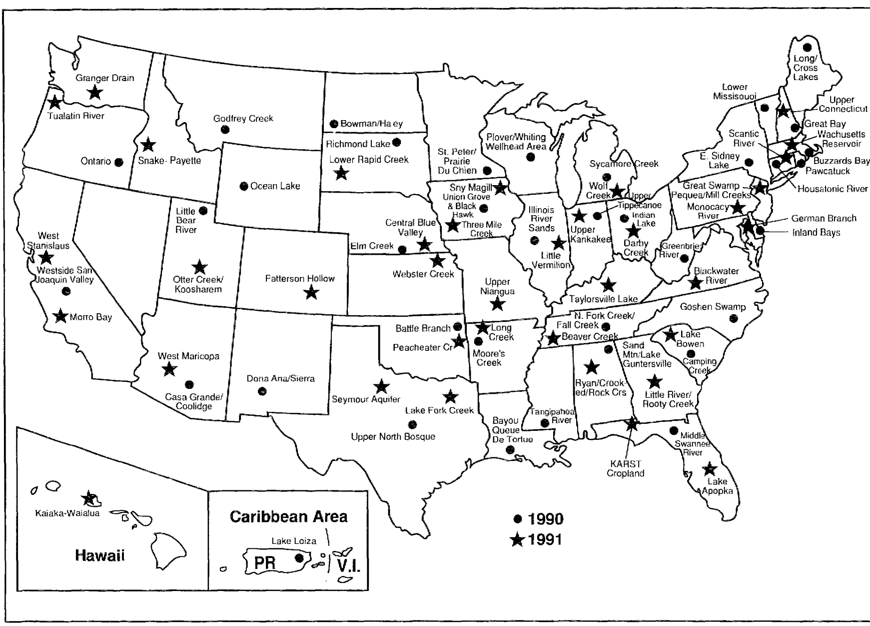
Jeff England sprays manure mixed with water into a holding tank on his Frederick County, MD, dairy farm.
Tim McCabe/USDA 90BW1777-15A

without undue economic hardship. States play an important role in identifying the problem watersheds as part of their responsibilities under Section 319 of the Water Quality Act of 1987. Whole-basin treatment planning for a given watershed is a coordinated effort by Federal, State, and local agencies and includes public involvement. Results are monitored, and information gathered provides a basis for expanding application to other areas with similar water quality problems. Figure 3 shows the approximate locations of the 74 hydrologic unit area projects now underway or being initiated.

Water Quality Demonstration Projects. These projects demonstrate the effectiveness of selected conservation practices in treating specific problems related to nonpoint source pollution and in promoting the use of these practices in other areas. Jeff England (see box) is a cooperator in the Monocacy River Watershed Demonstration Project near Frederick, MD.

The 16 projects in progress or being initiated during 1991 may be located in figure 4. In each

Figure 3. Hydrologic unit area projects



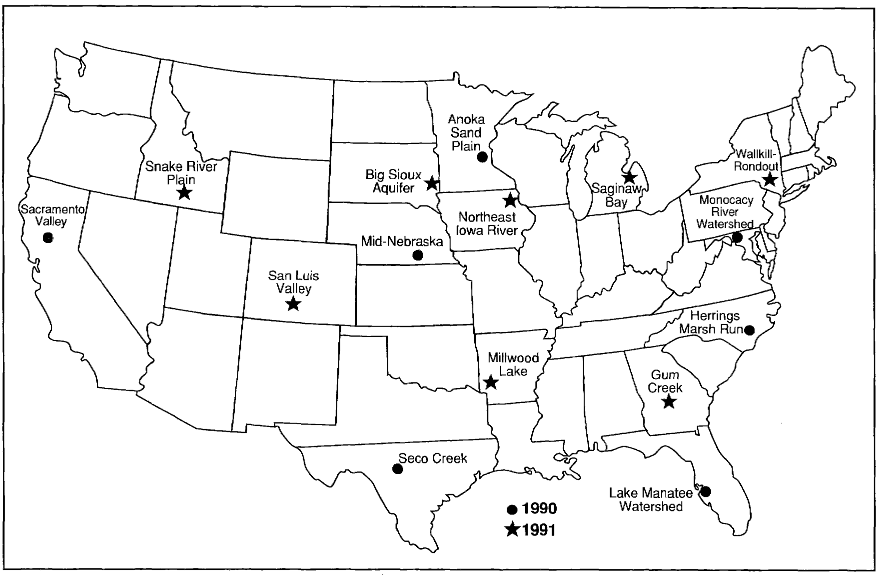
case, USDA and other Federal and State agencies identify critical nonpoint sources of contamination, and they establish location-specific treatment goals and treatment practices with cooperating landowners within the watershed. Federal and State financial assistance may be provided to implement selected practices. Applied practices and their results are demonstrated for the benefit of visiting farmers from the watershed and elsewhere.

USDA and other Federal and State agencies will evaluate demonstration projects to determine the effects that selected practices have on water quality, the economics of using the demonstrated practices, and the extent to which the demonstrated practices are adopted.

Water Quality Special Projects Program funds are reserved under the Agricultural Conservation Program (ACP) at the national level to fund these projects, which are developed locally by county Agricultural Stabilization and Conservation Committees. The emphasis of these projects is to encourage broad farmer adoption, within a problem watershed, of various conservation measures authorized under the ACP and designed to solve water quality problems within the basin.

These projects can also be coordinated with the nonpoint source

Figure 4. Demonstration projects



hydrologic unit areas and water quality demonstration projects or, as identified locally, projects that provide significant public benefits to nonagricultural interests.

Other Educational Programs. The Cooperative Extension System has made water quality a top priority in its nationwide educational network. In its water quality educational program, the Cooperative Extension System is concentrating on six key subject areas: the interactions of soils, nutrients, and water quality; the interactions of soils, pesticides, and water quality; the importance of drinking water supplies and consumer education on how to assess drinking water quality; animal waste; public policy education; and staff development and training.

Data and Evaluation

Although numerous surveys of water quality have been conducted, we do not have adequate information to systematically and consistently assess the magnitude of potential water quality problems—either on a geographic basis or on the basis of production of a given commodity. A major USDA contribution to the President's initiative is development of a comprehensive data base describing the nature of agricultural chemical use around the country. These data will allow USDA and others to assess current conditions and will form a basis for determining the extent of future changes in agricultural chemical use.

The three main data and evaluation activities are chemical use surveys, area studies, and water quality program evaluation.

Chemical Use Surveys. Within a State that is a significant supplier of a given commodity, USDA conducts personal interviews with a selected sample of farmers involved in production of the commodity. Commodities included in these studies are corn, soybeans, wheat, cotton, rice, potatoes, the major vegetables, and the major fruits and nuts.

From these interviews, the types and amounts of chemicals used in the State for such production are estimated, together with a number of related statistics such as number of acres and crop yields. Potential relationships to water quality are also estimated if water quality data are available. Because the studies include all major producer States for a given commodity, estimates of fertilizer and pesticide usage may be made on national and regional as well as State levels.

Area Studies. Certain specific areas or regions are studied more intensively to investigate the relationships among fertilizer and pesticide use, cropping practices, and resulting water quality effects.

The Delmarva Peninsula, on the east side of the Chesapeake Bay, is the first study area because it is also a pilot area for the USGS National Water-Quality Assessment program. Results of the two studies will complement each other.

The emphasis in these studies is on economic and sociological relationships, and it is expected that results will be useful in identifying successful approaches to overcoming obstacles to producer adoption of practices that enhance water quality. Obstacles to producer adoption of a seemingly desirable practice may include such concerns as uncertainty regarding risks entailed in adopting the practice and a lack of information on economic and other benefits that might occur.

Water Quality Program Evaluation. This program includes evaluation of efforts to achieve the goal of the President's initiative to provide farmers, ranchers, and foresters with the knowledge and technical means to respond independently and voluntarily to water quality concerns on their farms and to satisfy public water quality laws.

This publicly supported research, education, and technical and financial assistance should reduce the need for restrictive and difficult regulation in agriculture. An assessment of the initiative's impacts on agricultural water quality problems and the related costs will allow us to devise the most effective program with the least taxpayer burden.

The effectiveness of the initiative will be evaluated based on three types of information:

1. Extent of changes in (a) the use of fertilizers and pesticides, (b) management practices, and (c) crops and livestock grown
2. Effects on water quality of changes in agrichemical use, management practices, or crop and livestock patterns, and
3. Private and public costs in relation to benefits of achieving water quality improvements.

Commitment to the Future

USDA and its partners in the President's initiative are fully committed to working together to help Jeff England and other farmers reduce chemical risks to their families, their neighbors, and themselves and to enhance the desirable environmental characteristics of their rural communities. ■

Agriculture, Agricultural Chemicals, and Water Quality 13

by Ann E. Carey, Special Assistant for Science and Technology, Soil Conservation Service, USDA, Washington, DC

The American agricultural system is unparalleled in its ability to produce food and fiber, providing quality products for both domestic consumption and export. Total agricultural production today is over 2 times the level of 1930. Much of this productivity gain has been made possible by improvements in fertilizers and pesticides for crop protection, as well as crop varieties and cropping technologies.

This chapter discusses agricultural chemicals (fertilizers and pesticides), their potential for contributing to water quality problems, and some ways that USDA agencies are helping farmers to reduce agricultural contributions to nonpoint source water pollution. (Nonpoint source pollution is pollution that does not originate at any one source, but that develops over large areas through either natural or human systems and processes.)

Agricultural production involves the movement of soil and water and the growing of plant materials—all of which can affect water quality and quantity. Modern crop production chemicals (both fertilizers and pesticides) can move off-site through volatilization (evaporation), leaching (dissolving in water and seeping downward through the soil), and other pathways (such as runoff and erosion) to become significant contributors to pollution of surface and ground waters. Many farmers view themselves as stewards of the natural resources they manage. Today, these farmers need knowledge about environmental problems as well as crop production systems, and about farm practices that can preserve long-term soil productivity and water quality.

Water: Quantity and Quality

Earth—as seen from space—is a water planet: a serene, blue world swathed in white, moisture-laden clouds. Over 70 percent of the Earth's surface is covered by water, but most of this is salt water. It is the small fraction (less than 3 percent) that is fresh water which sustains all land-based plants and animals (see fig.1). In fact, only about 1 percent of all the water on Earth is available for human consumption.

This water is endlessly renewed in a cycle fueled by the Sun's energy: falling as precipitation, aiding in plant growth, recharging ground water, flowing to the ocean, and evaporating to form clouds again.

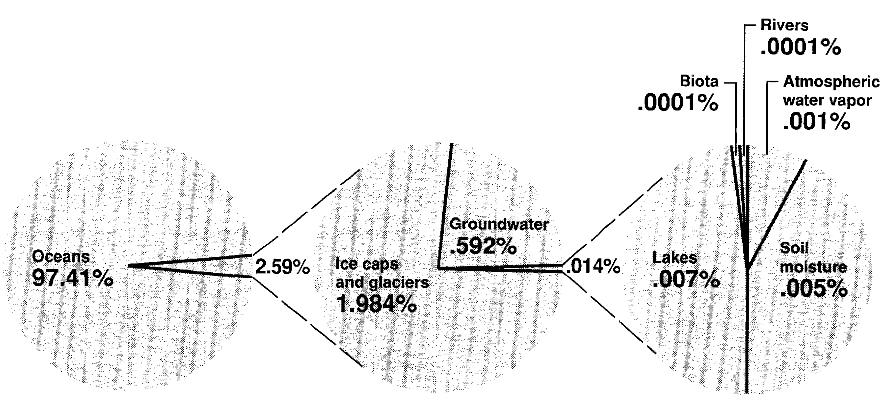
This fresh water supply is not distributed evenly across the Earth's land area, or even across the same country. Despite the semi-arid character of much of the Western United States, our country is considered relatively "water-rich" within the global community of nations. As human populations continue to expand and develop more of the Earth's land area, there is an increased need to protect and maintain this small fraction of life-supporting fresh water.

Agriculture and Agricultural Chemicals

Soil is the main nutrient source for growing plants, but farmers have for thousands of years added growth-enhancing nutrient substances to the soil or rotated their crops in a certain order to replenish nutrients used by plants. Until this century, most of these fertilizers (and the few available pesticides) were naturally occurring compounds, and crop rotation was almost universally practiced to help maintain soil productivity.

However, the development and widespread use of industrially synthesized nitrogen fertilizers in the 1920's, crop-protecting pesticides in the 1940's, and genetically improved crop varieties in the 1950's (which are usually grown in monoculture) have combined to make today's conven-

Figure 1. Distribution of the world's water



Source: David H. Speidel and Allen F. Agnew, "The World Water Budget," in *Perspectives on Water Uses and Abuses*, David H. Speidel, Lon C. Ruedisili, and Allen F. Agnew, eds.(Oxford University Press, New York, 1988) tional agriculture much more chemical-intensive than ever before. Pesticide use in U.S. agriculture has more than doubled since 1962; fertilizer use in 1985 was almost 13 times higher than in 1930. There is also a trend for farmers to use more-concentrated fertilizer materials.

Four major crops—corn, cotton, soybeans, and wheat—account for about two-thirds of U.S. fertilizer use. Corn, which makes up about 21 percent of U.S. acreage, accounts for about 43 percent of the nitrogen use. Economic forces and national agricultural policies have often combined to promote the continuous production of high-value crops on the same land. Also, the uncertainties always present in crop production cycles in some regions of the United States have contributed to farmers' decisions to increase the use of agricultural chemicals in some years as a form of insurance to try to boost yields.

The agricultural chemicals used by farmers are generally mixtures, or formulations, of two or more chemicals. One or more active ingredients (which provide the product's desired effects) are combined with one or more inert ingredients (such as carriers, diluents, stabilizers, or preservatives) to make the finished product that is applied to soil or crops. Other chemicals (formed during the manufacture of the active ingredients or the formulation pro-

Soybeans flourish in no-till wheat straw. Sustainable agriculture ensures long-term soil productivity and enhances water quality.
Gene Alexander/USDA KS-2053-32

cess) may also be present in minute amounts. Therefore, today's farm management planning includes an increasingly complex chemical management component.

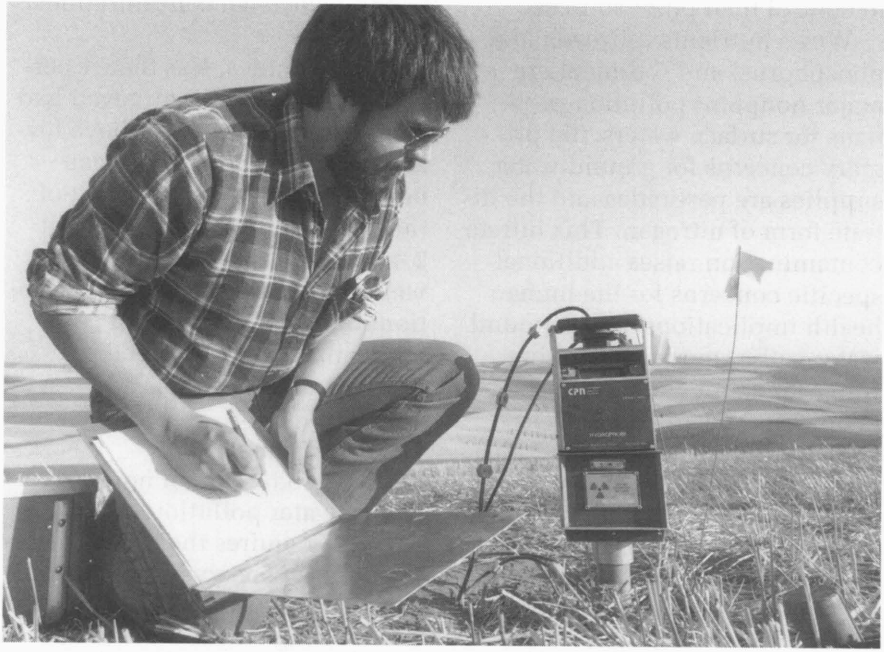
Protecting Water Quality

In the United States, improvements in surface water quality have occurred in the past 20 years since the passage of the Clean Water Act (Federal Water Pollution Control Act) in 1972. Most of this improvement has come about through reductions of "conventional" pollutants (sediment, organic matter, nutrients, salts, bacteria) from point sources of pollution such as industries and municipal wastewater treatment plants, primarily by the installation of more and better treatment facilities to remove pollutants.

During this same period, however, it has also become clear that:

- Conventional pollutants are not the only point-source pollutants of concern, and
- Point-sources are not the only cause of water quality degradation in the United States.

Toxic pollutants can continue to cause water quality problems



SCS technician Darren Lemmons takes a soil moisture reading to determine the soil's capacity to supply moisture to plants.
Tim McCabe/USDA 91BW0455

after conventional pollutants are cleaned up. Furthermore, nonpoint sources of pollution, primarily from human activities such as agriculture, forestry, urban runoff, construction, abandoned mines, and atmospheric deposition, are being recognized as significant contributors of both conventional and toxic pollutants to our water resources (see fig. 2).

Naturally occurring nonpoint source pollution can also occur, from processes such as geologic erosion, saline seeps, and dissolution of nutrient-rich rocks and soils. These nonpoint sources are proving to be much more difficult to control than point sources.

While nutrients (nitrogen and phosphorus) and sediment are major nonpoint pollution problems for surface waters, the primary concerns for ground water supplies are pesticides and the nitrate form of nitrogen. This nitrate contamination raises additional specific concerns for the human health implications, since ground water is the source of drinking water for about 105 million people in the United States (see table 1). About 97 percent of all rural drinking water, 55 percent of water for livestock, and more than 40 percent of all irrigation water is from ground water sources. Whereas surface water is subject to naturally occurring environmental processes that help to chemically transform or degrade pollutants—processes such as heating and cooling cycles, exposure to sunlight, microbial transformation, and oxidation—ground water is not subject to these processes. Therefore, once contaminated, this important resource recovers very slowly, if ever.

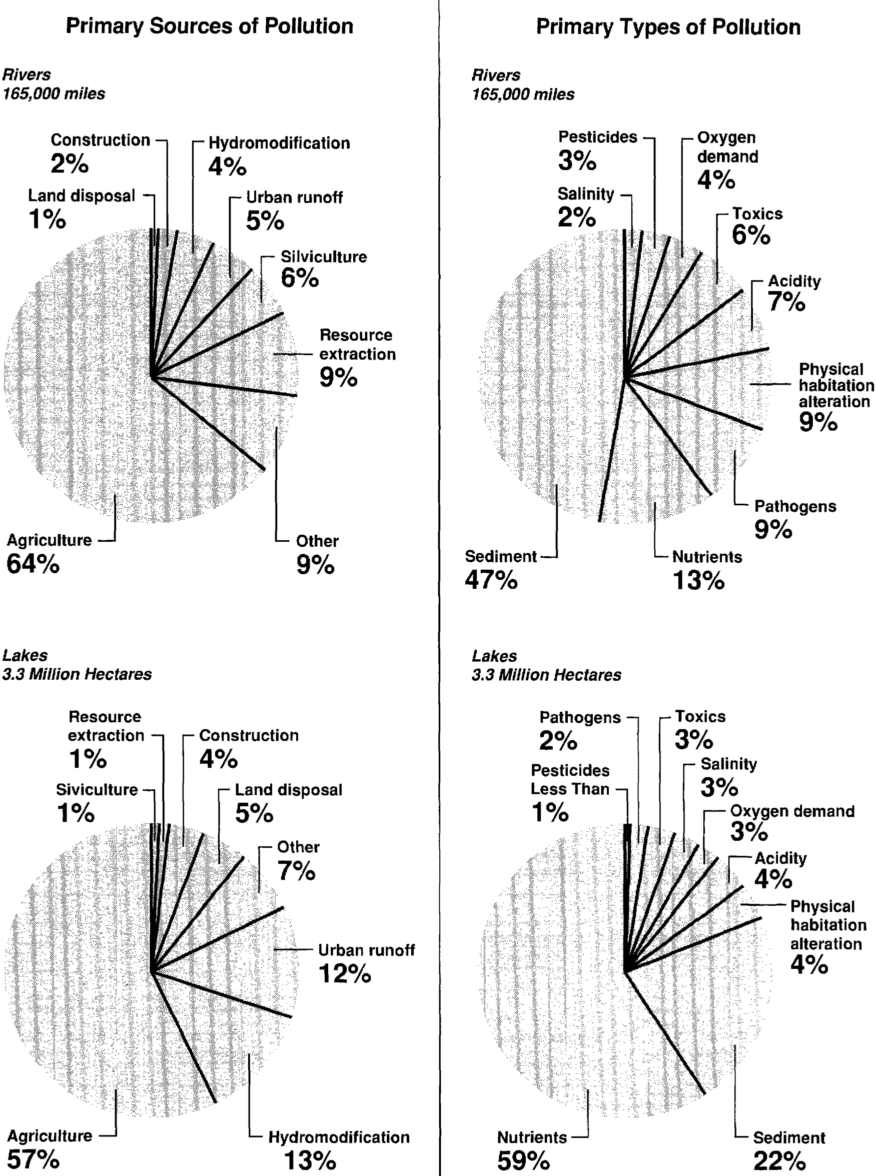
The U.S. Environmental Protection Agency (EPA), in 1990, released results of a national survey of pesticides in community water systems and rural domestic wells. About 10 percent of the community water systems and 4 percent of the rural domestic wells contained detectable concentrations of pesticides, while over 50 percent of the wells surveyed contained detectable concentrations of nitrates.

For pesticides, less than 1 percent of all the wells surveyed had concentrations slightly above levels considered safe for human health, while about 1 percent of the community wells and about 2.4 percent of the private rural wells contained nitrate concentrations above the maximum contaminant level established to protect human health.

The Task Ahead

Effective reduction of nonpoint source water pollution in rural America requires the timely delivery of new conservation technologies through educational materials and training—with State or Federal financial assistance, if necessary. USDA continues to strongly encourage voluntary actions to

Figure 2. Sources and types of nonpoint pollution in affected U.S. rivers and lakes



improve water quality and quantity. USDA has an established network of technical specialists and educators to help land users through local soil and water conservation districts, and to help other groups eliminate or avoid soil and water resource problems.

USDA's Agricultural Stabilization and Conservation Service (ASCS), Extension Service (ES), and Soil Conservation Service (SCS) have the personnel and systems to provide the necessary education, technical assistance, and financial assistance. These agencies are staffed with professionals experienced in sound management of water resources.

One of many new projects in-

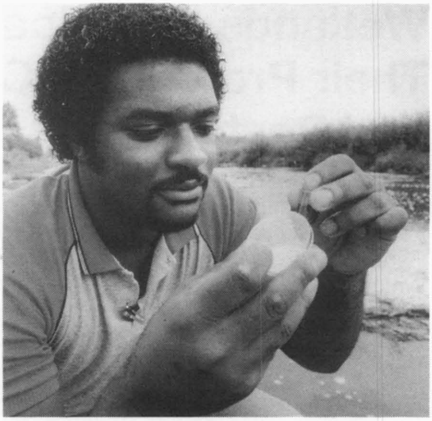
Table 1. Percentages of people relying on ground water for domestic use in the United States

States	Percent of State
Arizona, Florida, Hawaii, Mississippi, Nebraska, Nevada, New Mexico	Over 90
South Dakota	80 - 89
Delaware, Iowa, Maine	70 - 79
Alaska, Indiana, Kansas, South Carolina, Washington, Wisconsin, Utah	60 - 69
Arkansas, California, Illinois, Louisiana, Michigan, Montana, New Hampshire, North Dakota, Tennessee, Texas, Vermont, West Virginia, Wyoming	50 - 59
Georgia, Minnesota, New Jersey, New York, Ohio, Pennsylvania, Virginia	40 - 49
Alabama, Connecticut, Massachusetts, Missouri, North Carolina, Oklahoma, Oregon	30 - 39
Colorado, Kentucky, Rhode Island	20 - 29
Maryland, Puerto Rico, Virgin Islands	Under 20

Note: For this report, Puerto Rico and the Virgin Islands are treated as States.

Source: State Ground Water Program Summaries, Office of Ground Water Protection, USEPA, 03/85.

stituted by USDA as part of the President's Water Quality Initiative (see Chapter 12) focuses on the protection of private rural wells, the drinking water source which has been shown to be most often contaminated by nitrates and pesticides. SCS and ES employees are cooperating to develop this program. Agency personnel will work with land users to identify which areas of a particular farm are affecting the water quality in private wells, and will help clients plan and implement procedures to protect their water supply from the intrusion of agricultural chemicals. ■



Ed May, SCS soil conservationist, taking a water sample to check for bacteria in a stream, as part of a national water quality monitoring program.
Tim McCabe/USDA 91BW0457

This abandoned mine is an example of a nonpoint source contributing to pollution of our water resources.
Tim McCabe/USDA PA-41077-34

Wetlands and Riparian Areas: Their Protection, Conservation, and Restoration

14

by Larry Schmidt, Riparian and Watershed Improvement Program Manager, Forest Service; Billy Teels, National Biologist, Soil Conservation Service; and Randall Gray, Staff Biologist, Soil Conservation Service, all with USDA, Washington, DC

Wetlands and riparian areas (transitional areas between water bodies and uplands) are now recognized for their uniqueness and contributions to the environment. Within the last 30 years, as our knowledge progressed, these areas became recognized for their important functions and values: They reduce flooding, offer recreational opportunities, provide fish and wildlife habitat, and act as filters to improve water quality. In addition, these areas provide livestock forage, and in the case of coastal wetlands they are important links in the production of seafood.

Louisiana bayou country. Cypress trees and water hyacinths provide an excellent food source for aquatic life and a nutrient filter for the waterway.
Tim McCabe/USDA 91BW0596

USDA and agricultural producers are actively conserving these national treasures. Landowners, through voluntary efforts and a variety of USDA programs, are ensuring that wetland and riparian functions and values will be maintained.

Wetlands

Although it is difficult to determine how many acres of wetlands once existed within the United States, the U.S. Fish and Wildlife Service of the U.S. Department of the Interior estimates there were approximately 215 million acres of wetlands in the lower 48 States at the time of European settlement. Over the last 200 years, over 54 percent of these wetlands have been lost. The U.S. Fish and Wildlife Service estimates that between the mid-1950's and the mid-1970's some 458,000 acres of wetlands were lost each year. Approximately 80 percent of the loss of inland wetlands has resulted from draining and clearing for agricultural purposes.

The conversion of wetlands to other land uses was driven by a belief that wetlands had little value. In fact, some of these drained wetlands are now our most productive agricultural lands. However, with our growing understanding about the functions and values of wetlands, society is now choosing to protect them. In addition, efforts are being made to restore many of the wetlands already lost.

Most of the wetlands lost were converted to agricultural uses, and 76 percent of the remaining wetlands are in private ownership, so USDA is now playing an important part in the protection and conservation of wetlands.

During the last 40 years, USDA has implemented policies and programs to protect and conserve the remaining wetlands. Some more recent programs and policies include these:

- The USDA water bank program, authorized in 1970, provides cost incentives to landowners who protect and manage their wetlands for waterfowl. Currently, 12 States participate, with over 184,000 acres of wetlands enrolled in the program. To provide nesting cover for waterfowl and buffer zones around the wetlands, another 325,000 acres of upland areas are also included in the program.
- The 1985 Food Security Act opened up a new era in wetland protection and conservation on agricultural lands. The conservation title of the act, commonly referred to as the "swampbuster" provision, made anyone who planted an agricultural commodity on a wetland converted after December 23, 1985, ineligible for many USDA program benefits. This provision has slowed the conversion of wetlands for agricultural purposes. In fact, the

1987 National Resource Inventory data collected by the Soil Conservation Service (SCS) indicate that wetland losses have declined to between 100,000 and 200,000 acres per year, compared with the 458,000 acres annually from the mid-1950's to the mid-1970's. The exact percentage of this decline that can be attributed to swampbuster is unknown; however, the provision has played a significant role.

- The 1985 Food Security Act also included positive incentives for wetland conservation. The Conservation Reserve Program provides landowners with cost incentives to remove highly erodible land from agricultural production. Included in this acreage are over 410,000 acres that contain valuable wetlands. SCS, the U.S. Fish and Wildlife Service, and some State agencies are working with these landowners to restore previously drained wetlands.
- The 1990 Food, Agriculture, Conservation, and Trade Act (FACTA) continues to afford protection to wetlands. FACTA has modified swampbuster to make the act of conversion, not the planting of a commodity crop, the trigger that makes a landowner ineligible for many USDA program benefits. In addition to advancing the trigger, FACTA was designed to help farmers better manage their land while still protecting wetlands. For example, wetlands that are cropped more often than not can be converted to agricultural use if a farmer restores and maintains an area of equal size as wetland.
- FACTA also established the Wetland Reserve Program (WRP). Congress has authorized the Secretary of Agriculture to enroll up to 1 million acres in this program. The WRP primarily targets previously drained wetlands that can be restored and placed into 30-year or perpetual easements to protect the wetland's values and functions. Landowners who choose to participate are financially compensated for these easements and given financial assistance for restoring the wetlands. In addition, FACTA includes provisions for entering riparian areas into easements under the Environmental Easement Program and for entering riparian areas that connect two protected wetlands into the Wetland Reserve Program.

Riparian Areas

Riparian areas appear as distinct ribbons of lush, green vegetation when viewed against the surrounding arid land. While not as distinctive, riparian areas also occur along other rivers, streams, and water bodies in more humid regions from Florida to Alaska. Riparian ecosystems usually include many plants that require access to water within the root zone during the growing season. These important riparian ecosystems link dryer upslope ecosystems to the stream's aquatic ecosystem.

Riparian areas do much to enhance the environment. For example, they provide shade that cools the water and creates an inviting area for picnics and other water-centered recreation. Fish and aquatic wildlife such as beavers, otters, and many birds depend heavily on healthy riparian areas for habitat vital to life. The vegetation of healthy riparian areas on floodplains filters and slows flood waters that periodically overflow the streambanks.

Riparian areas often overlie key areas that recharge the underground water and provide temporary storage of water in the soil of streambanks. As streamflow from melting snow and rain diminishes late in the summer, water moves into the stream from the streambanks and sustains flows. These late-season flows are often vital to downstream farmers, communities, industries, and aquatic ecosystems.

The USDA Forest Service gives special attention to the stewardship of riparian areas. Many of these areas were damaged by early users who did not recognize their sensitivity and value. Efforts are underway on public lands administered by the Forest Service, Bu-

Waterfowl enjoying the benefits of a conservation-minded farmer in Louisiana. Harvested cropland is flooded to provide a wintering habitat for waterfowl.
Tim McCabe/USDA 91BW0603

The vegetation of healthy riparian areas on flood plains filters and slows flood waters that periodically overflow the streambanks (top). Many of these areas were damaged by early users who did not recognize their sensitivity and value (bottom). The Modoc National Forest's Lassen Creek riparian habitat was restored between 1983 and 1990. Stream protection structures and a new grazing system enable commodity production to be combined with environmental protection.
Sidney Smith/USDA 91BW0987 (top), USDA 91BW0988 (bottom).

reau of Land Management in the U.S. Department of the Interior, and other agencies to improve conditions that adversely affect riparian areas. Improved management of transportation systems, grazing use, recreation activities, recreational vehicle use, and mining is essential in this improvement effort.

Volunteers and Partners

Important work in wetland and riparian area improvement is also being accomplished through volunteers and partnerships with a wide range of interest groups. For example, the Oakwood Bottoms Greentree Reservoir on the Shawnee National Forest is a 3,400-acre wetland that provides essential winter and spring habitat for over 100,000 mallards and wood ducks. Recent work to expand the area has involved drilling a new well, constructing or reconstructing 19,800 feet of levee, and installing 10 water control devices. The work is a cooperative venture involving the Illinois State Department of Conservation, Ducks Unlimited, and the Forest Service in a challenge cost-share project to complete the design, restoration, and construction.

Many private landowners also recognize the importance and value of stewardship of riparian areas. They can make use of USDA programs, including technical support from SCS and information from the Extension Service. Assistance and support are also provided through State foresters.

One example of coordinated partnership with landowners and communities from several USDA agencies is the North Fork Feather River coordinated resource management effort in Plumas County, CA. This group works with local landowners, corporate partners, the county, and communities in carrying out riparian improvement projects that benefit local landowners and downstream users such as Pacific Gas and Electric Company, operators of water-power-generating facilities on the Feather River. The Soil Conservation Service, Forest Service, Agricultural Stabilization and Conservation Service, and Extension Service are assisting in this effort.

All of these efforts are vital in ensuring the survival of riparian areas and wetlands that support ecological benefits and uses desired by the public now and in the future. ■

Improving Water Quality at the Local Level

15

by Patricia Calvert, Deputy Director of Communication, Information, and Technology, Extension Service, Washington, DC; and Kristen Penner, Information Officer, Outreach Communication, Michigan State University, East Lansing

Ground water is one of our Nation's most precious resources. It supplies drinking water for half the country's population. Recent agricultural and public concern about water quality preservation—particularly that of ground water—has raised the issue to the national level.

Since 1987, the Cooperative Extension System (CES) has focused its total nationwide educational network on water quality as one of its national initiatives. In addition to participating in USDA and Presidential initiatives, the Extension System is concentrating its major water quality efforts in six basic areas: the interactions of soils, nutrients, and water quality; the interactions of soils, pesticides, and water quality; the importance of drinking water supplies and consumer education on how to assess drinking water quality; animal waste; public policy education; and staff development and training.

Emphasis continues to be given to cooperative projects and programs with other USDA and Federal agencies, State agencies, and the private sector. Ongoing programs in integrated pest management, pesticide applicator training, soil sample testing, irrigation scheduling, and best management practices are an integral part of this educational process. Education for consumers, homeowners, community groups, youth, and food industry representatives is also vital.

The message is: "Today, all Americans share a vested interest in preserving and maintaining an abundant, healthy water supply." Improving water quality at the local level is an important component of Extension's community education thrust. Let's examine several of Extension's programs:

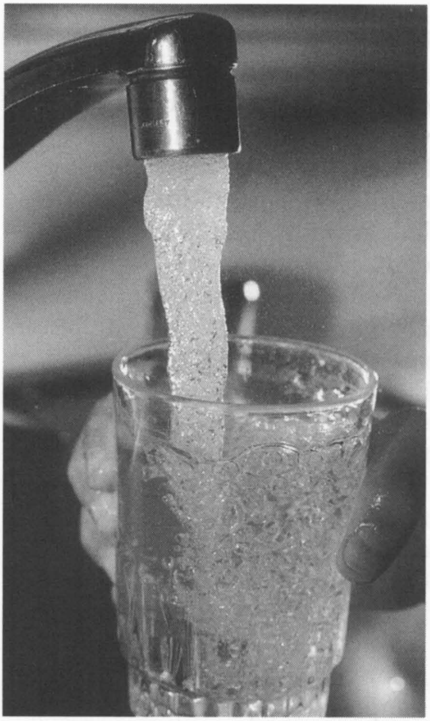
Water Use Reduced

Apartment complexes and other large businesses can now get help from Extension at the University of Arizona to reduce their landscape water use.

In conjunction with the Tucson Water Department, the Pima County Cooperative Extension Service has developed a 3-year pilot program targeting the city's

400 highest water users. Called "Low 4"—for low water, low cost, low maintenance, and low energy—the program demonstrates how apartment complexes and business owners can reduce landscape water and maintenance costs while still producing a landscape that will attract customers, said Patricia Waterfall, a Pima County Extension assistant agricultural agent.

Each business receives a water audit to determine the amount of water it is using and to check the efficiency of its irrigation system. Volunteers trained by Extension conduct the audits. Next, an irrigation schedule is devised to help conserve water.



Ground water is one of our Nation's most precious resources. It supplies drinking water for half the country's population.
Ken Hammond/USDA 91BW0867-28

Program workers are providing business owners with studies on the economic costs and benefits of converting to a xeriscape landscape (a landscape requiring only a small amount of water). Other program activities include workshops on irrigation scheduling, xeriscape design, installation and maintenance of drought-resistant plant material, and installation and maintenance of drip irrigation systems. Maintenance staff are trained in how to carry out the suggested changes.

Mobile Nitrate Testing

From the high-yielding field crop areas of southern and mid-Michigan to livestock operations in the State's Upper Peninsula, mobile nitrate testing clinics are helping farmers make more efficient use of the nitrogen fertilizer they apply to field crops and, at the same time, reduce ground water risks.

More than 70 clinics, developed and operated by Michigan State University's (MSU) Cooperative Extension Service, have made the rounds throughout the State over the past 2 years. The clinics provide farmers with a way to test soil and water samples for nitrate nitrogen levels. According to Maurice Vitosh, MSU Extension soil fertility specialist, nitrate testing of soil is an excellent, inexpensive way of evaluating the available nitrogen status of the soil. "Reducing nitrogen applications can have a double positive effect for farmers," Vitosh said. "Not only can it reduce the amount of nitrate nitrogen that may leach into ground water, but it also saves farmers money on fertilizer bills by reducing or eliminating applications of nitrogen fertilizer that crops don't need."

Vitosh developed the idea for the mobile nitrate testing clinics as a followup to MSU's mobile forage testing clinics that helped farmers test forage moisture levels after the State was hit by severe flooding in 1987. The nitrate testing clinics were funded by USDA and, more recently, the Michigan Energy Conservation Program.

Mobile van technicians can have water sample results in 10 to 15 minutes. Anyone whose water sample results indicate nitrate nitrogen levels higher than 10 parts per million is offered Extension literature on concerns about nitrates in drinking water. Soil sample results are usually available in about an hour, at which time technicians can provide producers with recommendations to meet a particular yield goal.

Sample tests are inexpensive, ranging from $1 per water sample to $5 for two soil samples. In the past, farmers have needed to provide two soil samples from different depths to get the most accurate nitrogen readings. Refinements in the testing process will allow farmers in 1991 to get accurate nitrogen readings from only one surface sample, resulting in lower test costs.

The clinics take place at farms, county Extension offices, and county fairgrounds. More than 3,600 samples have been tested so far. Vitosh said he hopes the mobile clinics will reach even more farmers this year, with the advent of regional clinics around the State.

Well-Water Testing

More than a half million private domestic wells in Georgia provide water for drinking and other household uses. Nearly 25 percent of them are 75 feet deep or less, making them likely targets of contamination.

Since there are no regulations governing quality of private water supplies, Georgia Cooperative Extension Service staff began advising well owners of the importance of testing water and installing treatment systems when necessary. The major concern is contamination by nitrates, calcium, magnesium, and certain heavy metals.

During 1988-89, Extension laboratories analyzed nearly 4,500 samples from private wells, twice the number requested by landowners just 5 years before. One-fourth of these wells had mineral contaminants above maximum accepted levels established by the Environmental Protection Agency. Extension staff are advising the owners of these wells on ways to reduce or eliminate the contaminants. Statistics from the analyses are used to track changes in ground water quality, and to compare geographic areas and values from wells of varying depths.

Homeowner Education

While Extension's work in water quality touches all Virginia residents in some way, many programs are specifically geared to homeowners.

In Fairfax County, for example, Cooperative Extension agents teach homeowners environmentally sound ways of establishing ground cover, applying fertilizer, and taking care of plant materials. Fairfax has also compiled results of a water quality survey of homeowners in the Franklin Farms area, which agents will use in developing a program to educate all residents about water quality issues.

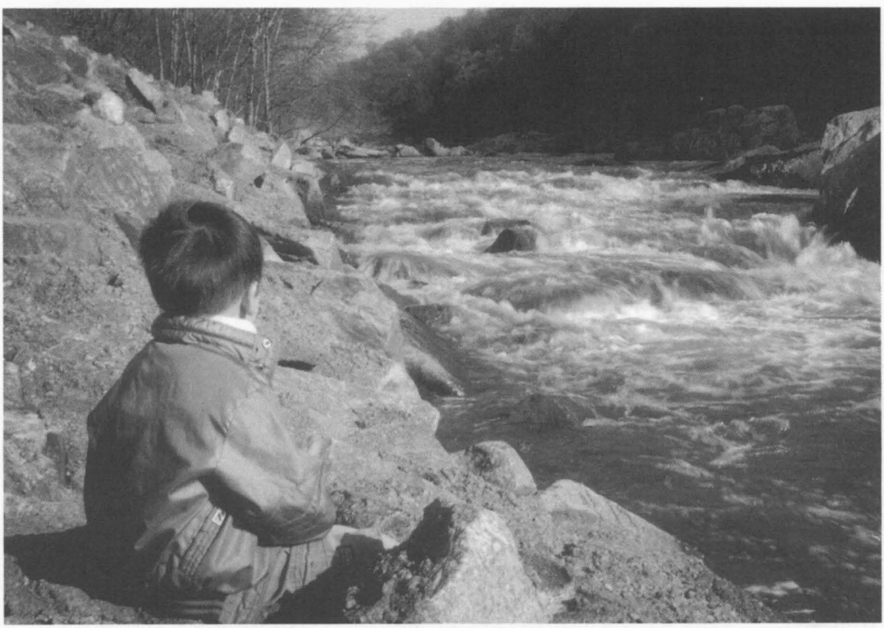
In Chesterfield County, agents hold workshops for homeowners, and other workshops for retail garden center personnel—to teach them how to answer consumer

Wildlife benefits from constructed wetland ponds. These sites provide food and shelter.
Ken Hammond/USDA 91BW0750-8

questions about water quality. In 1989, Extension agent Mike Henry led four homeowner classes, in which he discussed such topics as how to calibrate chemical applicators and how to safely dispose of excess pesticides. More than 300 homeowners attended. More than 110 people representing 12 retail establishments attended the garden center workshops.

In Warren County, where development and agriculture are becoming closer neighbors, concern about water quality is at an all-time high—especially after an EPA Superfund groundwater pollution site was identified in the county. Nearly half the homes in Warren County have individual water systems or wells, all but a few of which are supplied by ground water. An Extension project offered free testing and water diagnosis to approximately 400 households. Public meetings were held to discuss residents' concerns as well as testing procedures, and results of the water sample analyses are being compiled. Extension specialists look forward to repeating the study in other communities.

Youth projects in Virginia, such as the annual 4-H Marine Camp, give kids (including dis-



Extension Service youth projects in Virginia have given kids across the State a week of environmental training with emphasis on water quality.
Ken Hammond/USDA 91BW0750-27

abled children) across the State a week of environmental training with an emphasis on water quality. The Virginia Cooperative Extension Service distributed a series of youth publications with information on marine projects and the Chesapeake Bay—including soil erosion, nutrients, and underwater plants—which reached more than 5,000 Virginia youth last year. ■

Farmers and the Chesapeake: An Interagency Success Story

16

by Sharon I. Hogan, Communications Advisor, Department of Agronomy; Richard A. Weismiller, Department of Agronomy; William Magette, Department of Agricultural Engineering; and Billy Lessley, Department of Agriculture and Resource Economics; University of Maryland, College Park, MD

Anyone talking to farmers in Maryland today will discover that they are well aware of the importance of protecting water quality. The combined efforts of many agencies have produced tremendous changes in the behavior and attitudes of the agricultural community.

Both the unifying message of the "Maryland Farmers—Partners with the Bay" campaign and the coordinating efforts of the interagency State Conservation Committee are enabling various interest groups, as well as State and Federal agencies and the private sector, to craft complementary and cooperative programs that will benefit all concerned.

The "Maryland Farmers—Partners with the Bay" program has succeeded in raising awareness and winning acceptance of the goals of the Bay restoration effort throughout the agricultural community. It has provided new technologies and prompted farmers, over the past 5 years, to voluntarily adopt water quality protection practices in their own operations. It has helped policymakers and citizens alike understand the relationships between agriculture and the Chesapeake, as well as the challenges that farmers face when taking action to protect water quality.

The Kickoff

In 1985, Maryland implemented an educational campaign to involve Maryland farmers in the Chesapeake Bay restoration effort. This multiagency program was called the "Maryland Farmers—

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Partners with the Bay" campaign. At that time the Chesapeake Bay, the Nation's most productive estuary, was in serious decline; sea grasses were dying, fish and oyster harvests were plummeting, and vast regions of its depths had become oxygen-depleted wastelands.

Pollutants generated by a variety of sources, ranging from municipal sewage treatment plants and industries to homeowners and boaters, were implicated in the situation. Agriculture was identified, in particular, for excessive contributions of sediment and nutrients.

The Maryland Department of Agriculture's Soil Conservation Committee, the University of Maryland System Cooperative Extension Service, and other agencies had launched the "Partners" campaign at the 1983 Governors' conference on the Chesapeake Bay. This political summit, organized by the U.S. Environmental Protection Agency and the States surrounding the estuary, resulted

James Wood (left) and Howard Wood check the progress of a loblolly pine planted in an area set aside in the Conservation Reserve Program. The Chester River, a tributary of the Chesapeake Bay, flows in the background.
Bob Nichols/USDA 91BW0576-36

in the signing of the first Chesapeake Bay restoration agreement.

The "Partners" campaign was designed to do three things:

(1) educate farmers and citizens concerning agricultural pollutants and their role in the decline of the Chesapeake Bay,
(2) gain farmer participation in Bay restoration efforts, and
(3) demonstrate to citizens that Maryland's agricultural community was actively committed to restoring the Bay.

Keeping the Ball Rolling

This initial publicity campaign successfully launched the educational component of the agricultural community's Bay restoration effort. What sorts of programs were built on this groundwork in the ensuing 5 years, and what sort of impact did they have in Maryland?

In 1985, Maryland committed $36 million for 34 Chesapeake Bay initiatives that addressed a variety of sources of pollution. One of these initiatives was a program of cost-sharing, technical assistance, and education to promote farmer adoption of best management practices (BMPs)—which are defined as the most effective and practical means of preventing or reducing pollution to surface or ground water. The Maryland Cooperative Extension Service and Agricultural Experiment Station were charged with continuing the "Partners" campaign and expanding the Chesapeake Bay educational effort.

Teaching by Example: Indiantown Demonstration Farm

In the spring of 1985, the Maryland Cooperative Extension Service, the Agricultural Experiment Station, and Howard Wood III, owner of Indiantown Farm in Queen Annes County, signed an agreement to establish a demonstration site.

The demonstration farm would illustrate the effectiveness of various conservation practices in protecting surface and ground water. It would also give producers, legislators, State agencies, and the general public a "real world" example of how economic and production considerations influence the use of conservation practices.

Indiantown Farm covers 343 gently rolling acres along the Chester River, and is typical of farms on Maryland's Eastern Shore. Corn, soybeans, and alfalfa are its primary crops. A soil conservation and water quality plan was developed for the farm by local Soil Conservation District and Soil Conservation Service personnel. As part of the farm plan development, University of Maryland Extension specialists collected soil samples and developed fertility recommendations and a herbicide program. These specialists also conducted an aerial survey to identify drainage watersheds and land contours.

A monitoring network was established to obtain physical and chemical data on the quality and quantity of surface and ground water flows and to evaluate the changes in water quality that would result from the new management practices. Six runoff collection sites were installed at field edges; here samples were taken during every rainfall, and monitoring equipment measured the duration and intensity of each storm. These samples were analyzed to compare the amount of sediment, nitrogen, and phosphorus washed from no-till and conventionally tilled fields.

To monitor ground water quality, 23 wells were installed at strategic locations. Specialists sampled these wells monthly and analyzed the specimens to determine the amount of nitrogen and phosphorus percolating (dissolving and seeping) to the water table.

Scientists from the University of Maryland departments of agricultural engineering and agricultural resource economics constructed a 5-year history of Indiantown Farm's finances and production, and developed a recordkeeping system to analyze the farm's individual fields. These records of yields, BMP construction costs, and operating expenses (for such inputs as seed, fertilizer, chemicals, and machinery) were used to determine how BMPs affect the management strategy and economics of the farm.

Despite 3 years of drought that shrivelled crops and frustrated attempts to construct BMPs and collect runoff data, Indiantown yielded a wealth of useful information. The economic data collected there has helped farmers and policymakers select management practices that provide the most pollution protection per dollar in various farming situations. Data on surface and ground water have helped scientists and decisionmakers charged with developing a realistic statewide agricultural water quality management plan to more effectively evaluate various BMPs. The development of this statewide plan is mandated as part of Maryland's strategy to reduce by 40 percent nutrient loading from all nonpoint sources to the Bay.

Look and Learn

Indiantown Farm provides a unique educational opportunity. Situated on the banks of the Chester River, it is an ideal place to evaluate best management practices and to show the dramatic connection between farm practices and water quality.

The farm's first field day took place in October 1988. It featured farm tours and speakers discussing such topics as water quality monitoring, the effectiveness of BMPs, nutrient management, and government-sponsored conservation programs.

Over 1,000 people visited Indiantown between July 1985 and July 1989. Visitors from Maryland, the other Bay States (Pennsylvania, Virginia, Delaware) and the Nation as a whole came to Indiantown to get ideas and see a variety of effective and economical methods to control agricultural pollution.

The demonstration farm also provided an invaluable service to Maryland's policymakers. They learned more precisely how agriculture affects the Bay, and what practical and economical options exist to enable agriculture to do its part to meet the goals of the Bay Agreements.

The demonstration farm was the keystone of a broad educational effort, and the lessons learned at Indiantown were disseminated throughout the State. Taking advantage of an existing network of county Cooperative Extension Service and Soil Conservation District offices, project staff carried word about the work at Indiantown through slide shows and videotapes to farmers throughout the State.

Actions Speak Louder

Making farmers aware of water quality issues and protection technology wasn't enough. To reduce pollutant inputs to surface and ground water, farmers needed to make some real changes in their operations. To make these changes easier, the Maryland Cooperative Extension Service and the Agricultural Experiment Station developed a new full-service approach that went beyond traditional research and education.

Services such as individualized financial counseling, equipment calibrations, sample collection, and subsidized laboratory analysis were offered to reduce the burden on farmers trying to upgrade their operations. These services were particularly vital because Maryland's farmers at that time were caught in a double bind of drought and a poor economic climate. It was important that Extension recommendations not only minimized pollutant losses, but

No-till winter wheat planted in corn stubble.
Bob Nichols/USDA 91BW0574-36

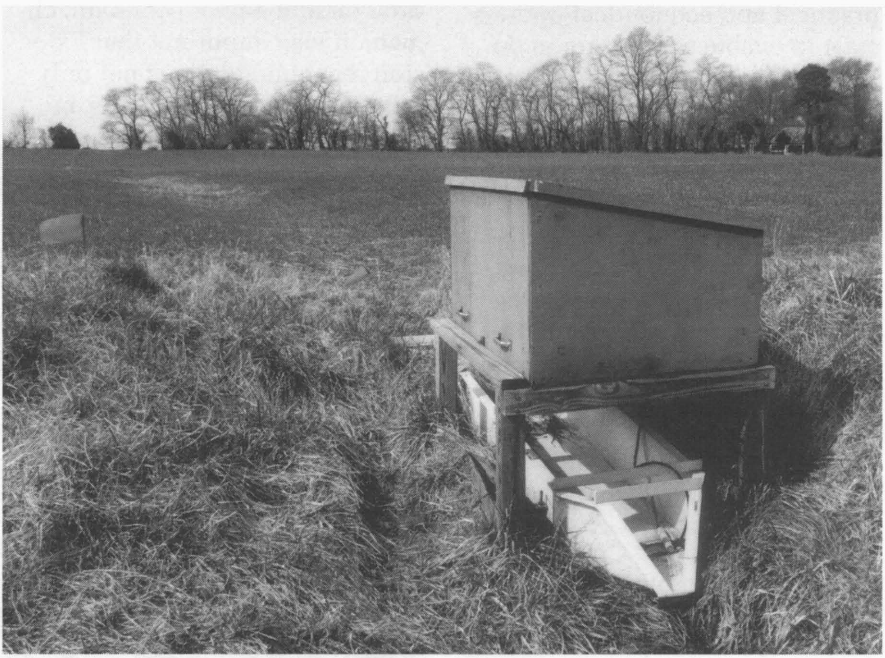
also maintained or enhanced farm profitability.

The highest priority under the agricultural community's Chesapeake Bay program was to control nutrient losses, particularly nitrogen and phosphorus from fields and livestock areas. As a first step toward helping farmers better manage the nutrient resources on their operations, a free manure analysis program was instituted through the University of Maryland's soil testing laboratory, with funds from the Maryland Department of Agriculture.

A publicity campaign was developed to promote this program; it included a "Nutrient Management Kit" and a poster stating, "Manure Testing Makes $ense." More than 500 of the nutrient management kits were dispensed in the first year. This promotional campaign prompted a dramatic increase in the number of manure samples analyzed at the University of Maryland's soil testing laboratory.

Follow Through

To help county Extension agents explain the significance of soil



One of six runoff monitoring flumes, this hydrograph records the intensity of the surface and ground water flowing through the flume during a rainfall. Water samples are collected and analyzed to measure soil and nutrient loss.
Bob Nichols/USDA 91BW0575-22

and manure test results to farmers, new analytical and educational computer programs were developed. These programs analyzed fertilizer costs, calculated sludge application rates, and optimized the allocation and use of animal wastes. In addition, the State Soil Conservation Committee sponsored the development of a State handbook on manure management. This handbook covered structures, storage, handling, application, safety, crop fertility, and legal aspects.

A Measure of Success

Since the inception of the "Partners" project, over 146,239 audience contacts have been made at meetings, classes, field days, and one-to-one consultations. (This figure represents participation in events, not the total number of individual persons contacted, as one person may have attended several events.) As Extension staff throughout the State were trained and began to reach out to producers, audience contacts went from fewer than 10,000 the

Agricultural Technician James Wood takes a water sample from 1 of 23 shallow ground wells. The wells are sampled monthly, and specimens are analyzed to determine the amount of nitrogen and phosphorus percolating to the water table.
Bob Nichols/USDA 91BW0575-6

first project year to almost 57,000 the final year.

The Ripple Effect

The "Maryland Farmers—Partners with the Bay" campaign has had a ripple effect in the agricultural community, lending impetus to the development of new programs in the State's Cooperative Extension Service and Maryland as a whole. One outgrowth was the March 1988 creation of an independent nutrient management program funded by the Maryland Department of Agriculture. This program currently employs Extension consultants in 14 counties dedicated solely to helping farmers develop nutrient management plans for their farms.

To expedite and enhance the planning process, the "Partners" project funded a computerized system for generating custom-tailored nutrient management plans for farmers. The computer system, called NUMEX (Nutrient Management Expert System), was developed through a cooperative agreement with the USDA Agricultural Research Service and the University of Maryland's soil testing laboratory.

The Chesapeake Bay restoration effort has also spurred research efforts such as the development of geographic information systems to target watersheds particularly vulnerable to loadings of agricultural nonpoint source pollutants. Other researchers and Extension personnel are exploring the effectiveness of potential new management strategies such as the use of riparian buffer zones and cover crops to reduce nutrient pollution of water resources.

The "Partners" program has expanded cooperation among agencies involved in water quality efforts. State educational programs and research will continue to improve and refine the actions taken by Maryland's agricultural community to protect the water resources of the Bay and the State. ■

Part III
Air

Introduction by
Bruce L. Gardner,
Assistant Secretary,
Economics

Air quality and its degradation through environmental pollution are usually viewed as an urban issue, but they have important agricultural dimensions as well. Acid deposition and ozone concentration can threaten the productivity of our cropland and forests. Remedies for air pollution also have an agricultural dimension. Ethanol-based fuels can reduce the emission of pollutants from internal combustion engines in automobiles and other vehicles. The promise of these fuels has given impetus to an important research program in developing methods for converting corn and other traditional feedstocks to ethanol more efficiently, and developing alternative crops to be used as ethanol feedstocks.

A longer term issue concerns basic characteristics of the atmosphere, in particular the concentration of "greenhouse" gases and implications for global change in climate and growing conditions. Agriculture is a contributor both to the accumulation of these gases—particularly methane—and to the removal of the most important of them—carbon dioxide.

The first chapter of this section, "Air Quality and the Productivity of Crops and Forests," provides a description of known facts and important questions about the future of air quality and agriculture. The authors have compiled the main ideas and assumptions experts are currently using in describing and analyzing the various sources of and remedies for air pollution. The authors address the effects of air pollutants on agriculture, soil chemistry, and the health and vulnerability of the Nation's forest lands.

Emissions from the burning of fossil fuels are a major contributor to air pollution. Agriculture provides several energy sources that are promising substitutes for fossil fuels. The chapter on "Alternative Fuel Sources" gives a comprehensive view of the current situation and future growth opportunities in alternative fuel production and use. The alternative fuels considered include ethanol, biodiesel fuels, and methane. Industries producing these fuel sources rely on many new technologies for which research is just beginning, and conversion costs remain high. The immediate future of these industries remains dependent on various forms of government assistance, but work looks promising to make these environmentally needed fuels economically independent.

Our final chapter, "Interagency Alternative Fuels Research," describes how the Federal Government is assisting the development of these new technologies through incentives, joint research, intergovernmental cooperation, and recent legislation included in the 1990 Clean Air Act. The Clean Air Act provides a strong tool for the Federal Government to use in reducing pollution and improving air quality across the Nation.

Air Quality and the Productivity of Crops and Forests

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by Walter W. Heck, Research Leader, Air Quality Research program, Agricultural Research Service, USDA, Raleigh, NC; David Radloff, Research Forester, Forest Service, USDA, Washington, DC; and George Frisvold, Economist, Economic Research Service, Washington, DC

Smoke problems were of concern to Londoners in the 17th century. Palls of black smoke, from the burning of soft coal in many homes across London, covered the city during calm winter days. This was regarded only as a nuisance at that time.

During the latter half of the 19th century, the smelting of ores became widespread throughout the industrialized world. The early smelters were often large pits in the ground, where the ore was smelted over open beds of coal. Gases escaping from such an operation were released directly to the atmosphere at ground level and could affect sensitive plant and animal life in the vicinity.

Research in Europe during the late 19th century pointed to sulfur dioxide as the most likely toxicant in the plume from the smelter. Sulfur dioxide was released from the burning of fuel and from sulfide oxides in the ores. Injury to plants was often the first evidence of toxic levels of sulfur dioxide in the atmosphere.

During the early part of this century, severe leaf injury to many plant species growing in the vicinity of several smelters in the United States was identified as sulfur dioxide injury. One of the most intensively studied smelters was in the copper basin of eastern Tennessee, often referred to as Copper Hill or Duck Town. After years of open pit burning at Copper Hill, all vegetation within a half mile of the smelter was lost. At a greater distance, trees and shrubs were gone and only a band of hardy grasses remained. A secondary effect of denuding the landscape was the severe erosion that resulted.

Even after the open pit smelting was stopped in the early 20th century and a smelter with low stacks was constructed, injury to vegetation around the new plant continued, and plants did not recover. The type of injury evident at Copper Hill is no longer found in the United States due to increasing environmental sensitivity of the U.S. public and to changing corporate management practices.

Which Pollutants Harm Plants?

Although many gases toxic to plant life were released from a multitude of industrial operations during the early days of industrial development, only sulfur dioxide received wide concern among scientists until the early 1940's. At that time, increasing evidence of injury from hydrogen fluoride was associated with the increase in aluminum smelters, where fluoride compounds are used in processing ores. Since then, considerable research has gone into studying the effects of gaseous fluoride on plant health. During the 1960's, concern for both sulfur dioxide and fluoride diminished because control technologies were developed to collect these gases from industrial plants, lowering emissions enough so they caused little or no harm to sensitive vegetation.

The effect of acid rain on trees on White Face Mountain in New York State. Acid rain, combined with other sources of atmospheric and ground pollution, triggered the damage.
Bernie Yee/USDA 88BW0051-24A

In the late 1940's and into the 1950's, another type of injury to many plant species was observed throughout the Los Angeles Valley in California. This was related to the increasing severity of the "smog" problem that was becoming more apparent in the valley during this time. Scientists finally related the problem to a group of chemicals that had strong oxidizing characteristics. In 1958 ozone was identified as the most important of these oxidants, and ozone's effects on numerous sensitive crop species were subsequently confirmed.

In 1961, a second plant toxicant was identified as PAN (peroxyacetyl nitrate—a stronger oxidizing chemical than ozone). Subsequently, ozone was identified as the cause for plant injury throughout the United States and in other industrialized countries. Although plants are more sensitive to PAN than to ozone, PAN is not considered a national problem because the concentrations are too low in most areas of the country to injure sensitive vegetation. However, some scientists believe that even small quantities of PAN probably enhance the reported widespread impacts of ozone on many crop species.

Air Pollutants Now

Today, hundreds of pollutants are emitted into the air in the industrialized and developing world. These are divided into primary and secondary pollutants. Primary pollutants are emitted directly into the atmosphere from sources such as power plants, factories, automobiles, and residential furnaces. There are also natural sources of pollutants, such as forest fires and volcanic eruptions. Primary pollutants include sulfur dioxide, nitrogen oxides, ethylene, other volatile organic compounds, and heavy metals.

Secondary pollutants form when certain primary pollutants undergo chemical changes in the atmosphere. The two groups of secondary pollutants of most concern to crop and forest resources are photochemical oxidants and acidic deposition (popularly called acid rain). Photochemical oxidants, such as ozone, form in the atmosphere when the primary pollutants (volatile organic compounds and nitrogen oxides) react in the presence of sunlight. Acidic deposition forms when nitrogen oxides and sulfur dioxide react with oxidants and moisture in the atmosphere to form nitric acid

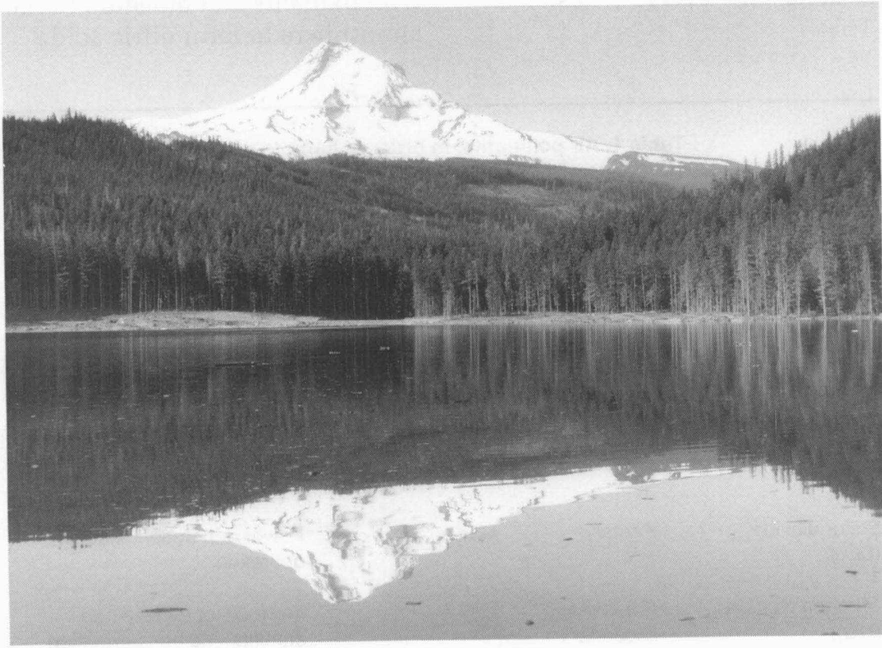
Table 1. Air pollutants, in order of harm to plants

Pollutant	Primary or secondary pollutant	Form	Major source(s)
Ozone (O_3)	Secondary	Gas	Product of chemical reactions in the atmosphere
Acidic deposition (sulfates and nitrates)	Secondary	Particulate	Product of chemical reactions in the atmosphere
Sulfur dioxide (SO_2)	Primary	Gas	Power generation, smelter operation
Nitrogen dioxides (NO_x)	Primary and secondary	Gas	From direct release and atmospheric transformation
Hydrogen fluoride (HF)	Primary	Gas/ Particulate	Superphosphate production, and aluminum smelters
Ethylene	Primary	Gas	Combustion, natural causes

and sulfuric acid; these are usually associated with wet deposition.

Ozone is the most important pollutant causing damage to crops and forests in the United States and will thus be the primary focus of this chapter. However, with the increase in large power plants over the past 20 years and the advent of high stacks, acid rain—resulting from sulfur dioxide and nitrogen oxides—has become of greater concern from a regional and national perspective. Some research, using expected levels of sulfur dioxide in the atmosphere, suggests that crop damage from ozone may increase slightly by the added sulfur dioxide; this could also be true for some sensitive forest species. The concern for acidic deposition, although a regional problem, has lessened following the intense studies on acidic deposition carried out during the 1980's. We touch briefly on wet deposition associated with acidic substances.

A final pollutant of regional significance is ethylene. Ethylene is a normal by-product of plant



The forest is a complex, interdependent community of plants and animals. Each living organism depends on the others. Vitally important to the health of the forest are factors such as soil quality, rainfall, and air quality, from which the forest gains nutrients. Pollutants enter the forests through the same pathways as nutrients.
Jack H. McCullough/USDA ORE-75343

metabolism and is considered a plant growth hormone. It is also a major emission from the automobile and can reach plant-damaging levels in the atmosphere. However, the information available on ethylene is too uncertain for consideration in this chapter.

Table 1 lists the air pollutants mentioned above, shows whether they are released directly from the source (primary pollutants) or are formed in the atmosphere (secondary pollutants), indicates the form of the pollutant, and lists the major sources.

The Air Quality System

We used to think that air pollution was just a city problem. Now, we know that pollutants can be transported hundreds of miles and can be found in elevated concentrations in rural and forested areas. The atmosphere can be thought of as an "ocean of air." Like an ocean of water providing dissolved nutrients and oxygen to aquatic plants, the ocean of air provides chemicals essential to terrestrial plants and animals. Like an ocean, the atmosphere also has the ability to spread, mix, and transport in its currents any polluting chemical put into it. Although pollutants emitted into the atmosphere eventually are deposited, they can travel hundreds of miles before coming to the ground. Exactly how these pollutants affect our agricultural and forest lands when they do reach the ground remains uncertain, but studies have provided some evidence of their effects on plants, and research continues.

For the assessment of crop and forest losses, a knowledge of both natural and synthetic sources of pollution is critical. This information permits the determination of maximum loading of the atmosphere for any given locality. Synthetic sources include mobile sources, such as automobiles, associated with pollutants of regional concern, as well as stationary or point sources. Transport and transformation processes must be understood to determine the distance a pollutant can be transported and the rate of loss or formation of different pollutants in the air masses. The concentration of gases in the atmosphere is related to the trace components, air movement, and atmospheric stagnation periods. Both ozone and sulfur dioxide can be transported long distances and cause problems in rural as well as urban areas.

To understand the effects of ozone or sulfur dioxide on crop or forest productivity, we must know:

- The atmospheric concentration to which the plant is exposed (the exposure concentration),
- The duration of each exposure, and
- The number of exposures during the growing season.

These three factors determine the exposure dose, which is the air quality unit that links the atmospheric scientist, the plant scientist, and the control official. The exposure dose is the air quality measure necessary to set an air quality standard. It can be used to determine gas uptake by the plant and is essential for a regional assessment.

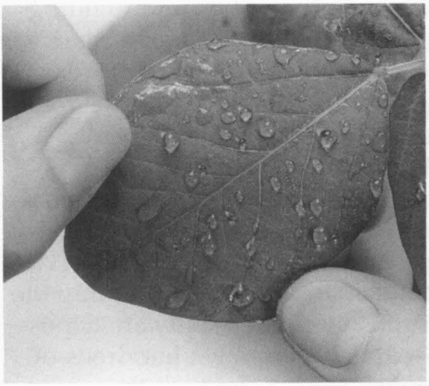
Air pollutants are removed from the atmosphere by both wet and dry deposition processes. Dry deposition of gases to plants occurs through small openings in the leaves called stomates. Ozone, sulfur dioxide, and other gaseous pollutants are taken up by plants in this way. When gases enter leaves they can cause a variety of physiological and/or biochemical responses. Depending on the concentration in the leaf, the effects may or may not affect crop or forest production.

To understand mechanisms by which air pollutants affect plant productivity, the effects on leaves must be understood. For assessment purposes, it is necessary only to relate reduction in productivity (yield of crops) with the exposure concentration of either ozone or sulfur dioxide. However, an understanding of mechanisms will improve our ability to predict the effects of different pollutant levels on crop or forest productivity.

Rain, snow, and dew are three wet deposition processes that deposit pollutants, such as acidic substances, on leaf surfaces. Although these substances can enter the leaf, the amount entering the leaf is less than from dry deposition. These substances are also less toxic than ozone or sulfur dioxide but can add to the impact of those two gases.

Symptoms of Leaf Injury

Visible leaf injury occurs as patterns of color change or dead tissue that result from major physiological disturbances in plant cells. Visible injury usually is classified as acute or chronic, depending on the length of exposure and the severity of the injury. Acute injury from both ozone and sulfur dioxide initially shows on the intact leaf as a slightly water-soaked or bruised appearance. The injury is caused by disruption of cell membranes which, if suffi-



Soybeans sprayed with a mixture simulating acid rain. Soybeans are affected adversely by acid rain. *Rob Flynn/USDA 89BW1683-6A* ciently severe, may result in the loss of cell contents and death of the cell. The affected areas generally dry out, producing necrotic patterns (dead leaf tissue) that tend to be characteristic of ozone or sulfur dioxide injury.

Chronic injury may be mild or severe. Initial disruption of normal cellular activity may be followed by leaf yellowing (chlorosis, the loss or reduction of the green plant pigment, chlorophyll) and/or other color or pigment changes; cell death may eventually occur. Chlorosis is a very common and nonspecific symptom in plants, somewhat analogous to anemia in animals. Other colors often appear from pigments normally masked by the green of the chlorophyll. Chronic injury may look like normal fall coloration (senescence) with or without loss of leaves.

Chronic injury patterns are generally not characteristic of a given pollutant and are easily confused with symptoms associated with other stresses. Chronic symptoms associated with ozone and sulfur dioxide injury may aid injury diagnosis but are not definitive for either gas.

Ozone: Broadleaf plants show upper-surface, red-brown spots (stipple); bleached tan to white areas (fleck); small irregular bifacial collapsed (necrotic) areas that may join to form irregular necrotic blotches; chlorosis and early fall coloration. Grasses show scattered necrotic areas (fleck) on both leaf surfaces; sometimes larger lesions or necrotic streaking may occur. Conifers may show brown-tan necrotic needle tips with no separation between dead and healthy tissues.

Sulfur Dioxide: Broadleaf plants show irregular necrotic areas bleached white to tan or brown which can occur on leaf margins or between veins of the leaf; chlorosis may be associated with necrotic areas, or a general chlorosis of older leaves may develop; diffuse to stippled colors ranging from white to reddish-brown have been observed.

Grasses show irregular, bifacial, necrotic streaking between larger veins that is bleached light tan to white; chlorosis usually is not pronounced. Conifers may show brown necrotic tips of needles often with a banded appearance; generally chlorosis of adjacent tissue occurs; needles of the same age are uniformly affected.

Impacts of Pollutants on Forests

Trees in forests are part of a complex, interdependent community of plants and animals. Each living organism in the community depends on others. The health of a forest also depends on certain nonliving factors, such as soil quality and rainfall. The chemistry and quality of the air are vitally important. Trees obtain nutrients from the soil through their roots; although it is less well known, trees also obtain nutrients from the air. Some nutrients are taken directly out of the air and into leaves; others fall onto the soil and are taken up by roots. Often, rain and clouds carry nutrients into the forest. Pollutants in the air and water can enter forests through the same pathways as nutrients. Most commonly, these nutrients enter into the forest through precipitation.

Normal precipitation contains many chemical compounds, including some of the nutrients plants need. Precipitation also can carry pollutants into forests. Trees may be exposed to air pollution in many forms, because pollutants can be brought into forests in gaseous or solid forms as well as dissolved in precipitation. Toxic metals (such as lead and cadmium) and aluminum, which are present in trace amounts in polluted air, can inhibit the uptake of needed nutrients and, on rare occasions, damage roots. Such damage increases a tree's susceptibility to winter injury.

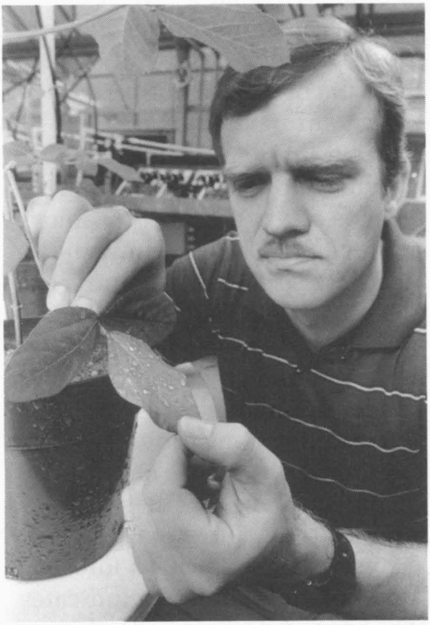
Forest declines and recoveries have been reported for at least several hundred years. Declines can occur from natural causes in areas where air pollution levels are very low. Determining if a decline is due to natural causes or to human causes—such as air pollution—can be difficult because symptoms from various causes often look the same. Furthermore, forest declines are caused by the interaction of more than one stress factor.

Other Effects of Ozone and Sulfur Dioxide

Both ozone and sulfur dioxide can affect various processes in sensitive plants at concentrations causing light to intense leaf injury. Research has shown that photosynthesis is a primary plant process affected by both gases. This means that the basic food-producing mechanism in the plant is affected. At the lowest level of effect, there is evidence in some plants that the reduced level of assimilate moves preferentially to new shoot growth at the expense of root growth. However, both shoot growth and yield of sensitive crop and tree species can be reduced by either gas.

Changes in growth rate can occur when plants are exposed during early vegetative growth, but normal growth resumes shortly after the exposure ends. Changes in the quality of the usable product can occur but are not always important. Changes in levels of plant metabolites have been found from exposures to each gas. These changes have been found for many enzyme systems in sensitive plants and in some more resistant plants. Although not all mechanisms of injury for either gas are understood, it is generally accepted that stomatal control of gas exchange and physiological factors play a role in plant sensitivity to both gases.

Variation in sensitivity to ozone or sulfur dioxide can be found among species and even among cultivars of single species. Most research has addressed annual field and vegetable crops, so our knowledge of perennial and woody species is more limited. However, we know that many woody plant species show sensitivity to either of these gases. In general, field corn and sorghum are considered to be two of the crops most resistant to either gas. Although the sensitivity of crop species to yield loss from sulfur dioxide is not as well documented as for ozone, some cotton, alfalfa, soybean, and tobacco cultivars are known to be very sensitive to sulfur dioxide.



Dennis Bubay inspecting the impact of acid rain droplets on soybeans.
Rob Flynn/USDA 89BW1683-10A

Some of the most important crops sensitive to ozone are soybeans, cotton, peanuts, tobacco, clover, alfalfa, dry beans, garden beans, potatoes, watermelons, other melons, and sugar beets. In all species studied, there is good evidence of resistance in the gene pool.

Many biological and physical factors, in addition to cultivar and species differences, affect the response of plants to ozone and sulfur dioxide. Biological factors such as plant diseases and insects can affect plant response. Environmental factors such as temperature, light, humidity, nutrition, and soil moisture can also affect plant response. Our knowledge of the effects of these factors on plant response to the two pollutants is not complete. A full understanding of their impact requires understanding the interrelationships among biological stresses and plant response to both ozone and sulfur dioxide.

Recent research indicates that the current level of ozone in rural areas causes growth and yield reductions in sensitive species, where concentrations are below the current ozone standard of 0.12 parts per million (ppm) for 1 hour. Sulfur dioxide concentrations in agricultural areas away from point sources rarely exceed 0.01 ppm for extended periods of time. Research to date suggests that regional concentrations of sulfur dioxide at or below these levels should not cause yield decreases in sensitive crop species. However, in the presence of ozone, these levels of sulfur dioxide may increase losses associated with ozone alone.

Effects of Acidic Deposition

Acidic deposition has been narrowly defined as the wet deposition (in rain, snow, or dew) of acid substances (nitric and sulfuric acids). A broader and more widely accepted definition includes the wet or dry deposition of acids or acidifying substances. The broader definition includes sulfur dioxide and nitrogen oxides in addition to the strong acids. In its broadest context, it has enveloped ozone, since ozone is part of the atmospheric acidifying process. However, we have confined this section to a discussion of wet deposition of acid substances, principally from rainfall.

The information on acid rain is not as extensive as that for ozone or sulfur dioxide. The current body of research indicates that acid deposition at current levels is not responsible for significant agricultural crop yield reductions. Soybeans are the only crop that would be adversely affected by rain that was slightly more acidic than current levels.

These negative impacts are counteracted by a "fertilization" effect, since sulfur and nitrogen deposition in acid rain provide part of the plant's nutrient requirements. Adam, Callaway, and McCarl estimated a $140 million benefit in 1980 dollars for a 50-percent reduction in acid deposition, when they excluded the "fertilization" effect. When the "fertilization" effect was accounted for, they estimated net benefits of reducing acid deposition to be negligible to negative.

This beneficial fertilizer effect is not as clear for forests. Excess nitrogen may be taken up through the roots or foliage of trees. Although nitrogen is an essential nutrient for plant life, excess nitrogen can disturb the nutrient balance or disrupt the physiology of the plant. We also know that acid deposition is not as directly damaging to forests as we once thought it might be. But acid deposition does cause changes in soil chemistry that might adversely affect forests over the long run. Similarly, acidic cloud water may be working together with other factors to further stress red spruce in high-elevation forests in the Northeast. Research indicates that ozone interferes with this tree's photosynthesis process.

Assessing Impacts of Ozone on Crop Production

In order to assess the economic effect of ozone on crop production, researchers study the response of the plant part intended for human use—the yield component. Local, regional, or national assessments of crop losses require three types of information: 1) a crop census indicating which crops are grown and their yields within a geographic unit such as a county or State, 2) an air quality data base for use in estimating the crop exposure dose, which covers the same geographic unit as the crop census, and 3) a crop response equation relating crop yield to the exposure dose.

USDA provides data on crop production on a county level every 5 years. In addition, crop production and yield data are reported each year on a State basis. These yield and acreage figures are averaged across cultivars to produce a countywide or statewide census for each crop. The county yield data for each crop are used in assessing the effects of ozone on crop yields.

The U.S. Environmental Protection Agency (EPA) has a large ozone data base that was used to develop the exposure dose on a county level.

Ozone exposure dose-crop response equations have been developed for a large number of crop species and cultivars through the National Crop Loss Assessment Network (NCLAN) program.

The National Crop Loss Assessment Network (NCLAN)

EPA initiated the NCLAN program in 1980 to help assess the impact of ozone on crop production. USDA's Agricultural Research Service was involved in planning and carrying out research in cooperation with EPA throughout the program. Four primary and three secondary regional sites were established to conduct field studies from 1980 through 1986. Forty-four field experiments on 17 crop species (38 cultivars and three genetic crosses) were run to determine the impact of ozone on growth and yield. Plants were grown under field conditions and exposed to different ozone exposure doses in open-top field chambers.

Thirty-five of the experiments included factors other than ozone, for example low soil moisture, sulfur dioxide, several cultivars, method testing, and detailed growth studies.

Yield loss estimates were obtained from crop response equations that reported yield loss on a percentage basis. The exposure dose was the seasonal mean of either the 7-hour or the 12-hour daily exposure period. The ozone monitoring data across the United States were interpolated by a technique called kriging to give estimated county level ozone exposure doses, and crop yields on a county basis were obtained from USDA. National yield losses were estimated from the models and were used in an economic model to derive estimated producer and consumer benefits with increasing and decreasing ozone concentrations.

EPA used the results from the NCLAN assessment program in considering a revision of the ozone air quality standard. The current standard is still 0.12 ppm for 1 hour, but longer term standards have been suggested based on the NCLAN data.

Estimated yield losses at current ozone exposure doses in the United States are shown in table 2 for several important agricultural crops. Soybeans were the most intensively studied crop, with 14 experiments using 9 different cultivars performed during the 7 years of the program. Cotton, with five studies and four cultivars, was the next most intensively studied of the major crops.

Cost to American Agriculture

Based on early crop response data, a number of regional and national economic assessments were made during the 1980's. Regional estimates found that crop losses due to ozone were about $30 million for Minnesota and about $670 million for the Corn Belt. National estimates based on different

Table 2. Yield losses of several crops from ozone

Crop	Percent yield loss under current ozone stress[1]
Alfalfa	7.1
Corn	3.3
Cotton	14.0
Forage	7.7
Peanuts	12.5
Sorghum	1.7
Soybeans	15.3
Tobacco	11.1
Wheat	5.8

[1]The percent losses shown are predicted losses based on a seasonal 7hr/day or 12hr/day average ozone concentration of 0.05 ppm. Actual seasonal averages across the U.S. for these time periods range from 0.035 to 0.065 ppm.

groups of crops ranged from $1.2 to $3.0 billion. Corn and soybeans were included in all of these estimates.

Early NCLAN data were used to develop an economic model from which the effects of reduced and increased levels of ozone on producer and consumer costs could be estimated and a total cost calculated. The economic estimates showed benefits of reduced ozone to both producers and consumers of agricultural produce. A final assessment effort using all NCLAN data and including some farm program provisions in the analysis gave results similar to the first assessment. The final results confirm that ozone causes a substantial economic cost to society. Increases in the yields of eight major crops associated with a 25-percent reduction in ozone would result in a $1.9 billion annual benefit, whereas a 40-percent reduction would result in a $2.8 billion annual benefit. In contrast, a 25-percent increase in ozone would cause an additional $2.1 billion annual loss in these same crops.

A summary of economic estimates currently available suggests that the current seasonal ozone concentrations are causing annual losses in crop productivity of more than $3 billion.

What Can Farmers Do?

Many times over the past 25 years, we have been asked to determine the cause of crop damage after plant pathologists and entomologists were unable to determine the cause. Often, we were able to determine that the probable cause was ozone. In all cases, the farmers would ask what they could do to help control or prevent the damage. This has been a most frustrating question for researchers as well as farmers. The truth is that we have no good answer for the farmer that can be put to use in a reasonable time or with a high expectation of success. We have three principal options:

- Management practices,
- The use of resistant cultivars, and
- Education.

There are no specific management practices that can be widely recommended for controlling ozone effects on any crop species. However, some practices may be used in some circumstances to reduce the effects of ozone on plants. In greenhouse operations, for example, withholding water or minimizing water use before and during periods of high ozone should reduce the plant's sensitivity to ozone. Likewise, when irrigation applications in regular farming operations can be planned to avoid days when high ozone is predicted, there should be less damage from ozone. There are chemicals that give some protection of selected crops from ozone exposure. These have been tested, but results to date are tentative and the chemicals are too costly for recommendations to be made. Beyond these, no specific practices can be recommended.

The use of resistant cultivars is the only acceptable tool for the farmer. We know that resistant germplasm is present in all major crops that have been tested. Likewise, there are a number of resistant cultivars on the market and in use. Most of these are being inadvertently used by farmers because other qualities of the cultivars are desirable. Currently however, there are no specific programs with a focus on breeding for ozone resistance. Such programs may or may not become viable depending on the success of current ozone control strategies. Farmers could request information on the likely susceptibility to ozone of crop cultivars that they plan to use.

Our primary recommendation to farmers is to become knowledgeable about the effects of ozone on crop production systems and to give some consideration to cultivar selection and management practices where they may be helpful. A knowledge of the symptoms associated with ozone on the crops of interest and how these translate to effects on yield can be used to help the farmers make management decisions. Those who keep up with EPA attempts to control ozone concentrations will have a better idea of the future importance of ozone in production management. ■

Alternative Fuel Sources

18

by John W. McClelland, Agricultural Economist, Office of Energy, USDA, Washington, DC

President Bush declared that "Every American expects and deserves to breathe clean air . . . . " Toward that end, agriculture has a crucial role to play. Farm products not only can substitute for fossil fuels, but are also renewable, and we do not have to depend on other countries for them. Agriculture also must adjust, along with other sectors of the U.S. economy, as the Nation moves closer to the goal of clean air.

Passage of the 1990 Clean Air Act Amendments marked the first major overhaul of the Nation's clean air legislation in more than a decade. This legislation will have a significant impact on U.S. agriculture. Mandates for clean fuels and oxygenated fuels are likely to boost the demand for tested, but results to date are tentative and the chemicals are too costly for recommendations to be made. Beyond these, no specific practices can be recommended.

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Passage of the 1990 Clean Air Act Amendments marked the first major overhaul of the Nation's clean air legislation in more than a decade. This legislation will have a significant impact on U.S. agriculture. Mandates for clean fuels and oxygenated fuels are likely to boost the demand for ethanol and nearly double the size of the industry by the year 2000. Further, the Budget Reconciliation Act of 1990 extends to the year 2000 tax credits that help make ethanol cost-competitive with other clean fuel additives. These tax credits, combined with the successful development of ETBE (ethyl tertiary butyl ether), an ethanol oxygenate compound, could increase the yearly demand for ethanol by 535 million gallons before the turn of the century.

Corn is the main feedstock used in ethanol production, but research and development money provided in the 1990 farm bill will help develop improved conversion technologies and diversify alternative fuels production in the agricultural sector. Research on using vegetable oils to produce a marketable replacement for diesel fuel could also increase the demand for these oils. This total package of legislation, research, and development could increase net farm income and provide American farmers with an opportunity to have a positive impact on an important resource: the air we breathe.

In this chapter, we will discuss those provisions of the Clean Air Act and other recent legislation that affects U.S. agriculture.

Carbon Monoxide Nonattainment Areas

Carbon monoxide is formed when fuels are burned incompletely. Automobile fuels, in particular, do not burn well at high altitudes because the oxygen content in the atmosphere is reduced and there is no oxygen in conventional gasoline. Cold weather can also increase the amount of carbon monoxide produced by automobile emissions. Carbon monoxide gets priority attention in the Clean Air Act because high levels of carbon monoxide are known to be hazardous to human health.

Under the Clean Air Act Amendments, carbon monoxide nonattainment areas are designated as moderate or severe. Table 1 shows the atmospheric levels and mandated dates for attainment. States with areas designated as moderate must make an inventory of all carbon monoxide sources and take steps to enhance vehicle inspection and monitor vehicle miles traveled. Areas of serious carbon monoxide nonattainment must meet these same standards as well as the standards for a severe ozone

Table 1—Carbon monoxide classification areas

Area classification	Design value	Attainment date
Moderate	9.1 to 16.4	Dec. 31, 1995
Serious	16.5 and above	Dec. 31, 2000

nonattainment area (see table 2 and discussion below). There are also provisions for controlling particulate matter from stationary and nonstationary sources, along with standards for sulfur dioxide, nitrogen dioxide, and lead.

Ozone Nonattainment Areas

Ozone is of major concern because ozone pollution is caused by the presence in the atmosphere of nitrogen oxide and other volatile organic compounds (VOC) that interact with sunlight to create smog. VOC's result from the evaporation of gasoline and other solvents, and from car and truck exhaust. Nitrogen oxides result from burning fossil fuels, including gasoline and coal. Ozone is a greenhouse gas that contributes to global warming. Aside from its contribution to global warming, ozone pollution is also associated with human health problems, and significant reductions in crop yields have been reported. Even brief exposure to high levels of ozone can cause temporary loss of some lung function, but there is only limited understanding of the risks of long-term exposure. Scientists in California estimate yield reductions as high as 45 percent for some crops in areas with high levels of ozone pollution.

According to the new Clean Air Act Amendments, areas can be classified as ozone nonattainment areas if they fall into any of the five categories listed in table 2. States that contain all or part of a nonattainment area are required to submit both State-level implementation plans for compliance with the law and a State emissions inventory. Areas classified as moderate or above are required to reduce emissions of VOC's and nitrogen oxides. Areas classified as serious or above will further be required to provide economic incentives for moving toward clean fuel vehicles. Severe areas must, in addition, enact an emissions reduction program that offsets any increase in emissions that would

Table 2—Ozone classification areas

Area classification	Ozone design value (parts per million)	Deadline for compliance
Marginal	.121 up to .138	3 yrs. after enactment
Moderate	.138 up to .160	6 yrs. after enactment
Serious	.160 up to .180	9 yrs. after enactment
Severe	.180 up to .280	15 yrs. after enactment
Extreme	.280 and above	20 yrs. after enactment

be caused by an increase in vehicle miles traveled. Finally, extreme areas must meet all previously mentioned requirements and make further use of clean fuel technologies at large commercial sites.

Methane

By 1992, the Environmental Protection Agency (EPA) Administrator is required to submit reports to Congress that identify the activities and processes for reducing methane emissions. The EPA Administrator must also prepare, with the Secretary of Energy and the Secretary of Agriculture, a report that will include an evaluation of methane emissions from agricultural activities. In particular, the report must include an inventory of activities in rice farming and livestock production, and the intentional burning of agricultural waste, grassland, wood, and forests.

Within 2 years after the studies are completed, the Administrator must submit a report to Congress outlining measures that could stop or reduce methane pollution from these sources. It is difficult to determine what steps might be taken to meet methane reduction goals in the agricultural sector, and the effects they will have. They could include regulations on waste disposal and changes in production practices. One possibility would be to improve existing technology that allows farmers to capture the methane from farm waste and convert it to usable forms of energy.

Ethanol's Role in Clean Air

Ethanol began to attract attention as a motor fuel additive in the late 1970's when the Federal Government got serious about eliminating lead emissions. Ethanol is an octane booster and can be used as a substitute for lead, and for VOC's, such as benzene, that have also been used as lead substitutes. Ethanol contains oxygen and thus can be used as an ingredient in oxygenated fuels. There is also a process that uses ethanol to remove sulfur and other impurities from coal, thus reducing sulfur dioxide emissions that contribute to acid rain.

The Clean Air Act Amendments call for the EPA to issue regulations establishing requirements for reformulating gasoline. The regulations are to be in place by October 1, 1992, for carbon monoxide nonattainment areas, and January 1, 1995, for ozone nonattainment areas. These regulations will also include the following requirements:

- Nitrogen oxide emissions from reformulated gasoline cannot exceed those from standard gasoline.
- The oxygen content of reformulated gasoline must exceed 2 percent by weight in ozone nonattainment areas and 2.7

percent by weight in carbon monoxide nonattainment areas.

- Benzene content cannot exceed 1 percent by volume.
- There can be no lead in reformulated gasoline, and aromatic hydrocarbons (these include benzene, toluene, and xylene) must not exceed 25 percent by volume.
- Fuel volatility (evaporation rate) must be reduced during the summer in high-ozone areas.

A system of market credits will also be established that allows producers to earn credit for reformulated gasoline that exceeds these standards. The credit system will allow distributors to average the oxygen content of all gasoline sold in a nonattainment area. Thus, a distributor may average the oxygen content of gasoline exceeding the standard with that of gasoline below the standard, and have the average of the two meet the standard.

Ethanol can be used as a blending agent to achieve the requirements of new regulations for reformulated gasoline. Gasohol contains 3.7 percent oxygen, well above the required standards—thus providing blenders with possible market credits. Since ethanol is an octane booster it can replace lead and aromatics in gasoline blends. Ethanol does increase fuel volatility (the rate at which VOC's evaporate into the atmosphere), but the legislation provides an ethanol exemption by setting higher volatility standards for ethanol blends.

Ethanol Demand From the Clean Air Act

Ethanol is not the only fuel additive that can be used by gasoline producers to meet the new standards. Methanol is an alcohol produced from natural gas or coal. Methanol alone cannot be easily blended with gasoline to produce a usable fuel. However, it can be converted to an ether called methyl tertiary butyl ether (MTBE) that can be blended easily with gasoline.

A major advantage of MTBE blends over ethanol blends is cost. MTBE blends can be produced at the refinery and transported in standard pipelines, while ethanol must be splash-blended and cannot be shipped in a pipeline. Ethanol blends also require increased diligence on the part of blenders and service station operators to maintain clean tanks that are not contaminated with residues from other fuels, water, or dirt. Ethanol is a solvent that will readily take these impurities from contaminated facilities and hold them until they are filtered or burned. This causes plugging of filters in gas pumps and cars, adding to the cost of providing ethanol blends.

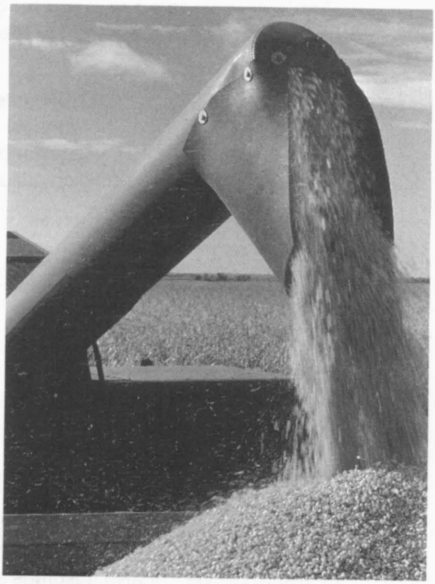
In 1990 the United States produced about 875 million gallons of ethanol. Ethanol's advantage is its high oxygen content. The EPA allows ethanol to be blended at a 10-percent rate to produce gasohol. Gasohol has an oxygen content of 3.7 percent. MTBE can be blended at a 15-percent rate, but contains only 2.7 percent oxygen; 11-percent MTBE blends contain 2.0 percent oxygen.

Under the regulations, blenders could get by using only MTBE blends, but in carbon monoxide nonattainment areas, all gasoline sold during times of the year when oxygenated fuels are required would have to be reformulated, and distributors would not be able to earn any credits. Using gasohol would allow sellers of gasoline to take advantage of credits because the high oxygen content of gasohol could be averaged with straight gasoline or MTBE blends to meet the minimum requirements.

While cost will be a consideration, the passage of the Clean Air Act will cause the demand for ethanol to increase. USDA and EPA have estimated that 20 percent of the market for oxygenated fuel will go to ethanol in 1993. This would require an additional 246 million gallons of ethanol, the equivalent of 98 million bushels of corn. Current annual U.S. ethanol production stands at 825 million gallons. Table 3 shows preliminary estimates of additional ethanol demand up to the year 2000 and the corn feedstock equivalent. Actual demand will depend on future technologies for producing ethanol and on future policies.

Enhancing Ethanol

An important innovation that may soon have an effect on ethanol's position in the market is ethyl tertiary butyl ether (ETBE). ETBE is made from ethanol and isobutylene, an oil refinery gas. ETBE incorporates the positive properties of neat (100 percent) ethanol, but ETBE blends, similar to MTBE, can be transported in pipelines and handled as regular gasoline.



Corn is the main feedstock used in ethanol production. However, research and development provided for in the 1990 Farm Bill will help develop new technologies that can permit use of diversified alternative fuels that will be produced in the agricultural sector.
Gene Alexander/USDA SD-885-23A

This will reduce some of the additional costs associated with neat ethanol. ETBE also reduces fuel volatility to levels that meet the new standards. A recent study by Phillips Petroleum Corporation found ETBE to be superior to both ethanol and MTBE as a blending agent.

Because ETBE is still experimental, it is difficult to predict its effect on the oxygenated fuel market. Positive test results suggest that ETBE could strengthen ethanol demand over the next 10 years.

Vegetable Oil as a Diesel Fuel Substitute

Unprocessed vegetable oils such as soybean, sunflower, rapeseed, and crambe oil tend to be 20 times or more thicker than diesel fuel. They will not flow in cold weather and when burned produce sticky deposits on engine parts, quickly leading to engine failure.

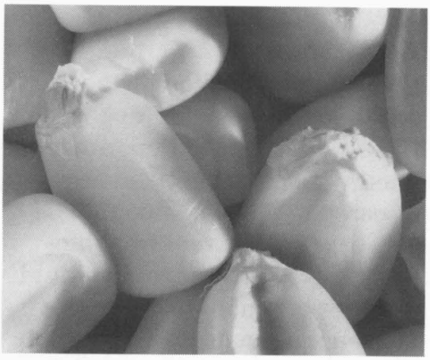
Table 3—Estimated demand for gasoline, oxygenated fuel, ethanol, and corn feedstock to meet Clean Air Act, 1993-2000

Year	Gasoline (billion gallons)	Oxygenate (ethanol equivalents) (million gallons)	Ethanol[1] (million gallons)	Corn feedstock (million gallons)
1993[2]	115.4	1,230	246	98
1994	116.5	1,242	248	99
1995[3]	117.7	2,544	509	204
1996	118.9	2,570	514	206
1997	120.1	2,596	519	208
1998	121.3	2,622	524	210
1999	122.5	2,648	530	212
2000[4]	123.7	2,674	535	214

[1] Assumes 20 percent market penetration.
[2] Clean Air Act (CAA) requires 2.7 percent oxygen in 41 cities not meeting the CO standard, effective Oct. 1, 1992. (Assumes a 4-month winter CO period with an additional month spillover to assure delivery. It also assumes a 15-percent spillover into adjacent areas that are in compliance due to distribution patterns).
[3] CAA requires 2.0 percent oxygen yearround in nine cities not meeting the ozone standard, effective Jan. 1, 1995. Assumes a 15-percent spillover into adjacent areas that are in compliance due to distribution patterns).
[4] CAA requires 3.1 percent oxygen in any area not meeting the CO standard by Jan. 1, 2000. The estimates shown do not consider the impact of any area not meeting the standard.

But through a process called esterification, whereby ethanol or methanol is added in the presence of a catalyst, a restructured vegetable oil is formed that is nearly equivalent to diesel fuel. It even has some properties that make it superior to diesel, including its extremely low level of sulfur and sharply reduced particulate levels. Even a 15-percent blend of esterified vegetable oil will sharply reduce the smoke from a diesel bus, truck, or tractor. Esterified vegetable oil can replace or be blended with diesel fuel, without affecting engine service life.

Research is continuing to determine the exact components of vegetable oil emissions and to improve the conversion process and reduce production costs so that it can compete with diesel fuel.



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USDA BN-14327

How Other Legislation Affects Alcohol Fuels

Two other pieces of legislation passed in 1990 will also facilitate development and production of ethanol from agricultural products.

The 1990 farm bill authorizes $20 million for each fiscal year, 1991 through 1995, for research on alcohol fuels, industrial oilseed crops for diesel and petrochemical substitution, and other biomass as a feedstock for alcohol production. The bill provides that at least 50 percent of these funds be made available for research on technologies to increase the energy efficiency and commercial feasibility of alcohol production.

Research priorities include improvement in cellulose conversion and membrane technology, improvement of byproducts as animal feed, and development of new markets for byproducts. Appropriations for fiscal year 1991 are $514,000. The provisions of this bill could significantly improve the technology used to produce alcohol fuels and diversify the number of agricultural products that can be converted to alcohol.

The Budget Reconciliation Act of 1990 extends tax credits for ethanol as an alternative fuel under the Clean Air Act, because it affects the cost of producing ethanol and the market price of ethanol. This Act changes the alcohol fuels tax credits and provides an additional tax credit for "small" producers of ethanol. The tax credit for producers or blenders has been reduced from $.60 per gallon of ethanol to $.54 per gallon. In lieu of the income tax credit, a $.054 per gallon exemption from the Federal fuel excise tax may be claimed for sales of fuel that is 10 percent ethanol. These exemptions are extended through the year 2000. The law also provides small producers with an additional $.10 per gallon income tax credit for the first 15 million gallons of ethanol production from facilities that have a total annual production capacity of less than 30 million gallons. These provisions help to make ethanol cost-competitive in the marketplace. They also provide additional incentives for small producers who lack economies of size, and for those who may use other feed stocks, such as cheese whey, which are available in areas outside the Corn Belt. ■

Interagency Alternative Fuels Research

19

by Roger Conway, Director, and Earl Gavett, Consultant, Office of Energy, USDA, Washington, DC

USDA fosters clean air goals by coordinating with other Federal agencies in order to achieve environmental objectives as efficiently as possible. Some of these efforts have just begun; others are recently completed or still in process. All of these efforts seek to achieve and maintain cleaner air while at the same time supporting strong and sustainable economic growth with a sound energy policy. Whenever possible, market-based approaches are pursued.

USDA and DOE Work Together on Alternative Fuels Research

USDA and the U.S. Department of Energy (DOE) are collaborating on research to develop alcohol and substitute diesel fuel from biomass energy crops, which would enhance air quality and improve U.S. energy security. To facilitate this cooperation, a Memorandum of Understanding was recently approved by the two Departments. The Memorandum provides a strategy that outlines goals, opporfuels tax credits and provides an additional tax credit for "small" producers of ethanol. The tax credit for producers or blenders has been reduced from $.60 per gallon of ethanol to $.54 per gallon. In lieu of the income tax credit, a $.054 per gallon exemption from the Federal fuel excise tax may be claimed for sales of fuel that is 10 percent ethanol. These exemptions are extended through the year 2000. The law also provides small producers with an additional $.10 per gallon income tax credit for the first 15 million gallons of ethanol production from facilities that have a total annual production capacity of less than 30 million gallons. These provisions help to make ethanol cost-competitive in the marketplace. They also provide additional incentives for small producers who lack economies of size, and for those who may use other feed stocks, such as cheese whey, which are available in areas outside the Corn Belt. ■

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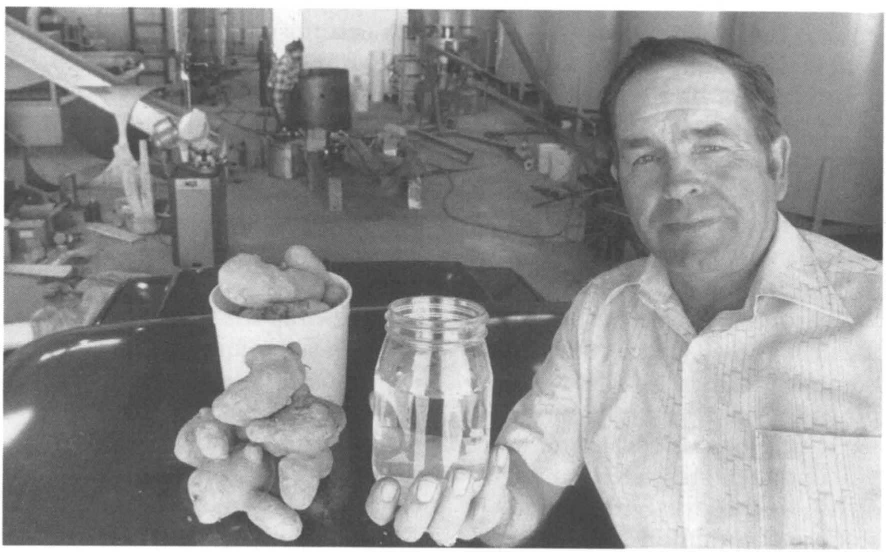
An immediate collaborative goal is to develop the biomass energy crops. Specifically, we want to develop environmentally benign, cost-competitive alcohol fuels from grain, as well as diesel fuel substitutes from vegetable oil feedstocks in the short run, and lignocellulosic energy crops (fast growing trees and grasses) in the long run.

From the USDA perspective, this research provides an opportunity to develop and commercialize a number of new farm and forest products that can utilize up to 150 million acres of farm productive capacity.

Is there enough land for a large-scale effort, and what is the likely influence on agriculture and forestry markets? One of the bases used for calculating the potentially available land resources suitable for conversion to energy crops is the National Resources Inventory conducted by the Soil Conservation Service every 5 years. This inventory indicates whether there is an adequate land



These misshaped potatoes (roughs) are the raw material that Ferrell Palmer uses to produce 190-proof alcohol to run his farm equipment. The mash that is left over is used as a protein supplement for his cattle.
USDA 1080X1288-9A

base for large-scale biomass energy production in addition to conventional food and fiber production. The success of the Conservation Reserve Program (continued in the 1990 farm bill), which was designed to remove highly erodible cropland from farm production, indicates there is indeed much cropland in excess of that required for current food crop needs, which might be suitable for short-rotation woody and herbaceous energy crops that are environmentally benign.

Research projects on energy feedstock production and conversion technology are the two principal areas where USDA and DOE resources will be coordinated. In the past, USDA has had a program in both feedstock production and conversion technologies related to production of liquid transportation fuels. USDA will maintain this expertise while collaborating with DOE, which has shifted its biomass research emphasis primarily to feedstock conversion.

The principal technical goal of the partnership is to further lower the cost of feedstock production. Some ways to do this are to improve the energy quality of the feedstock for less costly and more efficient conversion and to increase the productivity of feedstock species in tons per acres per year over wide geographical areas. A key focus of the research will be to integrate biotechnologies, such as genetics, with plant breeding to:

- Identify desirable energy traits that can be genetically modified to increase energy content,
- Define genetic heritability to improve the chemical composition of energy crops,
- Use environmentally sound amounts of water, nutrients, pesticides, and herbicides, and
- Expand plant adaptability to climate and geography.

Reducing costs in the conversion process will also allow ethanol and methanol from biomass to become more competitive with gasoline. USDA is focusing on converting more of the energy in corn to ethanol, while DOE has a major program to efficiently convert cellulose from wood and other nonstarch nonfood crops to ethanol.

For ethanol to become more competitive, the USDA/DOE partnership will address:

- Decreasing the reaction time and increasing the ratio of conversion,
- Increasing the yield and concentration of ethanol,
- Producing key enzymes more rapidly and cheaply,
- Improving the utilization of xylose (a sugar) and lignin (the glue that holds wood and grass cells together) contained in these plants, and
- Decreasing undesirable byproducts.

For methanol to become more

competitive, research targets will include:

- Increasing synthesis gas production from biomass for methanol conversion,
- Improving synthesis gas cleanup, and
- Increasing gas compression.

For vegetable diesel oil, research is progressing toward developing a pilot plant for economic conversion of vegetable oils and analysis of their emissions.

National Energy Strategy

On July 26, 1989, President Bush directed the Secretary of Energy to develop a comprehensive National Energy Strategy (NES). Besides increasing the efficiency of energy use and securing future energy supplies, an important goal was to develop policies that respect the environment.

The goal of the NES is to improve environmental quality through policies that emphasize clean and efficient energy sources and technologies without sacrificing economic growth or affordable energy. Energy policies need to enhance environmental quality and protect public health. Environmentally sensitive energy policy plus science and technology can reduce any adverse effects on the biosphere of energy production, distribution, and conservation.

USDA participated with many other agencies to help fashion the plan, by participating in working groups on such issues as energy supplies, alternative fuels, electricity, technology transfer, and environmental effects—to provide information on the contributions agriculture can make in these various areas.

The Clean Air Act and the Memorandum of Understanding between USDA and DOE for alternative fuels research are two important environmental policy pillars of NES. Another key aspect of NES is the Budget Reconciliation Act of 1990. This law extended through December 31, 2000, the Federal subsidies for ethanol; it will provide support for the continuation and growth of this important clean air alternative fuel.

USDA is currently engaged in its own climate change initiative. This initiative will correspond to the NES goal of pursuing research aimed at resolving uncertainties associated with potential global climate change.

Interagency Commission on Alternative Motor Fuels

USDA is an active member of the Interagency Commission on Alternative Motor Fuels. The purpose of the Commission, chaired by the Secretary of Energy, is to develop a national alternative motor fuels policy and to coordinate efforts to implement such policy.

The Interagency Commission has identified liquid fuels from renewable biomass as a significant alternative energy source for the

Nation in the coming decades. The Economic Policy Council, in developing the NES under the leadership of the Secretary of Energy, has concurred with the Commission on the potential of liquid transportation fuels from renewable biomass.

However, policies and programs designed to produce major volumes of biomass fuel from agricultural resources must be coordinated with agricultural policies and commodity programs to ensure that some specific resources are not overextended while others are neglected. Close coordination and cooperation are essential if we are to minimize any adverse effects.

The objectives of the Interagency Commission on Alternative Motor Fuels can be met by modifying agricultural policy to reduce commodity surpluses and commodity program costs while at the same time providing farmers and foresters with new opportunities to produce biomass energy crops on land that otherwise might be idled. By more effectively utilizing our agricultural resources to produce transportation fuels, we can revitalize our rural areas, improve our balance of trade, and increase our energy security.

The Leaded Fuel Issue

In the early 1970's concern over air pollution, on the part of both health officials and the public, resulted in the Environmental Protection Agency (EPA) seeking ways to reduce exhaust emissions for automobiles. In 1973, the catalytic converter was introduced on new automobiles as the most practical way to reduce noxious exhaust emissions. Lead (tetra ethyl lead) in gasoline was found to quickly and permanently destroy the converter's catalyst, so new cars had to operate on unleaded gasoline.

To prevent misfueling, vehicles were manufactured with smaller nozzle gasoline tanks. The leaded gasoline pump nozzle would not fit into the tank. Both leaded and unleaded gasolines became readily available.

During this period, health concerns heightened over the effects of lead pollution on humans. Lead was banned as a component in household paints, as children had been found to suffer serious mental retardation after eating chips and peelings of leaded paint. Atmospheric lead, such as that from automotive emissions, was found to similarly affect children and was implicated in elevated blood pressure levels in adult males.

In 1982, EPA started a program to reduce lead in the atmosphere by lowering the maximum content of leaded gasoline from 2.5 grams per gallon to 1.1 grams per gallon. On July 1, 1985, EPA lowered the lead content of leaded gasoline from 1.1 grams per gallon to 0.50 grams per gallon and subsequently lowered the level to 0.10 grams per gallon effective January 1, 1986.

In 1985, EPA also proposed to ban leaded gasoline as an automotive fuel as early as January 1, 1988. This announcement concerned the USDA and the farm community. Farm equipment is built to be extremely durable so that it can stand up to heavy draft loads and the rough terrain in which it must operate. Accordingly, farmers were still using millions of tractors, combines, and trucks that were designed to use leaded gasoline.

Tetra ethyl lead, in addition to its octane-boosting power, served as a lubricant in the engine's cylinders. As the gasoline is burned, lead oxide compounds are deposited on the surfaces of the engine's valves and combustion chambers. The lead oxide layer serves as a cushion or lubricant against the impact of valves slamming shut against the valve seats—which would occur thousands of times per minute in an operating engine. Lead deposits also lubricate the valve stems as they slide through valve guides, greatly reducing the rate of wear.

USDA and the farming community expressed concern that older farm engines designed to operate on leaded gasoline might be damaged using low-lead or unleaded gasoline. In response, Congress required that EPA and USDA jointly study the use of fuels containing nonlead additives and alternative lubricating additives on gasoline-powered agricultural machinery.

The USDA/EPA engine tests determined that the low lead level of 0.10 grams per gallon was sufficient for controlling valve seat recession. Tests of nonlead additives indicated that when used at the additive manufacturers' suggested dosage, valve seat recession was not controlled. However, when one additive was tested at 4 times the manufacturers' recommended level, recession was stopped but significant engine deposits developed. USDA concluded that more testing was necessary before it could recommend use of nonlead additives in unleaded gasoline for older farm engines.

USDA determined by survey that there were about 1,800,000 tractors, 271,000 combines, and 750,000 trucks (larger than 1-ton capacity) with gasoline engines on U.S. farms. About 58 percent of the tractors were in medium and heavy uses that would make them vulnerable to excessive valve seat wear if fueled with unleaded gasoline. However, some one-third of all gasoline-powered tractors may have hard valve seats, which would not be vulnerable to valve seat recession with unleaded gasoline.

All combine engines have hard use, as do many farm trucks. Thus, many of these units would also be vulnerable to excessive valve seat wear.

The cost to farmers to eliminate leaded gasoline is sizeable. On average, it costs about $1,000 for an engine overhaul to replace valves and valve guides and to insert hardened valve seats. If all the vulnerable units were rebuilt, it would add from $1 billion to $1.5 billion to farmers' production costs.

Given the inability of so many gasoline-powered farm machinery units to operate successfully on unleaded gasoline and the heavy cost to repair or replace these units, the EPA agreed not to proceed with the regulation to ban leaded gasoline. They felt that by reducing the lead level from 2.50 grams per gallon to 0.10 grams per gallon they had reduced about 98 percent of the lead in the atmosphere from the 1970's level. With fleet turn-over and reduced market demand, EPA concluded that over time leaded gasoline would disappear without their intervention.

Four years have passed and leaded gasoline now represents less than 5 percent of total motor gasoline. Leaded gasoline generally is no longer available except in a few Midwestern States.

Clean Air Act Amendments of 1990

The new Clean Air Act, in addition to the requirements discussed in the preceding chapter, includes some specific requirements for the Secretary of Agriculture in concert with other agencies.

One amendment requires the Secretary of Agriculture to participate with EPA and others in determining the effectiveness of nonlead fuel additives in protecting farm equipment engines.

Another section requires the Secretary of Agriculture to conduct, with EPA and DOE, studies on the emissions of methane from domestic sources. One report is required on methane from agriculture including that from production of rice and livestock. Another report is required on methane emissions from intentional biomass burning including agricultural wastes, wood, grassland, and forests. Other energy provisions having impacts on agriculture are identified.

Within 2 years of the completion of the above methane studies, EPA must submit to Congress a report on options that could be implemented to stop or reduce growth in methane concentration from domestic sources.

The act bans the production, sale, or introduction of engines that require leaded gasoline after model year 1992 and directs EPA to ban the sale and use of leaded gasoline after 1994. The act directs USDA and EPA to develop a procedure for testing nonlead additives to prevent valve seat recession in engines designed for leaded gasoline; it also requires all additive manufacturers who wish to register their products with EPA to submit their products for testing. Thus, farmers should not have to incur major farm machinery repair costs.

EPA will contract with a laboratory which has done research on alcohol esters of rapeseed oil to evaluate the feasibility, engine performance, emissions, and production capability associated with an alternative to diesel fuel composed of ethanol and high erucic-acid rapeseed oil. The EPA must report the results of this study to Congress within 3 years of issuing the contract. USDA and DOE have jointly funded this alternative diesel fuel research at the University of Idaho.

Bioenergy Coordinating Committee

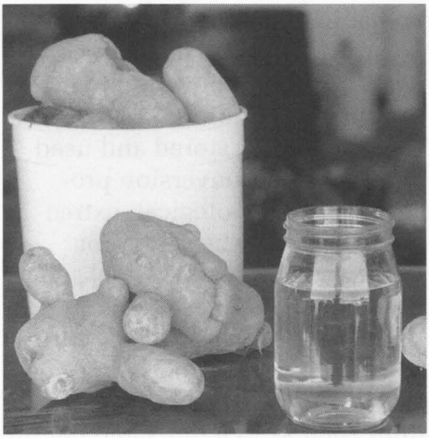
The Bioenergy Coordinating Committee aims to facilitate exchanges of research information among various Government agencies. Participants include USDA, DOE, the Department of State, and the National Science Foundation, as well as nonprofit institutions such as the Office of Naval Research. A prime focus of this information exchange is the relationship between biomass as a source of energy and as an enhancer of air quality.

One of the major benefits of using renewable biomass is that carbon is recycled in a short time and no additional carbon is released. Fossil fuel, by contrast, uses previously sequestered carbon and, thus, adds more carbon to the environment. It can play an important role in contributing to global warming.

Many renewable energy forms from biomass are highly viable. Sources encompass much of the plant kingdom and include trees, seeds, fruits, the residues or byproducts of various extraction and food-processing operations, and animal manure. Biomass may be burned directly to produce heat or may be converted to more useful solid, liquid, or gaseous forms. It can be stored and used later for fuel. Conversion processes can be biological, extractive, or thermochemical. For example, biomass feedstocks for gasification could include agricultural crop residues such as corn cobs, corn stover, and wheat and rice straw; crop processing residues such as rice hulls and cotton gin waste; or forestry products and residues such as wood, woodbark, and logging and mill residues.

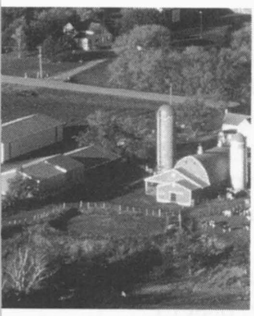
In 1990, about 81 quads of energy were used in the United States. (A quad is a measure of energy that equals 10^{15} British Thermal Units.) Of this total, 3.5 percent or 2.8 quads were from biomass sources. Wood is the principal biomass feedstock for energy, with 1.3 quads used by the wood products industry to furnish virtually all process heat and about half the electrical demand of that industry. Another quad of wood energy is used in heating residences and the remainder is used by institutions and the commercial sector.

The ethanol industry is a well-known biomass source and currently provides about 825 million gallons of high-octane liquid fuel to the gasoline industry. Blended at the rate of 10 percent ethanol and 90 percent gasoline, ethanol blends represent approximately 7 percent of the gasoline market.



A collaborative goal of the USDA and the U.S. Department of Energy is to develop biomass crops. Biomass crops are crops that may be used to produce environmentally benign, cost-competitive alcohol fuels from grain, as well as diesel fuel substitutes from vegetable oil feedstocks.
USDA 1080X1288-32

A promising biomass energy option is the use of animal waste. By fermenting animal waste in an anaerobic digester, the waste is broken down into methane, carbon dioxide, water, and fiber. The methane can be burned to produce hot water or space heat or used in an internal combustion engine to produce shaft power or electricity. Currently, there are about 100 anaerobic digesters in the United States producing hot water or electricity. Most of them are operating on dairy farms. There is a potential for many thousands of these energy facilities on livestock farms. In addition to producing energy, the digester produces a powdery substance that contains all the nitrogen, potassium, and phosphate that was in the original manure. But the nitrogen is converted into a form more readily useable by crops, thereby making this an excellent fertilizer. ■



Part IV Technology

Introduction by
Charles E. Hess,
Assistant Secretary,
Science and Education

Through technology, the United States has developed the most efficient food and fiber system in the world. In fact, it is because of our advanced agricultural technology that the average American spends only about 12 percent of disposable income for food—down from 15-18 percent 20 years ago.

Therefore, as we become more and more sensitive to the environmental implications of agriculture, it is only natural that we consider technology—specifically agricultural research—as an essential part of the equation.

Overall, agriculture seeks to operate in an environmentally responsible fashion, while continuing to produce abundant supplies of food and fiber both economically and profitably. One way of doing this is through sustainable agriculture. Though there are many different definitions of this term, it is basically the use of the very *best* of technology in a balanced, well-managed, and environmentally responsible system that is at the same time economically viable. It relies on skilled management and scientific know-how. All the agricultural sciences—and especially the newest one, biotechnology—are helping to reduce the impact of food production systems on the environment while still allowing agriculture to be a profitable way of life.

This is most emphatically *not* a return to the low-tech methods of the 1930's. It does not mean going back to hoes, hard labor, and low output. In fact, it can include such state-of-the-art technologies as computer models, electronic monitoring, and remote sensing to promote the most efficient pesticide and fertilizer use.

As an example, rather than relying solely on the chemical pesticides, herbicides, and fertilizers that aided our abundant production in the past, biotechnology now gives us the ability to introduce disease or insect resistance directly and precisely into plants through recombinant DNA technology and permits the exchange of genetic information between completely unrelated organisms.

Through sustainable agriculture, USDA can help provide farmers with a wide range of options to best fit their economic and environmental situations. The choices range from the optimal use of fertilizers, pesticides, and other off-farm purchases in conjunction with best management practices—to operations that actively seek to minimize farmers' off-farm purchases, and emphasize crop rotation, integration of livestock and crop production, and mechanical or biological weed control. The thing they have in common is Integrated Resource Management (IRM)—a systems management approach that looks at the farm as a whole.

The preservation of our environment is a pressing issue affecting *all* of us—and few of us live in a closer day-to-day relationship with our planet, or depend more directly on maintaining a quality environment, than our farmers and ranchers. USDA believes in the necessity of using science and technology to help farmers respond to environmental needs and still make enough money to feed their own families.

The President and Congress have recognized that in order to offer the farmer a broad range of practices and to tap the full potential of technology we must depend on research. As a result, the 1990 farm bill included the National Research Initiative for Research on Agriculture, Food, and the Environment. This competitive research program—for which $500 million was authorized—focuses on six major research areas: natural resources and the environment; plant systems; animal systems; nutrition, food quality, and health; processes and new products; and markets, trade, and policy.

Thanks to research and technology, we have developed tremendous efficiency in food and fiber production. The ultimate beneficiary of research that increases our agricultural efficiency is the consumer—who enjoys an inexpensive, reliable, wholesome, and safe supply of food produced in an environmentally sound manner.

There are some people who may question pursuing new technologies such as genetic engineering, even though this research offers us the chance to help feed and clothe a growing world population on a finite amount of agricultural land in an environmentally sensitive manner. However, objections to new technology are often based on *perception* of risk, not on *reality,* and they should not result in tighter regulations, but rather should prompt a redoubling of efforts by scientists to explain the myriad benefits of emerging technologies to the public so that society can make informed judgments as to their use.

The supposed conflict between production and the environment is a myth. If we are serious about ensuring the future productivity of agriculture, we will naturally want to protect the natural resources and the environment on which it will depend. While on the one hand, agriculture needs to be highly efficient and internationally competitive in order to be economically viable, on the other, it needs a system of production that is environmentally sensitive and sustainable. With the help of solid science-based technology, both goals are achievable.

New Electronic Technology for Monitoring the Environment

20

by Galen F. Hart, Research Leader, Remote Sensing Research Laboratory, Agricultural Research Service, USDA, Beltsville, MD

Concerned physicians and nurses are clustered around the bed of the patient, intently watching the nearby flickering electronic display screens for changes in temperature, pulse rate, breathing, blood pressure, and other "vital signs." The scene is familiar to some from personal experience, and to anyone who has ever watched hospital dramas on television.

It comes as no surprise that planet Earth's vital signs are being monitored electronically to ensure that we know when, how, and to what extent its "health" may be endangered by natural events or human activities. Cropland, forests, and rangeland play an important role in planetary health, because the human activity in agriculture has a major effect on the extent, composition, and quality of the Earth's environment.

USDA agencies have long been active in monitoring the Nation's natural resources to ensure continued production of necessary food and fiber products and the flow of essential services and benefits. Research, development, testing, and use of electronic monitoring techniques are being intensified as threats to environmental health become more evident.

Like the patient in the hospital, planet Earth can be hooked up directly to sensors on the ground that provide critical environmental measurements. For example, gauges have been used for many years to measure river and stream flow. Measurements of weather variables—such as air temperature, barometric pressure, and wind speed and direction—have traditionally been taken at ground sites. But the Earth is a big place and humans occupy only a small portion of the land surface, so we have turned to "sensors" carried on aircraft and satellites to take measurements over large areas. These "indirect" measurements are often generically referred to as remote sensing—the detection and analysis of objects or phenomena at a distance, without actually touching them.

Aerial photography has been and will continue to be an important source of remotely sensed data. But electronic sensors that provide digital data rather than film are becoming vital components of environmental analysis. The advantages are numerous. Analysis can be performed quickly and easily on computers, and digital data from remote sensors can be combined with digital data from other sources for detailed analysis previously not possible or too expensive.

USDA is developing a variety of remote sensing techniques and procedures to monitor major sensitive aspects of our environment—water quality; vegetation health; disease and insect infestations; and the effects of natural disasters such as fire, drought, and floods.

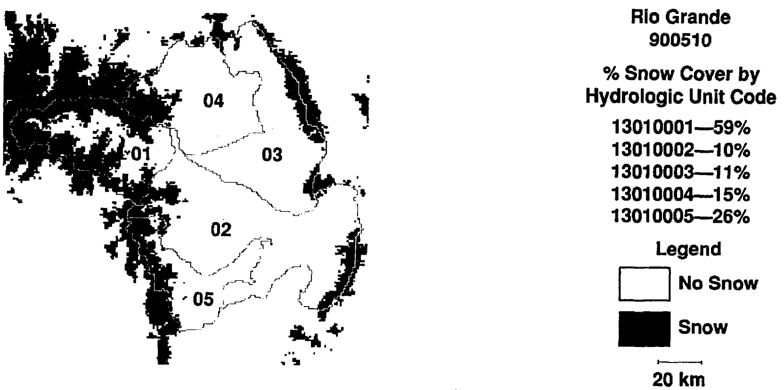
Snow Monitoring for Water Supply

Accurate and timely information on the extent and content of the snowpack of the West's high mountain ranges—the source of 50 to 80 percent of that region's annual water supply—is essential in managing efficiently the growing and often competing needs for water by households, agriculture, and industry. Remotely sensed data from weather satellites are used in forecasting water supply available from snowfall.

Satellite measurements of the snow-covered area of a river basin are now made by the National Oceanographic and Atmospheric Administration (NOAA) and transmitted to other Federal agencies. Snow cover maps can be sent over telephone lines and used for input to snowmelt analysis by computers (fig. 1). The data on snow cover derived from the satellite image are combined in a computer model with temperature data (degree days) to produce the daily amount of snowmelt runoff.

The snowmelt runoff model can also be used to forecast future runoff. In the Western United States, satellite data and the model are used to forecast water

Figure 1. NOAA AVHRR View of Snow Cover in the Rio Grande Basin ($4,319 km^2$) in Colorado

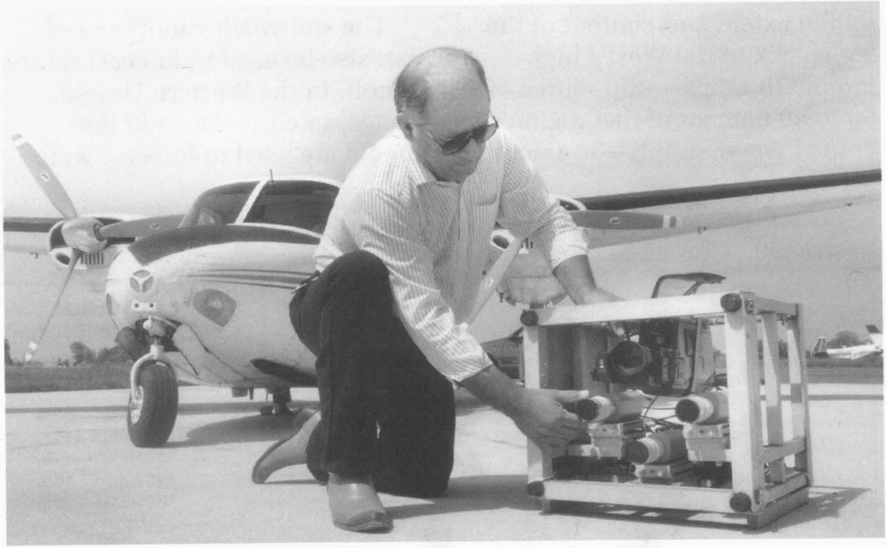


supplies for irrigated agriculture as well as for hydropower, domestic supplies, and recreation.

Additionally, unattended sensors on the ground relay data on local conditions to centrally located receiving stations for water supply forecasts and weather analysis. The SNOwpack TELemetry (SNOTEL) network, operated by the Soil Conservation Service (SCS), measures snowfall in remote areas of the Western United States where manual surveys are difficult or hazardous to carry out.

The automated SNOTEL remote sites include various sensors and measuring devices—"snow pillows" to measure the weight of the snow, precipitation gauges, and temperature sensors. As required, other sensors may be present to measure wind speed and direction, snow depth, soil temperature, and other weather variables. A shelter at the site protects the radio telemetry equipment and the communications antenna and also holds solar panels that keep batteries charged to provide power for the entire site (fig. 2).

Snow pillows are envelopes of stainless steel or synthetic rubber containing an antifreeze solution. Snow accumulates on the pillows, exerting pressure on the solution, which is sensed as "weight" by automatic measuring devices in the adjacent shelter house. The weight of the snow is then con-

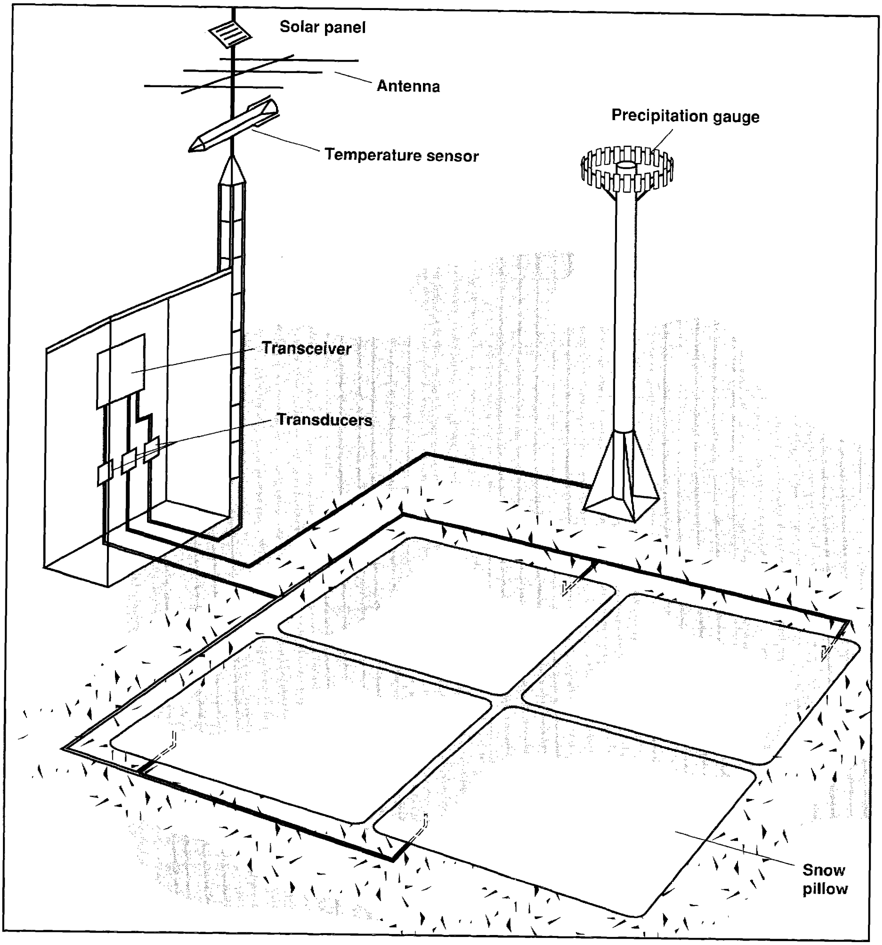


Remote sensing specialist David Escobar inspects the three-camera video system used to monitor false broomweed at the Punta del Monte Ranch in Texas.
Keith Weller/USDA 90BW0952-3

verted into an electrical reading of the snow's water equivalent—that is, the actual amount of water in a given volume of snow.

All remote SNOTEL sites transmit data daily, with additional data transmissions as required. Radio signals aimed skyward from over 500 solar-powered SNOTEL remote sites are reflected off the ionized layer of the Earth's atmosphere—the "meteor burst" zone—to master receiving stations at Boise, Idaho, and Ogden, Utah. Stations cover the 10 Western States, about 1 million square

Figure 2. SNOTEL automated remote site



miles. Data from the receiving stations are sent by dedicated telephone lines to SNOTEL's centralized forecasting system computer in Portland, Oregon, where they can be easily accessed by forecasters, any SCS personnel, and the public (fig.3).

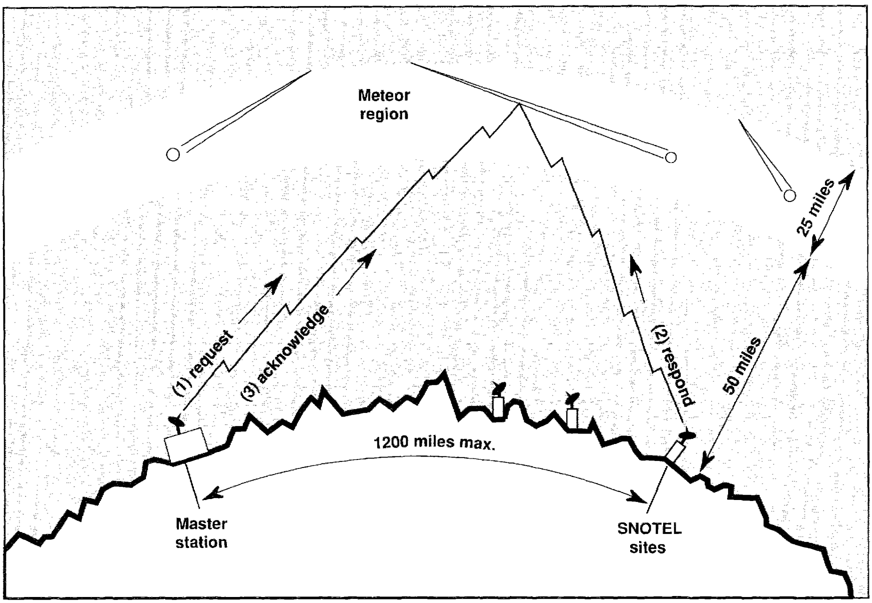
Data provided by the SNOTEL network and ground snow surveys, combined with modeled information from weather satellites, provide up-to-date information on streamflow potential—information that is especially valuable during periods of flood or drought. Water supply forecasts are issued monthly by SCS offices from January to June in cooperation with the National Weather Service and are used for planning by major sectors of the western economy—agriculture, industry, and recreation.

Cloudy Water

In addition to certain agricultural and industrial chemicals and sewage wastes, our lakes and streams often contain suspended particles of soil. The amounts of suspended soil sediments are greatly influenced by agriculture and other human activities on the watersheds.

Conventional ways to measure and monitor the extent of this pollution have been costly, since

Figure 3. How SNOTEL transmits information



site visits by trained personnel are required. A quicker, easier, and more cost-effective method was needed; thus, remote sensing methods were investigated to provide broad coverage and to detect and quantify suspended sediment in lake and reservoir surface waters. Monitoring with remote sensing to detect a pollution problem can alert those locally responsible to take conservation action in a watershed.

Research initiated by ARS in the mid-1970's using hand-held spectroradiometers which quantify relationships between suspended sediment concentrations in the surface waters and solar radiation (reflected sunlight), was continued and expanded with LANDSAT satellites measuring the amount of reflected solar energy. Lake Chicot, Arkansas, was the initial study area. Five LANDSATs over 13 years were used to collect more than 85 days of data over the lake. LANDSAT and ground data were processed and analyzed using a number of known and experimental relationships.

The initial research on Lake Chicot was expanded into Oklahoma to produce a time sequence of data for several lakes. Satellite data for 16 lakes covered by 22 LANDSAT images during 1987-89 were combined with appropriate ground information. This research led to the development of a satellite method that, when used with State of Oklahoma water quality standards, established criteria to assess the surface water quality in lakes for the entire State of Oklahoma.

Statewide assessments were conducted during the summer of

David Escobar, remote sensing specialist, checks an infrared video scan of cropland thousands of feet below.
Keith Weller/USDA 90BW0951-30

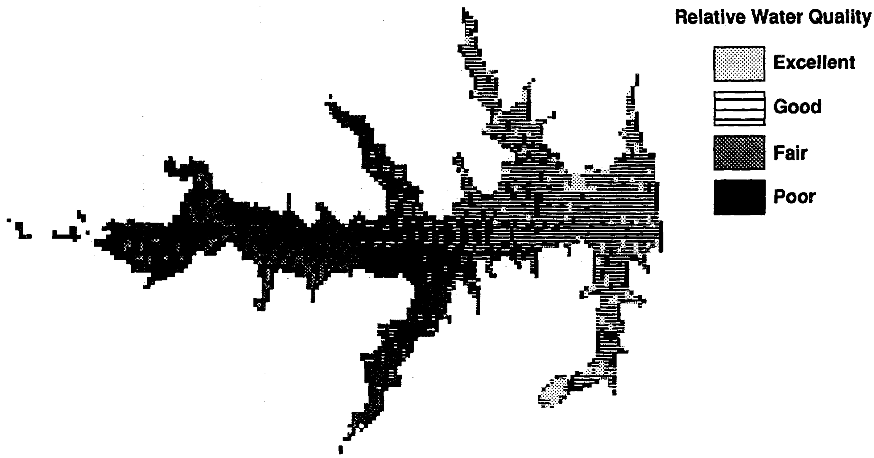
1989, the winter of 1989-90, and the spring of 1990. In these three efforts, 103 lakes totaling 650,000 acres were classified by placing each lake into one of three categories: clean water, clay-impacted water, or eutrophic water (containing substantial amounts of dissolved material). Maps of Oklahoma were produced indicating areas of the State where lake water quality was a problem.

When suspended sediment was indicated as the problem, individual lake maps were generated showing differing degrees of the sediment problem (fig. 4). This capability gives State conservation authorities the kind of timely information necessary for prompt action.

Airborne Video for Immediate Assessment

Imagine the hand-held camcorder in an airplane and you have the start of a very promising remote sensing system for monitoring vegetation and other environmental features. Recognizing the utility of video imaging systems for a "quick look," ARS scientists have taken advantage of recent improvements and advancements in video and computer image processing technology. Black and white, color, and color-infrared video systems with sensitivity to both visible and infrared light (just beyond the part of the light energy spectrum where we see) have been developed and used successfully to characterize a variety of natural resource factors. All

Figure 4. Relative Suspended Sediment Concentrations Measured by LANDSAT MSS During the 1989-90 Lake Assessment



of these systems were developed using off-the-shelf equipment.

Video from aircraft has many characteristics that make it attractive for remote sensing, but the most prominent is that the images are available so fast. Video action can be viewed during acquisition on a monitor in the airplane or assessed within minutes after landing. This is particularly important in highly time-sensitive applications such as monitoring catastrophic events. For example, insurance adjustors could use video to quickly and accurately determine hail or flood damage to crops. Video is also important in areas of the world where processing of color-infrared film may not be available. Video recording systems also cost less to operate than photographic systems. Video tapes costing less than $10 provide 2 hours of playing time, and are reusable, while color-infrared film (70mm or 9-inch format), plus developing, costs $200 to $1,000 per roll. Another advantage of video is the electronic format of the video signal that makes it compatible with computer image processing systems.

Airborne video has been used for a variety of agricultural and rangeland applications. Important agricultural applications include detection or assessment of soil drainage and salinity, soil erosion, crop vigor and production, plant diseases and nutrient deficiencies, and insect and weed infestations.

Due to the generally great expanse of rangelands and their low productivity per unit area, low-cost video systems are becoming attractive tools for assessing these areas. Rangeland applications include detection or discrimination of plant communities and species, brush and weed infestations, grazing intensity, plant production, drought stress, and rodent and insect infestations.

Continuing development in all areas of video technology should lead to improvements in the effectiveness and utility of aerial videography for natural resource assessment.

Espidio Salinas (center), Punta del Monte ranch foreman, examines a false broomweed plant with David Escobar (left) and James Everitt, both from the USDA-ARS Sub-Tropical Agricultural Research Laboratory, Weslaco, TX.
Jack Dykinga/USDA 90BW2135-10

Regional Water Consumption

Water plays a critical role in agriculture, and in many areas we don't have enough, so irrigation and irrigation management are required. The need for agricultural irrigation depends on the extent and amount of rainfall and plant water use, which are difficult to estimate over large areas. However, from satellite imagery, we can accurately assess evapotranspiration (moisture loss from the soil by evaporation or through growing plants) by observing temperatures and the vigor of vegetation. Healthy vegetation shows up clearly in satellite visible and near-infrared imagery, and the effects of evapotranspiration are manifested through lower apparent temperatures, since evaporation has a cooling effect.

The problem is that to observe large areas, we must often rely on the weather satellites which do not clearly depict individual cultivated fields (less than 80 acres). However, by graphing the vigor of vegetation and, at the same time, the surface temperature, we can estimate separately the evaporation from vegetated fields, from dry bare fields, and from mixed fields with little vegetation. Then we may add all the components to get a value of regional water use, even though estimates are not possible for individual fields. That's a help, when you are managing a scarce resource.

Lasers To Measure Soil Erosion

Lasers were developed in the early 1960's and have been used over the last 30 years to study many environmental and physical problems such as accurately measuring the distance from the Earth to the Moon, studying continental drifts by measuring distances between fixed points on different continents from satellites, and measuring pollutants in the atmosphere.

ARS scientists are using the same laser technology to study land surface features related to environmental pollution. A laser, operating from an airplane during flight, has been able to measure vertical changes as small as 2 inches in the land surface. While these measurements can be made with current ground survey techniques, using an airplane allows measurements to be made over large and sometimes inaccessible areas much more quickly and less expensively.

These aircraft laser measurements allow scientists to locate and estimate soil loss from ephemeral gullies (small gullies that are erased by cultivation), to measure changes in stream channel locations, and to estimate streambank erosion. Tree and shrub heights, distribution, and density can be determined from the laser measurements. Using the tree height and distribution measurements, scientists are able to estimate plant biomass and canopy ground cover and the effects of changes in canopy cover and biomass on soil and water loss from the land surface.

Accurate measurements of the location and amount of gully and streambank erosion and canopy will allow the development of conservation plans to reduce soil erosion and soil loss and improve water retention, thus conserving our soil resource for future generations.

Seeing the Forests and the Trees

Remote sensing has long been a significant source of information for the Forest Service, the USDA agency charged with the administration and management of over 191 million acres of national forests and grasslands and the responsibility to assist State and private forest owners.

Aerial photography is the primary form of remote sensing used to map and conduct inventories of the timber, forage, wildlife habitat, soil, water, recreation, and mineral resources on the national forests. All forms of aerial photography are used, from hand-held 35mm to high-altitude photos taken by U-2 aircraft. Black and white, color, and color-infrared films are used.

Some of the newer forms of remote sensing involve video cameras, laser profilers, and Earth-observing satellites. Most of the remote sensing activities with State and private landowners are concerned with forest pest management; the Forest Service has the responsibility to conduct surveys of insect and disease infestations across all forested lands in the United States. The most recent technology to be incorporated in insect and disease surveys is the use of a video camera in an aircraft.

The availability of data from satellites is opening many new avenues for inventorying and monitoring our forest resources. Imagery from weather satellites is being used to monitor changes in vegetation. Weather satellite data are also being used in the Western United States to map forest fuels and to assess forest fire suppression activities.

Imagery from the LANDSAT satellites is being used to rapidly map vegetation resources on national forests in California, Oregon, and Washington. This, combined with imagery from the French SPOT satellite, is being used to update maps showing new roads and clearcut areas in California.

Microwaves Help Monitor Soil Water

Information about water in the soil is valuable in irrigation and farm water management but is hard and expensive to obtain. Sensor systems that are being developed and tested will provide soil water measurements from airplanes and satellites. These sensors measure the amount of microwave energy coming from the soil. Recent research has shown that the amount of this energy depends primarily on the amount of water in the soil. Current research by ARS and the National Aeronautics and Space Administration is systematically testing prototype instruments on airplanes and comparing their measurements with ground measurements.

Microwave remote sensing offers three unique advantages over other types of remote sensing. First, clouds and rain have no effect, so it can be used in any weather. Second, it does not require sunlight for illumination, which means that measurements can be made at any time of day or night. Finally, the effects of vegetation on the ability to sense moisture in the soil below are usually correctable.

To be of value, soil moisture information must be available on a frequent basis. It should also be available to users almost immediately (like the images we see from weather satellites) before changes in crop conditions, weather, or soil water content make the information worthless.

In another application, new research shows that microwaves hold great promise for determining the depth or water equivalent of the snowpack. ■

Integrated Pest Management, a Sustainable Technology

21

by T.J. Henneberry, Laboratory Director, Western Cotton Research Laboratory, Agricultural Research Service, USDA, Phoenix, AZ; E.H. Glass, Professor Emeritus of Entomology, New York State Agricultural Experiment Station, Cooperative State Research Service, USDA, Geneva, NY; R.G. Gilbert, National Agrichemical Specialist, Soil Conservation Service, USDA, Washington, DC; E.G. King, Jr., Laboratory Director, Subtropical Agricultural Research Laboratory, Agricultural Research Service, USDA, Weslaco, TX; R.W. Miller, Research Animal Scientist, Agricultural Research Service, USDA, Beltsville, MD; and C.J. Whitten, Research Leader, Tuxtla Gutierrez, Mexico, Screwworm Research Laboratory, Agricultural Research Service, USDA, Laredo, TX

The farm value of cultivated crops and animals produced in the United States and used for food and fiber exceeds $160 billion annually. Pests—including insects, mites, pathogens (disease-causing organisms), weeds, nematodes, rodents, and others—significantly ellites. These sensors measure the amount of microwave energy coming from the soil. Recent research has shown that the amount of this energy depends primarily on the amount of water in the soil. Current research by ARS and the National Aeronautics and Space Administration is systematically testing prototype instruments on airplanes and comparing their measurements with ground measurements.

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The farm value of cultivated crops and animals produced in the United States and used for food and fiber exceeds $160 billion annually. Pests—including insects, mites, pathogens (disease-causing organisms), weeds, nematodes, rodents, and others—significantly contribute to high farm production costs and reduced quality and yields. Farm production losses to pests are estimated to exceed 35 percent annually. Continued sustainable agricultural production will rely on effective, safe, environmentally benign, and efficient crop and animal protection methods.

Goals of Integrated Pest Management

Integrated Pest Management (IPM) is an ecological approach to pest suppression. Briefly stated, the goals of IPM systems are to reduce losses in crop and animal quality and yield caused by pests and to increase net profits to the producer. Methods are selected that cause minimal environmental damage and pose little or no risk to human health. IPM involves selection, integration, and implementation of pest control actions on the basis of predictable economic, ecological, and sociological consequences. Success is most likely when the focus is on a large area. Although this paper focuses primarily on integrated management of crop pests, these same management principles are being applied to livestock pests.

Development and use of many efficient and economical pesticides during and since the 1940's have permitted unprecedented crop and animal protection and improved public health. Since these control agents have been available, however, many of the components of IPM (integrated pest management) systems—such as crop rotations, sanitation, time of planting, resistant varieties, and genetic and biological control methods—have been neglected.

However, the bright future of the pesticide era became clouded as the problems of secondary pests (in addition to the target pests), destruction of natural enemies, pesticide resistance, and environmental and health hazards were recognized. Experience has shown that adoption of a single control measure for suppression of a target pest or pest complex is destined to fail sooner or later.

Integration of multiple pest suppression techniques has the highest probability of sustaining long-term crop protection. Since the 1960's, there has been much interest in and effort to develop IPM.

Much progress has been made, and efforts to integrate IPM into crop management systems continue. These efforts include the introduction of community-involved, areawide approaches to suppression and management of pests. This is a commonsense approach that has evolved with our increasing awareness of the limitations of attacking local infestations without considering total pest populations. Areawide pest suppression involves the coordinated efforts of many parts of an agricultural community cooperating to use effective pest management strategies.

Essential prerequisites for establishing successful IPM systems are a thorough knowledge of the following:

- Crop and animal production methods
- Biology and ecology of each pest species
- Basic information on genetics, behavior, and physiology of pest species
- Relationships and interactions of the pests with the crop and other biological and physical components of the ecosystem
- Potential economic damage of each pest and pest complex

This information is necessary if community-involved, areawide programs are to effectively identify and integrate control technologies that are compatible with crop production methods as well as other parts of the ecosystem.

Knowledge of farmland production potential, agronomic inputs, and plant growth and development is essential in development of IPM systems. Cultivar selection and planting date, as well as cultural practices (irrigation, fertilization, and tillage) may have a major influence on pest severity. Decisions on the need for control action are based not only on the pest population levels but also on the present and predicted weather, the levels of existing biological control agents, and the stage of plant development and potential for yield losses. Similar information is vital in development of animal protection IPM systems.

IPM Technologies and Procedures

An array of technologies and data analysis procedures have been developed for informing growers and other decisionmakers about those strategies and tactics most appropriate for use in implementing specific IPM systems. These include: economic thresholds, sampling technology, modeling, natural controls, geographic distribution, effects of pest migration and movement, host resistance, and pesticides.

Field evaluation is the most effective method to determine how biological predators find and consume their prey. Bruce Shambaugh releases ladybeetles into a small field cage enclosing wheat plants infested with Russian wheat aphids. *Laurie Smith/USDA 91BW0620*

Economic Thresholds. The economic threshold of a pest population is the population level below which the cost of taking control action exceeds the losses caused by the pest. Pest population levels that can be tolerated within a crop system can vary because of crop harvesting schedules and inherent crop tolerance to pest attack.

Ladybeetles are collected from wheatfields that have high numbers of them, to be released into fields with low numbers. Bruce Shambaugh holds a release net with predators just swept from rows of wheat plants in Cheyenne, WY.
Laurie Smith/USDA 91BW0618

Economic thresholds may also vary from area to area, among cultivars, and even between farms that are in the same area but under different management systems. Further, levels must be adjusted when two or more pests are attacking the same crop. For insects and mites, thresholds will vary depending on the population levels of naturally occurring parasites and predators that may control the pests. Pest population levels requiring control action in animal production systems are less well defined than in crop production systems, but the need for this information is equally important. Application of the economic threshold in determining the need for control action has helped producers reduce the number of pesticide applications or other control measures and increased net profits to the individual grower.

Sampling Technologies. Appropriate and cost-effective sampling methods for each pest are necessary to determine pest levels for purposes of establishing economic thresholds. These methods range from simple to complex and include such techniques as the following:

- Counting the numbers of insects, mites, biological control agents, or pathogen lesions on a few leaves
- Counting nematodes in soil samples and counting weed species and densities in several

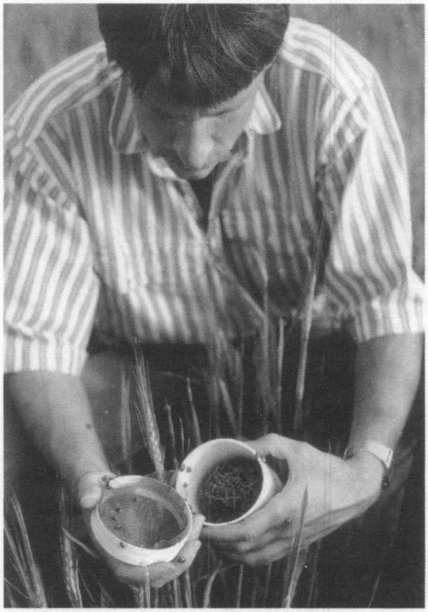
locations in crop fields
- Using sophisticated vacuum machines that collect insects from crop plants or spores from the air

Data reflecting the number and locations of samplings must be accurate enough to allow sound decisions on whether to take action. Field research for various pests and conditions determines how many samples are needed from how many locations.

Modeling. A basic principle of IPM is that it must have a systems approach to good decisionmaking. Farming systems are complex, involving many factors. Changes in one part affect others. It is not only the biological system that affects deci-sionmaking, but often also economic factors and social pressures. Neither budgetary nor human resources are sufficient to allow detailed field experiments that include all possible variables. So we turn to simulation models.

These models have helped us develop our understanding of the complexities of biological systems; however, they have not been useful in solving specific problems in the field. Knowledge-based systems (called expert systems by some) have the potential for improving decisionmaking at the farm level. Importantly, incorporation of models in IPM systems has required the user to define available knowledge regarding the problem and to provide information to explain deficiencies that occur between model simulation and field observations. Models also provide prediction capabilities that ensure that management decisions are increasingly accurate.

Natural Controls. IPM's basic framework is built on natural controls. These include natural enemies, weather, climate, and food resources. Natural enemies play an important role in regulating populations of all pest classes, in both natural and farm ecosystems. For arthropod pests such as insects and mites, parasites and predators are



Ladybeetles being released into a wheatfield low in predators. Bruce Stambaugh opens an ice cream carton containing beetles recently collected by sweep net from a nearby field.
Laurie Smith/USDA 91BW0619

major natural control agents. A primary focus of IPM is on conservation of these natural enemies to maintain insect and mite pests below economic thresholds. Where possible, selective pesticides are used that are least harmful to natural enemies. So the effort is focused on conserving natural enemies and introducing appropriate species from other regions. Microbial pesticides have been developed and are being used where they are effective.

Biological control for pathogens, nematodes, weeds, and other pests is also achieving increased success. Weather plays a very important role in the incidence and extent of infection by pathogens. The knowledge and understanding of interaction of temperature, humidity, and rain on disease incidence is critically important. The amount of fungicides required to control diseases can be greatly reduced based on this knowledge and on accurate weather predictions.

Geographic Distribution. Areawide management systems that target the total pest population involve, in most cases, large geographic areas that may extend across county, State, and national boundaries. Therefore, local, State, national, and sometimes international cooperation, in addition to an understanding of the technical complexities of target pest suppression, is essential to ensure a high degree of success.

Effects of Pest Migration and Movement. Many pests and natural enemy species move short distances as their populations grow. This may occur for many reasons, including crowding and search for food as a result of host depletion in the initial habitat. Some pests, such as insects and pathogens, migrate or are carried long distances by winds and atmospheric weather patterns. Other pests can move only short distances but may be carried long distances by ground animals, birds, or humans. They are often transported in or on plant products, a major cause of the introduction of pests into formerly noninfested regions.

Movement of pests over even short distances affects IPM strategies. For example, pathogens, insects, rodents, and other pests often move from one crop to another in adjacent fields or from adjacent natural habitats to agricultural crops. IPM strategies must be developed to deal with such situations.

Long-distance migration and movement of pests are of particular importance in areawide management systems. Where there are no effective natural barriers such as mountains or large bodies of water, artificial barriers such as the release of sterile insects or quarantine of certain plants and produce can be useful to prevent or reduce unwanted movement of pests. The pest management technique of releasing sterile insects for suppression of the screwworm and pink bollworm in the United States is an excellent example of the use of barrier zones to prevent infestation from migrating pests.

Host Resistance. Host resistance is another key component of pest management. Over time, many plants and animals evolve resistance mechanisms that enable them to prevent or survive attacks by pests. Geneticists, in many cases, have made outstanding progress in identifying and incorporating pest resistance characteristics in farm production systems.

However, many of our crops and animals do not have adequate defense mechanisms against introduced or native pests, given the conditions under which we grow them. Also, breeders have not always attempted or been able to incorporate resistance into desirable cultivars and farm animals. In recent years, much progress has been made in finding genes for disease resistance and transferring them to plants and animals. The rapid development of new methods for gene transfer promises that host resistance will play a much greater role in IPM in the future.

Pesticides. Discovery and use of synthetic pesticides greatly improved farmers' ability to cope with pests and enabled modifications in farming practices, espe-

Maintaining laboratory colonies of a pest is an essential step in rearing the numbers of its natural enemies needed for biological control programs. Here a technician at the APHIS Biological Control Laboratory in Mission, TX, infests new wheat seedlings with Russian wheat aphids to build up the colony. The lab-reared aphids will serve as prey for several species of predators and parasites under study at the lab.
Laurie Smith/USDA 91BW0617

cially with the use of herbicides. These benefits, however, have been accompanied by low-level contamination of ground water, other undesirable environmental effects, and potential health risks for humans, livestock, wildlife, and domestic animals. Further, many pesticides, including many of the safer and more selective ones, are no longer effective against several key pests. So it is important to reduce the use of pesticides to the absolute minimum necessary to maintain economical production and storage of food and fiber. Also, reduced use is effective in preventing or delaying development of pest resistance.

A key component of IPM is judicious use of pesticides only as needed and in consideration of the environment, health, and economics. The IPM approach is essential for reducing the undesirable side effects of pesticide use. The combination of suppression tactics used in IPM programs will reduce not only environmental effects, but also the incidence of pests' resistance to pesticides and lead to development of pest-resistant cultivars or "biopesticides." More sustainable protection systems should result from the use of pesticides in a more balanced manner.

IPM Success Stories

Successfully implemented IPM programs have provided economic benefits to farmers and more environmentally acceptable crop and animal protection practices. The systems and programs are being continually refined and improved based on experience, continuing research, technology transfer, and Extension education efforts.

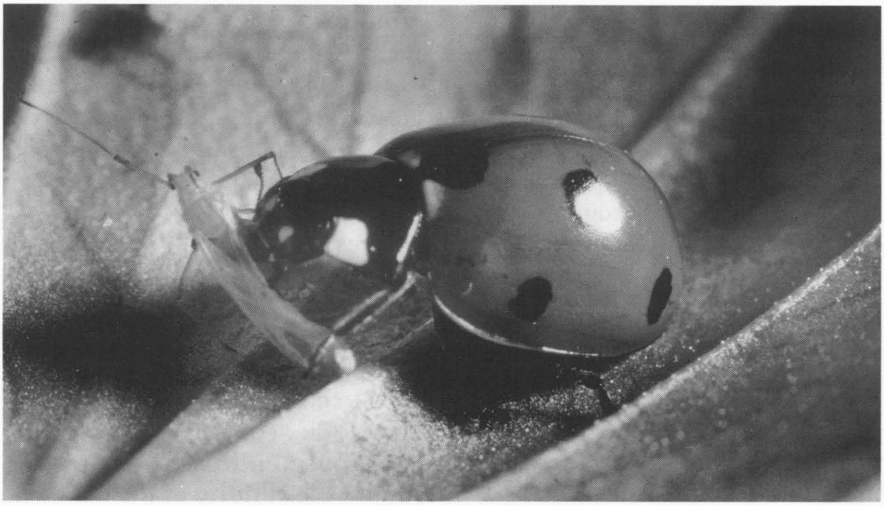
Some of the outstanding successes of IPM in suppressing major pest populations—such as the boll weevil eradication program—have relied on early detection, selective pesticide use, and cultural practices. In other programs—such as suppression of Mediterranean fruit fly, pink bollworm, and screwworm populations—sterile insect releases have been the main component of IPM systems supported by intensive population sampling, attractants, cultural practices, and other methods.

Host plant resistance has provided the foundation for effective IPM approaches to control the alfalfa aphids. Native parasite releases have been successfully used as the focal IPM component to suppress fly populations around poultry houses and livestock yards, and a complex of imported parasite species has been used to control alfalfa weevil. Many other equally successful applications of IPM have demonstrated the validity of the concept. IPM, in each case, has provided increased economic benefits to the farmer within the framework of environmentally acceptable pest management methods.

Implementing IPM. The implementation of IPM systems in agriculture requires more research, development, extension and transfer, and farmer time and effort than the simple use of pesticides. Some producers have been cautious in adopting IPM because it takes time to develop effective practices that producers can feasibly incorporate into existing crop management systems. Often, significant modifications in farming practices must be made to adopt IPM systems. These practices might include, for example, crop rotation, destruction of crop residues, and variations in time of planting.

The USDA sustainable agriculture effort is a substantial program to test and promote efficient agricultural production practices that may involve reduced economic and physical resources. IPM is an essential component of these efforts.

Communities Using IPM. IPM systems can be adopted by individual farmers, by small groups, or by farmers across broad agricultural systems. The nature of the farming systems and the pest problems often dictate whether single, small group, or regional adoption will be most effective. Where farms are scattered, crops are diverse, and pest migration from other farms is not a factor, adoption by the individual is ap-



Biological control employs natural enemies to control pest insects. Here a Coccinella septempunctata or "C7" ladybeetle attacks an aphid. Ladybeetles are general predators and eat a variety of aphid species. *Laurie Smith/USDA 91BW0616* propriate. In specialized areas with extensive plantings of the same crop or crops where pests move freely from one farm to another, IPM systems must be adopted by all farmers in the region to be successful.

An example is cotton in parts of Texas, where destruction of crop residues after harvest drastically reduces the survival of the boll weevil through the winter and eliminates the need for pesticide applications that often destroy natural enemies and create secondary insect pest attacks. The group and regional adoptions require much community involvement and support.

Long-Term, Areawide Suppression

Areawide suppression or management of total pest populations incorporates the principles and tactics of IPM as an ecological approach to pest control. Coordinated agricultural community involvement in pest population management over large areas is becoming more prevalent in research, extension, and teaching efforts dealing with most of the key pests. The areawide approach focuses suppressive measures on the total pest population, as opposed to uncoordinated efforts by individual farms or small local areas to control limited segments of the population—an approach that will not work on pests that move or migrate extensively. Areawide programs include producers as active participants in the program, a practice that helps ensure success. The producer is not a bystander, nor are Extension personnel and private consultants. The entire community has an active part in the program. ■

Computer Models for Pesticide and Fertilizer Use

22

by Donn G. DeCoursey, Research Leader, Hydro-Ecosystems Research Unit, Agricultural Research Service, Fort Collins, CO

Models are groups of equations which describe the environment of an organism and predict its response to environmental factors. —Monteith 1973

Did you listen to the weather forecast last evening? If you did, did you stop to think about where it came from? How did the person making the weather forecast decide if it was to rain, or clear up? How are longer range (6–10 day and 30 or 90 day) outlooks made? Did you know that a computer model was used?

The National Weather Service's National Meteorological Center in Camp Springs, MD, has several computer models to aid in making its weather forecasts. Local weather forecasters have access to output from these models, and their forecasts are a verbal interpretation of the computer output. The weather service models require local data from radiosonde instruments attached to balloons. These data represent clouds, wind, pressure, and temperature at the surface and wind, temperature, and humidity at higher levels. Supplemental information is provided by aircraft.

The current weather forecasts from various models are projected on 12-hour intervals up to 72 hours into the future and are updated every 12 hours. The models provide location and likely amount and type of precipitation, maximum and minimum temperatures, windspeed, and cloud cover. Output from different models is used for longer range (3–5 and 6–10 day) outlooks. Thus we all rely on the computer model output to some degree to help us plan our day-to-day activities.

Computers, Friendly Tools

Computer models, often without our knowledge, have increased the information used in our day-to-day decisions. A computer is now a "must have" fixture in many of our homes. Today's young people use computer models routinely in games and schoolwork. Computer models are especially helpful to scientific research on certain kinds of problems. One area of research where models come in handy is estimating the use and fate of pesticides and fertilizers.

The effectiveness of a pesticide or fertilizer application depends on rainfall, soil conditions, chemical characteristics of the pesticide, and many other factors. Farmers, in determining how much fertilizer to put on a field, must consider nutrients left from previous applications and those contributed by plants as they decompose. If too much fertilizer is added, some may leach through the soil and could pollute the ground water.

If a pesticide was applied to a field in the past, how much remains in the soil today, is it toxic to the crop being planted now, will some of it move off with surface runoff or leach through the root zone and pose a hazard to future uses of ground water from the area? If changes in our climate are likely, what impact will they have on agricultural production? Can we compensate for some of the likely changes if we modify our cropping systems and our fertilizer or pesticide application rates? These are the kinds of questions that computer models are designed to answer.

What Is a Computer Model for Pesticide and Fertilizer Use?

Computer models can describe what happens to pesticides and fertilizer in the soil. Assume that a farmer applies nitrate fertilizer to a corn field. Immediately after application, a light storm produces about 1 inch of rainfall. The soil consists of rock and mineral particles, organic material, and voids filled with air, water, dissolved minerals, and other chemicals. The rainfall and nitrate move into the voids. At low rainfall intensities, all of the rainfall enters the soil, and nitrate, coming in with the rainfall, mixes with water already in the soil. However, some of the water in the soil may be in such small pores that nitrate mixing may be delayed for a time.

Over the next several days, the corn plants will take up water and nitrate for use in growth, removing these materials from different regions of the soil. As a result, the water and nitrate move within the soil. Sometimes rainfall exceeds what the soil can hold; some runs off, and the excess in the soil, along with nitrate, moves beyond the range of plant roots and continues a slow, steady migration to underlying ground water tables.

Computer models simulate these processes and use this information to estimate movement and what happens to the nitrate concentrations and those of other salts. Similar models describe pesticide fate and movement. Some pesticides, however, are much less mobile in the soil than others, attaching themselves to clay and organic matter in the soil. Also, pesticides decompose in the soil at different rates. Computer models use research information on the pesticide chemistry, soil properties, and estimates of soil water movement to predict what happens to the pesticides and their concentrations.

Computer models of both fertilizer and pesticide use evolved from rather simple formulas such as those used to estimate application rates based on desired crop production. As computer capabilities increased, so did knowledge of the physical and chemical processes involved, and more penetrating questions were raised. Answers to these questions require more complex computer models.

Follett (1989 and 1991) is editor of two books that thoroughly investigate the nitrogen management problem from both the crop production and the environmental perspective of ground water contamination. Models of the various processes are described. The Soil Science Society of America has two books that describe very well the fate and movement of pesticides in the soil (Sawhney and Brown 1989 and Cheng 1990). The book by Sawhney and Brown describes the many processes that pesticides are subjected to as they move within the soil. The book by Cheng describes how these processes are modeled. The whole area of modeling water quality of agricultural nonpoint sources is discussed with reviews by both the modeler and the user in DeCoursey (1990). (Nonpoint sources are fertilizer and pesticides that are applied to large areas.)

Other chapters in this Yearbook describe the seriousness of environmental problems related to agricultural crop production and various attempts to solve these problems using new technology and better management techniques. The models described in this chapter are part of the new technology.

Applications of Computer Models

Computer models are designed for use in a variety of ways, and that use, in turn, dictates the type of model selected. Frequently, this is not understood and models are not appropriately selected. For purposes of this discussion, computer models of pesticide and fertilizer use can be divided into three categories:

- Screening models—used for preliminary assessment, to screen response in specific areas, and to compare alternatives. Data requirements are minimal, and interpretation of the output is limited in scope.
- Research models—which provide quantitative estimates of water and solute (nutrients, pesticides, and other chemicals dissolved in the water) movement and the fate of nutrients and pesticides. These models are comprehensive descriptions of the processes involved and require much more data.
- Planning or management models—which lie in between the

above two extremes. These models are used in planning, regulation, and management.

The distinctions among these models are fuzzy, and many models serve more than one purpose. In general, the differences among the models, dictated by their use, are primarily in the data required to drive them, the level of detail used to describe the processes, and the accuracy or type of output required.

Screening Models

One screening model used in fertilizer management, NLEAP (Nitrate Leaching and Economic Analysis Package) (Shaffer and others, 1991), was recently developed by scientists with USDA's Agricultural Research Service (ARS) to assess the potential for nitrate leaching. It was developed for use under a range of soil, climate, and management conditions so that potential high nitrate concentration spots could be identified and site-specific management techniques developed to minimize nitrate leaching to ground water from those areas.

NLEAP predicts the amount of nitrate available for leaching by using the amount of nitrogen added in fertilizer and calculating the amounts of nitrogen—

- Added by precipitation or in irrigation water,
- Produced in the soil from organic matter,
- Used in plant uptake,
- Lost in biological activity and runoff, and
- Still available in the soil.

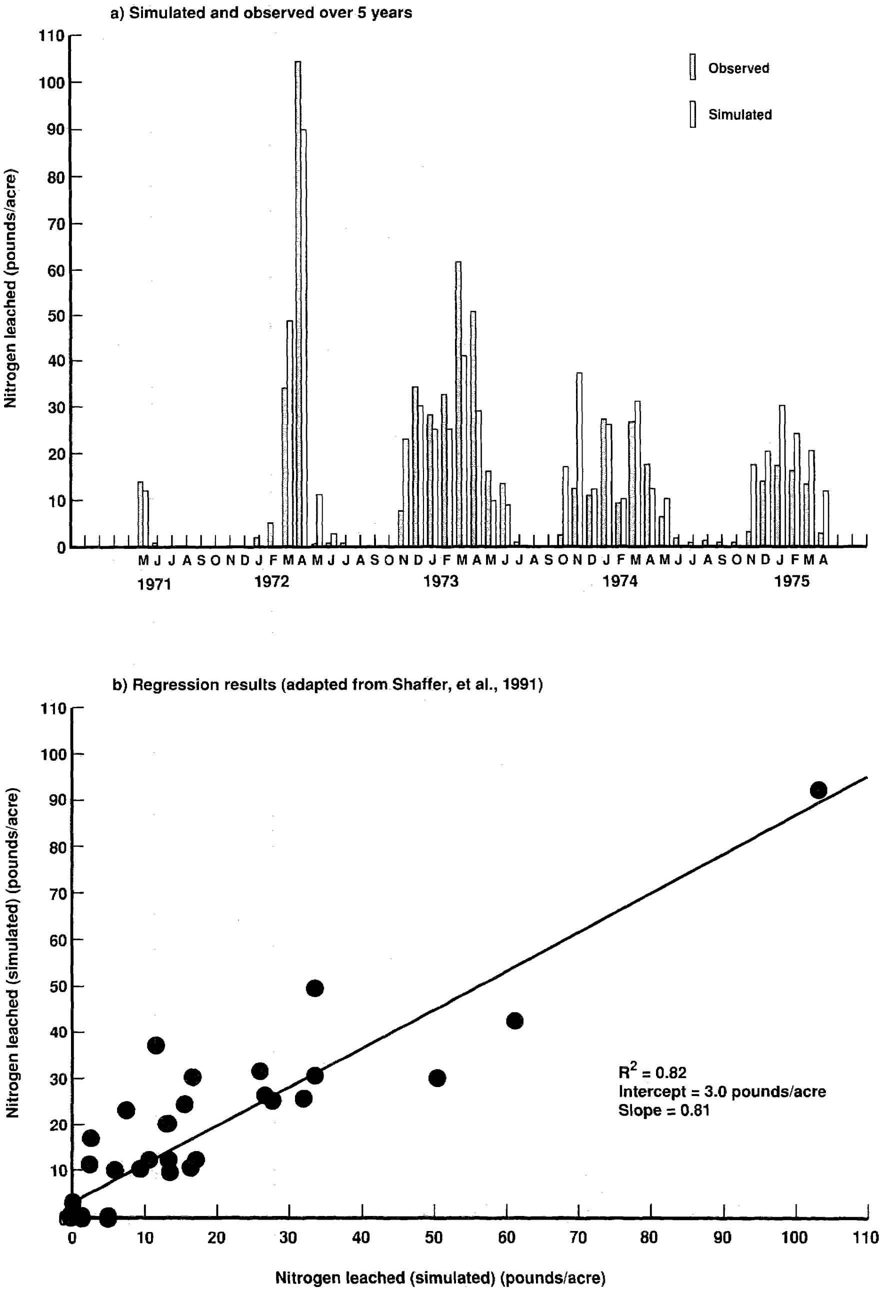
To calculate the nitrate used or produced by the various processes, the soil is divided into a biologically active top 1 foot and a second layer that extends to the bottom of the root zone. Output values of nitrate leaching potential are calculated by NLEAP using the soil properties and water available for leaching. Information provided by the model helps the user interpret the significance of these output values.

NLEAP has been used on several case studies, and with good results. Some examples include an assessment of leaching in studies of continuous corn (no other crops are rotated with the corn) in Ohio (see figure 1), draintile water from fields with a corn-oats-corn-soybean rotation in Iowa, and irrigated and dryland corn fields at Colorado State University.

Pesticides Screening Model

An example of a screening model for pesticides use is SPISP (Soil Pesticide Interaction Screening Procedure) (Goss and Wauchope, 1991). The model was developed by USDA's Soil Conservation Service (SCS) to evaluate the relative loss of pesticides from soils. Data from which the model was developed were obtained from more than 40,000 runs of the GLEAMS model (described later)

Figure 1. Nitrate-N leached at Coshocton, OH



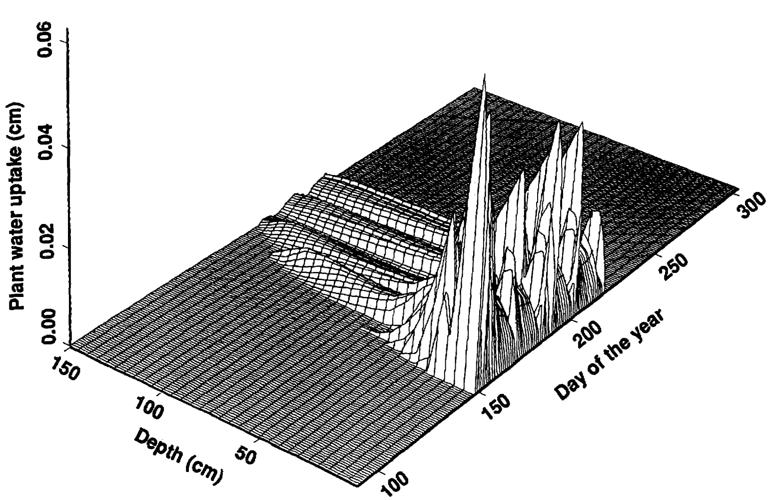
using a wide range of variations in soil and pesticide properties.

From these computer data, equations were developed to estimate pesticide loss associated with surface runoff, eroded soil particles, and seep water leaching below the root zone. Information is provided to help the user interpret the significance of losses indicated in applying the model to a specific site. Data required to drive the model include soil series and hydraulic properties, depth to ground water, and pesticide characteristics. Pesticide characteristics are provided in a data base.

Research Models

At the other end of the spectrum are very complex models used in research. In general, these models simulate all the physical processes of soil water movement, nutrient transformation, pesticide decomposition, adsorption to soil particles, and so on. Such models permit assessments of how long it takes for pesticides and nutrients to dissipate. They also help in designing remedial measures to reduce the movement of these pollutants to ground water. Such models are also used to predict the mobility and persistence of pesticides in soils and to test alternative formulations for likely environmental impact before use.

Figure 2. Root Water Uptake by Corn Over the Growing Season



One of the most recent such models is RZWQM (Root Zone Water Quality Model) (DeCoursey and Rojas 1990), developed by ARS scientists. It simulates in great detail the movement of water and solutes from layer to layer in the soil profile. It includes flow through such large pores as wormholes and cracks. It also includes descriptions of all the ways pesticides disappear or change within the soil; breakdown in water, by sunlight, by evaporation, digestion by bacteria, and so on. Nitrogen cycling is simulated in the soil using soil moisture levels, temperature, bacteria populations, degree of acidity, amount and quality of organic matter, etc.

The model includes a plant growth submodel that simulates root and surface vegetative growth and grain production. Plant stresses caused by temperature, nutrient, and soil water extremes are simulated. Also included are those physical properties of the soil that change as a result both of tillage and of the reconsolidating effects of rainfall. All of these processes are incorporated in RZWQM because of their effect on the movement and fate of nitrates and pesticides in the soil.

Models such as RZWQM are used in research because they describe, as best we can, our understanding of the processes being studied. Thus they can be used as guides to help field research identify data to be collected and know what to expect when experiments are carried out. When field research turns out differently than expected, then concepts in the model may need to be changed and different data collected to help explain why certain things happen as they do.

Because models such as RZWQM are much less expensive to run than field experiments, they can be used to investigate alternative management strategies. Those strategies that appear feasible can then be tested using field trials.

Figures 2, 3, and 4 are examples of the type of output these models provide. Figure 2 shows root water uptake over time and the layers in the soil from which it comes. Figures 3 and 4 show nitrate and atrazine concentrations in the soil water over the growing season. The rapid disappearance of nitrate is due to plant uptake, but its movement into the soil profile with infiltrating water is obvious. The disappearance of atrazine is primarily due to biodegradation.

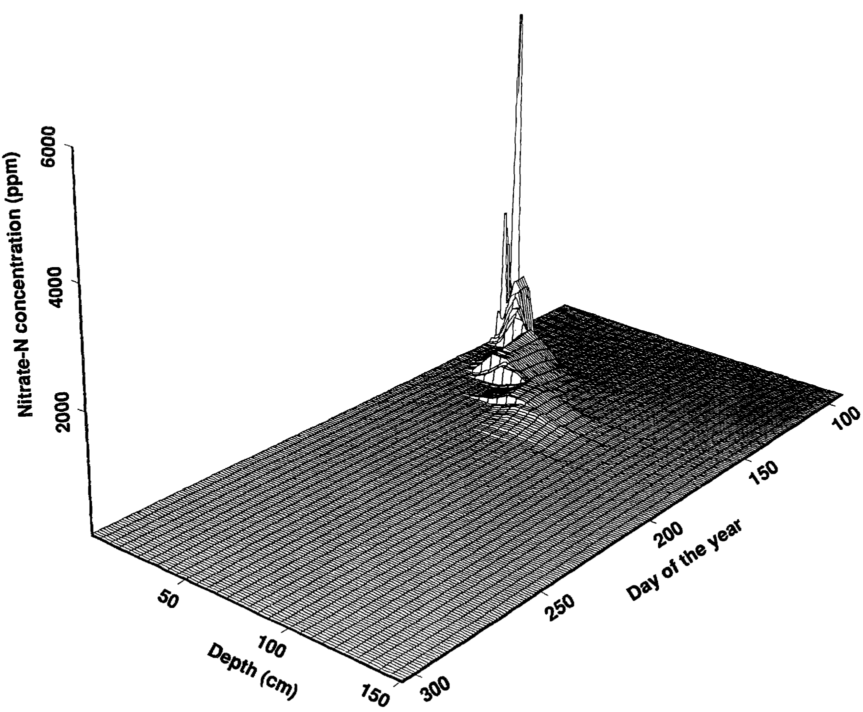
Planning and Management Models

Between the two extremes of screening and research are the bulk of the models. They are used in regulation and planning and as guides to farming practice, where they are used both to select fertilizers and pesticide varieties and timing and to fit alternative practices to specific soil properties.

This type of model has been used by regulatory agencies such as the Environmental Protection Agency (EPA) to screen new pesticides and as an aid in interpreting data obtained from monitoring surface and subsurface waters. These models are more empirical than research models in that they don't try to simulate all the physical processes but attempt to predict response to a set of input conditions or changes in inputs. Some of these models incorporate economics and the costs of farming practices.

Numerous models have been used quite extensively. Some of the best known models include AGNPS (Agricultural Non-Point Source Pollution Model) (Young and others, 1987), EPIC (Erosion-Productivity Impact Calculator) (Williams and others, 1984), CREAMS (Chemicals, Runoff and Erosion from Agricultural Management Systems) (Knisel 1980), PRZM (Pesticide Root Zone Model) (Carsel and others, 1985), PRMS (Precipitation-Runoff Modeling System) (Leavesley and oth-

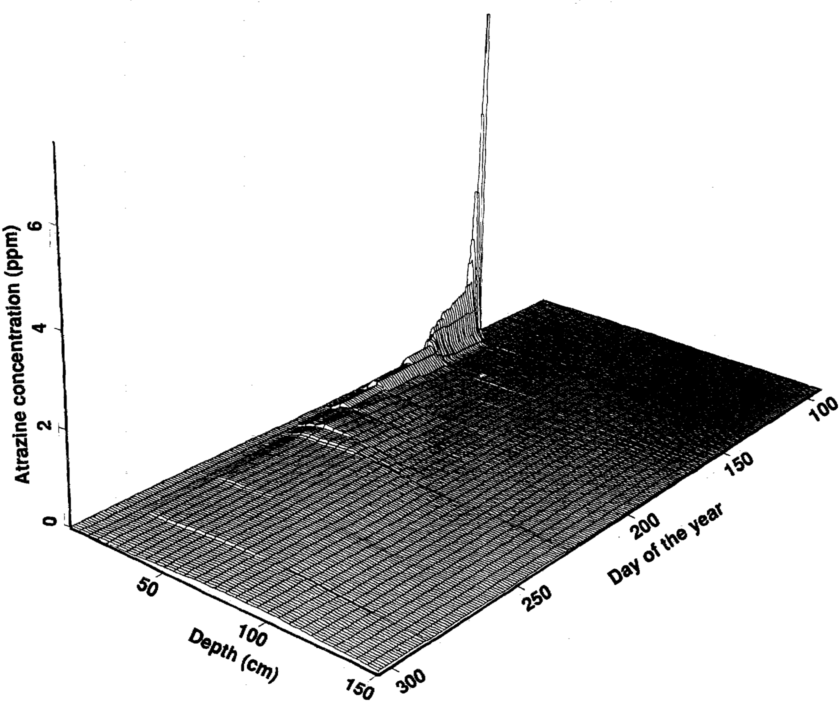
Figure 3. Concentration of Nitrate-N in Soil Water Over the Growing Season. The Crop Was 120-day Corn Growing on a Bethany Silt Loam Soil.



ers, 1983), HSPF (Hydrologic Simulation Program - Fortran) (Johanson and others, 1984), and ANSWERS (Aerial Nonpoint Source Watershed Environment Response Simulation) (Beasley and others, 1979). AGNPS, EPIC, and CREAMS were developed by ARS to look at nonpoint source pollution, the effects of soil erosion on crop productivity, and the environmental consequences of alternative agricultural practices, respectively. They are now regularly used by SCS. PRZM and HSPF are primarily EPA models, with PRZM developed to evaluate pesticide response in the root zone. HSPF and PRMS are primarily hydrologic models; PRMS was developed by the U.S. Geological Survey. ANSWERS was developed at Purdue University to simulate pollutant movement for small watersheds.

Recently, many symposiums have been held to inform both those using the models and those developing them of new developments and needs. Obviously, space does not permit an in-depth description of the numerous mod-

Figure 4. Concentration of Atrazine in Soil Water Over the Growing Season. It Was Applied to a 120-day Corn Crop Growing in Bethany Silt Loam.



els that have been developed in the United States and in other countries. (See DeCoursey 1990 for a discussion of these and other models.) We can, however, focus on one recent, comprehensive model, GLEAMS (Groundwater Leaching Effects of Agricultural Management Systems) (Leonard and others, 1987). GLEAMS is an outgrowth of the CREAMS model, incorporating many of its original process descriptions but adding numerous improvements, especially in the pesticides and nutrient subsystems.

GLEAMS was developed by ARS for field-size areas to evaluate the effects of agricultural management systems on the movement of agricultural chemicals within and through the plant root zone. A hydrologic component simulates infiltration and soil water and solute movement through soil layers. A soil erosion component estimates soil loss by particle size and includes pesticides adsorbed to clay and organic matter particles. Pesticide processes simulated in GLEAMS include degradation, extraction in surface runoff, adsorption to eroded soil particles, and movement with water through the soil profile. The CREAMS model, parent of GLEAMS, has been used extensively and was thoroughly tested; thus GLEAMS has a sound base from which to start. Recently, it has been applied to numerous pesticide and nutrient databases.

Model To Assess Effects of Global Climate Change

In the last few years, data on global temperature suggest that increases in carbon dioxide levels may be causing changes in the global climate. These potential changes have significant implications for crop production and thus management of our agricultural resources. The fertilizer and pesticide models previously described are particularly helpful in studying the potential impacts of climate change.

Global climate models (GCM's) have been used to predict changes in the Earth's temperature and precipitation as levels of trace "greenhouse" gases such as carbon dioxide and methane increase. Even though we cannot be sure the changes will take place, the likely effects of such changes (shifts in soil productivity, water availability, etc.) are extensive enough that we need to try to evaluate them.

Models such as GLEAMS, RZWQM, and another outgrowth of CREAMS, Opus (Ferreira and Smith, 1990), can be used to systematically assess some of these changes. These models are not comprehensive enough to do a complete assessment. But by running them with anticipated changes in such factors as temperature, precipitation, and solar energy, it's possible to get estimates of the effect these changes in climate would have on productivity, plant stress, water yield, soil moisture levels, and potential environmental problems. Thus it is possible to study alternative pesticide, fertilizer, irrigation, and tillage practices designed to mitigate the undesirable effects of potential climate change.

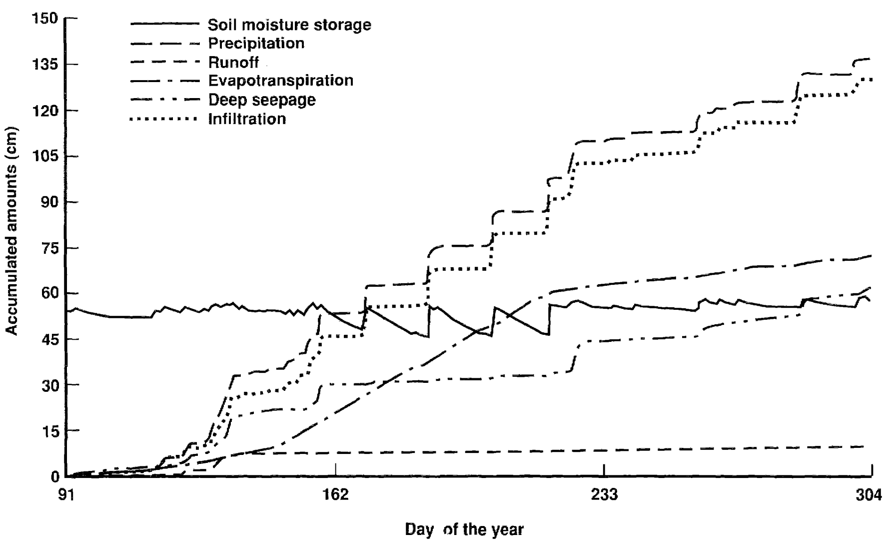
Some very specialized plant physiological models can predict likely plant response to increased levels of carbon dioxide. It is known, for example, that increases in carbon dioxide lead to increases in vegetative growth.

Model Input and Output

The data requirements of models such as those described above vary considerably. The recently developed pesticide screening model, SPISP, for example, requires only the soil properties, depth to ground water, rainfall, and pesticide characteristics from a prepared data base. RZWQM, on the other hand, simulates many different processes and their interactions; thus it requires much more information.

Even though the data requirements are extensive, they are generally available; very seldom does a researcher develop a model, even a research model, that requires data that are not generally

Figure 5. Hydrologic data from a cornfield, generated by a computer program, show a continuous record of soil moisture and accumulated values of precipitation (and irrigation), evapotranspiration, deep seepage, infiltration, and surface runoff.



available. Sometimes the data may require additional effort to get, for example meteorological data—such as rainfall, solar energy, temperature, and wind—over short intervals of time. Soils data can generally be obtained from SCS data bases. Pesticide data are now becoming available in SCS and ARS data bases. Also, new models such as RZWQM often provide the user with default values. Of course, the user must provide the site conditions that are required by the model.

In the last few years, geographic information systems (GIS) have been developed and used to provide estimates of data that vary substantially from location to location (see Chapter 29).

Model output varies considerably, depending on the type of model. Many older models provided tabular values of the input variables, driving data, and output. If the user wanted it in graphic form, it had to be plotted by hand. However, the multitude of software programs now available has virtually eliminated the need for this type of output. Now, most output data are presented in graphic forms that are much easier to interpret: multicolored bar or pie charts, comparative plots of model response to input data, temporal plots of model output, and three-dimensional plots of model performance. Figure 5 shows typical hydrologic data obtained from one model. Model output is also available in statistical summaries for predetermined time periods. Written summaries, analyses, and recommendations based on model output are also being produced.

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Planetor: A Computer Program for Analyzing Environmental Problems

23

by Richard O. Hawkins, Extension Economist; and Dale W. Nordquist, Assistant Extension Economist, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul

Planetor—it sounds like a new intergalactic space game, but it's not. Actually, it is a new computerized tool for use in developing environmentally sound and economically feasible farm plans. It was created by the Center for Farm Financial Management at the University of Minnesota, with the cooperation of several USDA agencies—Extension Service, Cooperative State Research Service, Soil Conservation Service, and Economic Research Service. Planetor is currently being tested by Extension specialists and farmers around the country.

Farmers and ranchers are increasingly aware of environmental considerations that go far beyond traditional resource conservation concerns. They are concerned about surface and ground water quality, potential pesticide toxicity, and the long-range sustainability of their farming systems. But while trying to meet these new or refocused concerns, producers still need to maintain farm incomes in order to meet financial responsibilities to their families as well as their creditors. Planetor is a tool to help farmers balance these sometimes conflicting goals and search for solutions to potential environmental problems while maintaining or improving financial well-being. Planetor can analyze the potential environmental problems of a specific farm plan within the whole-farm system framework. It identifies the potential for soil erosion; water quality hazards from excess nitrogen, pesticide leaching, and pesticide runoff; and the potential for pesticide toxicity. Planetor does this on a site-specific basis, field by field. If there is a potential for environmental hazard, Planetor will help determine the source of the problem and aid in the search for alternative strategies.

Planetor's integrated whole-farm economic analysis will help farmers and ranchers adopt more environmentally sound farm plans. The program's economic results project net farm income and net worth change for each year of up to 12 years of farm plans. This analysis also evaluates the potential financial risks associated with farm plans and helps farmers evaluate whether crop and livestock diversification will help reduce financial risks.

Farmers also need to be sure that their feed needs are met; that labor requirements do not exceed their supply; and that energy, water, and manure resources are in balance. Planetor identifies the supply of these resources, balances them with the requirements of the plan, and raises flags in areas of potential shortages.

To accomplish this, Planetor draws on typical crop rotations and livestock budgets developed by Extension specialists for specific areas of their States. Typical rotations include projected yields and prices; fertilizer and manure requirements; specific pesticides to be applied to each crop; water, energy, and labor requirements; and direct expenses per acre. Also included are specifics concerning tillage methods, irrigation requirements, and the degree to which the specific rotation is expected to aid in erosion control.

Individual farmers specify the fields on their farm, identify the predominant soil type on each field from a list of soil types in their county, and choose crop rotations that they want to evaluate. Farmers are encouraged to examine the typical crop rotations and revise them to fit their own situations. The program combines the characteristics of each soil type with the pesticide characteristics, tillage methods, and input levels chosen to evaluate site-specific environmental concerns.

Farmers and ranchers are encouraged to first evaluate their current farming systems to see if there are areas where they are potentially falling short of their environmental or economic goals. If so, they are encouraged to look at alternative crop rotations, tillage methods, and input levels for more satisfactory alternatives.

Extension specialists in many States are currently developing typical regional crop and livestock budgets and other local information for incorporation into Planetor. They are also testing the program with farmers and ranchers to obtain the most important piece of information—producer response.

Having this kind of a tool in use across the country will help farmers and ranchers identify potential environmental problems. Over time, it will also help identify where more information and research are necessary. The results of these initial tests and new research results will then be incorporated into future versions of Planetor.

For more information about Planetor for your State, or to obtain a demonstration copy, contact: Center for Farm Financial Management, 249 Classroom Office Building, University of Minnesota, 1994 Buford Avenue, St. Paul, MN 55108. ■

Sustainable Agriculture

24

by Paul F. O'Connell, Deputy Administrator, Cooperative State Research Service, USDA, Washington, DC

In the United States, as in other industrialized countries, farming practices are being reexamined. Consumers of food and fiber, many farmers, and various environmentalists are expressing concerns about how modern agriculture is being practiced.

Agriculture should welcome this increased interest. Modern agriculture has done a tremendous job of providing high-quality and reasonably priced food for consumers. All you have to do is visit any supermarket to realize the tremendous variety of products available. One of the first things Eastern Europeans look for when they visit the West is the broad selection of food supplies available.

But changes can be made to respond to health and safety issues, such as persistent soil erosion and a loss of natural soil productivity; contamination of ground water by agricultural chemicals; pesticide residues in food; growing resistance to pesticides by insects and other pests; loss of genetic diversity; depletion of irrigation water supplies; aggravated salinity; and the loss of fish and wildlife habitat. Improvements in these areas can occur without disrupting the many positive aspects of today's agriculture.

The unforeseen costs of conventional agriculture include not only these environmental issues, but also the economic risks and losses experienced by a great many farmers during the early 1980's, when foreign demand for U.S. farm products stagnated and land values plunged. A few years ago, "sustainability" was seen as

Neil Eash and Aaron Steinwand, ARS research associates, examine a soil core sample. Samples will be analyzed to see how nitrates and other nutrients are distributed, and to locate carbon accumulations from decaying organic matter. *Lowell Georgia/USDA 89BW1229-10* an environmental issue, but the economic questions that grew out of the farm financial crisis of the last decade expanded the definition to include an economic component. While the circumstances surrounding that situation were unusual, the future could bring similar shocks, such as a cutoff of petroleum or a jump in costs of petrochemical-based inputs as global supplies dwindle.

Different people have different viewpoints on these issues. For example, in the case of pesticide residues and ground water contamination, there is evidence to support or to refute the claim that a major problem exists. But it is true that a great many people believe these problems are serious.

The benefits of sustainable agriculture do not rise or fall on evidence for or against these concerns. Much of the public's growing interest in sustainability is a reaction to the sum total of unanticipated consequences of modern agriculture.

The public wants an agriculture that will not only be productive and profitable, but that will also conserve resources, protect the environment, and enhance the health and safety of the public. That's what is meant by sustainable agriculture.

Definition

As defined by Congress in the 1990 farm bill, sustainable agriculture is "an integrated system of plant and animal production practices having a site-specific application that will, over the long term: satisfy human food and fiber needs; enhance environmental quality and the natural resource base upon which the agricultural economy depends; make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls; sustain the economic viability of farm operations; and enhance the quality of life for farmers and society as a whole."

Sustainable farming practices vary from farm to farm but commonly include:

- Crop rotations that mitigate weeds, disease, insects, and other pest problems; provide alternative sources of soil nitrogen; reduce soil erosion; and reduce risk of water contamination by agricultural chemicals.
- Pest control strategies that are not harmful to natural systems, farmers, their neighbors, or consumers. This includes integrated pest management techniques that reduce the need for pesticides by practices such as scouting, use of resistant cultivars, timing of planting, and biological pest controls (see chapter 21).
- Increased mechanical and biological weed control; more soil and water conservation practices; and strategic use of animal and green manures

(legumes used to add nutrients and organic matter to the soil).
- Selection of synthetic chemicals whose use poses no significant hazard to humans, animals, or the environment.

Sustainable agriculture focuses on an integrated approach to the science and art of farm management. This approach encompasses the whole farm, relying on the expertise of farmers, interdisciplinary teams of scientists, and specialists from the public and private sectors. Technologies for an individual crop or livestock enterprise can be essential components of sustainable agriculture. Standing alone, however, the components do not provide sufficient answers.

If they are to be effective, results of research and education programs must be presented in a practical, easily understood framework that will enable the farmer to make informed choices among various societal and individual goals—such as income, yields, environment, food safety, and risk aversion.

This approach to farming uses the wisdom of the past, combined with today's improved knowledge about biological, ecological, and economic processes. In essence it looks for complements between production and environmental goals. This type of farming can include farming without manufactured chemicals (commonly known as organic farming), if that is the farmer's choice. However, it is not limited to that option. Wise and conservative use of synthetic chemicals is also compatible with the goals of sustainable agriculture.

Activities Underway in USDA

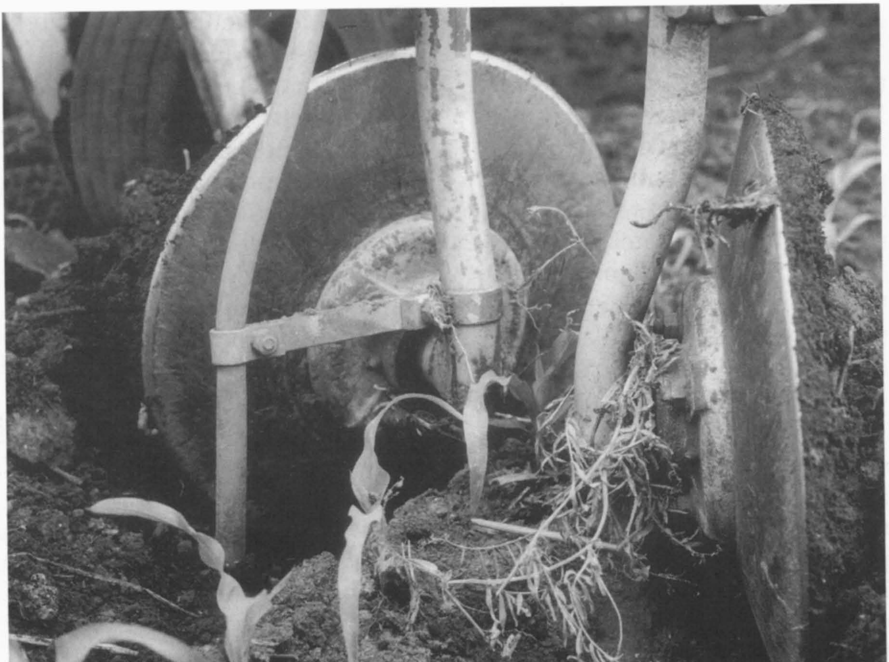
USDA agencies have been addressing some aspects of sustainable agriculture for some time. In addition, several agencies are redirecting their programs to more effectively incorporate sustainable agriculture attributes into them.

Research and Education. USDA research and education in sustainable agriculture are of two general types—component and whole farm. The component activities are those concerned with the cause-and-effect relationships underlying specific farming problems, and the development of particular technologies, equipment, practices, and crop and livestock varieties. The whole-farm activities deal with the total picture, including the farmer's goals and resources, and the interactions of all farming practices. Each makes an essential contribution.

USDA's ***Agricultural Research Service*** is currently spending about $11 million annually for sustainable agriculture research in the whole-farm category. About $83 million is devoted annually to research on components of sustainable systems, such as biological pest controls and integrated pest management, crop varieties that will be more resistant to or tolerant of pests, diseases, drought, acid soils, and air pollution; prediction and control of soil erosion; nutrient management and crop rotations to reduce water pollution, enhance yields, and reduce farmers' dependence on agricultural chemicals; and improved productive capacity of soils through incorporation of agricultural, municipal, and industrial wastes.

The ***Cooperative State Research Service*** has a long history of partnership with State Agricultural Experiment Stations to provide research on farming systems that help U.S. farmers meet their site-specific needs. The most recent estimate indicates that $76 million is being spent on important components of sustainable agriculture. This includes such topics as crop breeding, soil testing, and biological and cultural control methods for pests, including biotechnology research and integrated pest management (IPM).

CSRS also administers the Sus-



Closeup of a Buffalo ridge tiller.
Lowell Georgia/USDA 89BW1230-2

tainable Agriculture Research and Education program previously known as Low Input Sustainable Agriculture (LISA). This program was first funded at $3.9 million in 1988 and has grown to $6.7 million in 1991. Matching funds from successful applicants have more than doubled the amount of research and education activity. The focus of these projects is on integrated crop and animal production systems, or whole-farm management systems.

In the 3 years since this program began, it has funded 100 team projects, plus 9 planning grants and 45 renewals. To date, 1,860 farmers have participated in the funded projects. Hundreds of farmers have helped generate ideas for these projects and have provided land for studies and demonstration plots. They also helped manage the projects and over 500 evaluated the outcomes. Most importantly, farmers are actively involved in the leadership of the program, helping to decide which projects to fund.

As the project results become available, they will be disseminated to farmers through special reports, publications, and video presentations, and through existing channels such as the State Cooperative Extension System and the Soil Conservation Service.

The Sustainable Agriculture Research and Education (SARE) program is carried out by collaboration with the ***Extension Service***. All of the State Cooperative Extension Services conduct programs contributing to agricultural sustainability. These include educational programs on IPM, soil testing and fertility management, pesticide management, soil conservation, water quality protection, and farm management. Extension personnel in several States have also developed comprehensive programs linked to research and on-farm demonstrations.

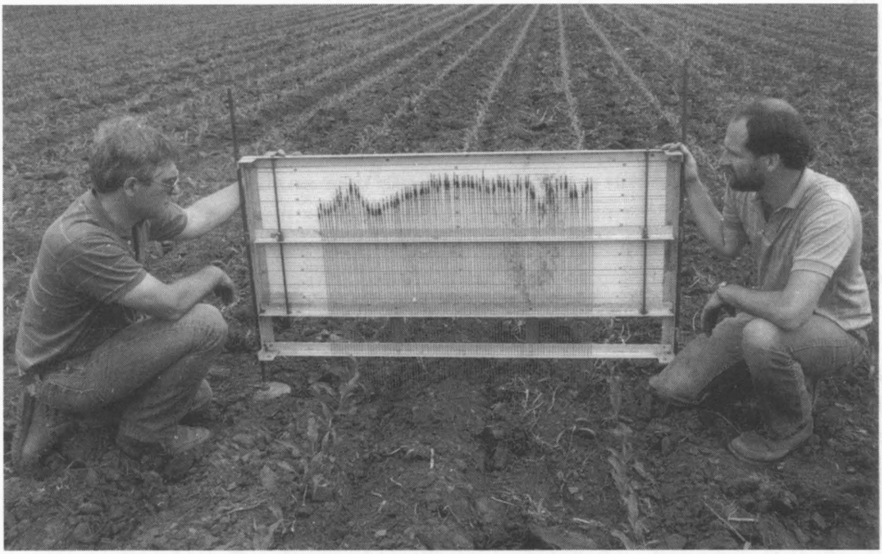
USDA's Extension Service has had a lead role in developing a nationwide "farmer-friendly" computer software package under the direction of Extension personnel at the University of Missouri. Called the Farm Decision Support System, this project integrates the findings of plant and animal sciences, economics, and environmental studies into a process that enables farmers to make informed choices about the adoption of sustainable farming practices. This innovative system has been partially supported by the SARE program.

Extension is also pioneering a computerized information delivery system to make research available to farmers.

The ***National Agricultural Library*** plays a critical role through its Alternative Farming Systems Information Center, authorized in the 1985 Food Security Act and supported in part with SARE funds. Since its establishment 5 years ago, the number of inquiries and requests for information on sustainable farming handled by the center has increased tenfold.

The center not only serves as a clearinghouse for information, but has also produced timely publications. They include a directory of educational and training opportunities in sustainable agriculture and a series of bibliographies on sustainable farming topics, from composting, green manures, and cover crops to how to capitalize on allelopathy—the toxicity of certain plants to weeds. The latest service introduced at the center offers on-line computerized literature searches to people preparing applications for sustainable agriculture research and education grants.

The ***Economic Research Service*** does national and regional research on a number of natural resource and technology issues related to sustainability. Studies now underway are examining the effects on costs and profitability of different levels of chemical use on Corn Belt farms, and the economic impacts of banning or restricting the use of certain chemical pesticides and fertilizers.



Doug Karlen (left), soil scientist at the ARS National Soil Tilth Laboratory, Ames, IA, and Research Associate Neal Eash (right), study the profile of the needle board. When the board with solid wires projecting below it is placed over the tilled rows and then lowered, the top of the needle measures the roughness of the soil surface.
Lowell Georgia/USDA 89BW1229-19

Programs of Action Agencies. The challenge of ensuring sustainability is no stranger to the USDA ***Soil Conservation Service*** (SCS). SCS and the professional conservation network that reaches into virtually every county have fostered resource conservation and environmental protection for over 50 years. The agency offers farmers a wide range of technical assistance and cost-sharing programs to help them develop environmentally and economically sustainable practices.

With the broadening of support for sustainable agriculture in the 1985 Food Security Act, SCS has done more to address the need for sustainability. For example, in 1989, the agency added to its handbook of conservation practices two new standards involving nutrient and pest management. The new standards examine the amount of chemical fertilizers and pesticides actually needed on farms, thereby reducing the potential for ground water contamination and chemical runoff.

The ***Agricultural Stabilization and Conservation Service*** contributes to agricultural sustainability in three different ways.

First, in 1990, ASCS launched a new pilot program permitting cost-sharing of conservation practices that encourage lower applications of chemical pesticides and fertilizers. Called the Integrated Crop Management program, it is partially compensating up to 20 farmers in each of 5 counties per State that participate in the program (see box).

The second way ASCS contributes is through administration of support programs for major crops. To the extent permitted by existing legislation, ASCS gives farmers who enroll in major crop programs as much latitude as possible in growing rotation crops, without incurring a loss of their base acres and program payments.

ASCS plays a third and very significant role in carrying out the cross compliance provisions of the commodity support program. Farmers must plan and implement effective erosion control and wetland management practices in the Conservation Reserve Program to remain eligible to receive support payments.

The ***Animal and Plant Health Inspection Service*** continues to support a more sustainable agriculture through its operation of biological pest control programs. Now funded at $10 million annually, these programs aim to control the Mediterranean fruit fly, screw worm, boll weevil, Gypsy moth, Africanized honey bee, and fire ant.

Presidents' Water Quality Initiative. Individual agency programs to foster a more environmentally and economically sound agriculture are complemented by interagency efforts. The President's Water Quality Initiative (see Chapter 12) is an interagency, interdepartmental program to develop, test, and deliver to farmers information on crop and livestock management systems that reduce the risk of agricultural chemicals reaching water supplies, particularly ground water. The initiative is bringing together the contributions of 11 USDA agencies working in partnership with the State Agricultural Experiment Stations, the State Cooperative Extension Services, and six other Federal departments and agencies.

Some Findings

In April 1990, the Board on Agriculture of the National Academy of Sciences held a conference for scientists, innovative farmers, and policymakers to discuss progress in sustainable agriculture research and education efforts across the United States. The following reports are highlights of the conference:

- A team of scientists at South Dakota State University started a crop rotation study in 1985, comparing conventional farming, a choice of ridge tillage or minimum tillage, and a crop rotation approach. The study now includes experimental plots at two locations, Watertown and Madison. When this study became a sustainable research and education project in 1988, the scope of investigations was expanded to include whole-farm studies on several

Integrated Crop Management

The Integrated Crop Management (ICM) program helps farmers develop an overall crop management system that promotes the efficient use of agricultural inputs in an environmentally sound and profitable manner. It is adminstered by the Agricultural Stabilization and Conservation Service (ASCS) as part of the Agricultural Conservation Program (ACP).

The ICM practice is designed to encourage the adoption of farming methods that integrate many farming activities into a management system. It encourages producers to try different approaches of production by providing financial assistance to help defray the costs and overcome the risks of changing production methods. The long-term benefits of the ICM practice will be preservation and improvement in the natural fertility of the soil, prevention and abatement of agriculture-related pollution, increased farm efficiency, and conservation of the land.

Why ICM?

Each year, over 20 billion pounds of fertilizers and 1.1 billion pounds of pesticides are applied to U.S. land. Further, over 95 percent of rural Americans depend on wells as their sole source of drinking water. ICM practices are some of the most effective means of reducing runoff and see page of nutrients and pesticides that affect water quality.

—by Jim Lucas, Assistant to the Director of Information, ASCS, USDA, Washington, DC cooperating farms, biological control of pests, nutrient cycling, and soil properties. Economists on the project team have adapted the experimental findings from the first 3 years to develop preliminary estimates of the net returns that would be earned by a typical family farm of 540 tillable acres.

- During the drought of 1988, the only approach tested in this South Dakota study and expected to earn a profit was the lower input farming system. Lower input refers to less purchased inputs, but very often they require use of more on-farm inputs, such as legumes in a crop rotation to satisfy nutrient and pest control needs. At the Watertown site this farming approach was estimated to earn a profit of about $4,900, using a crop rotation of oats, alfalfa, soybeans, and spring wheat. The simulated farms using a conventional rotation (corn, soybeans, and spring wheat), with chemical pesticides and conventional tillage, incurred net losses of about $23,000 and $25,000—a difference of about $30,000 compared with the lower input system. At the

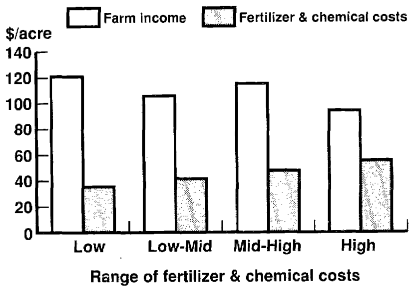
Farmer Dick Thompson, a proponent of ridge tillage, cultivates his study plot. He says ridge tillage eliminates the need for fall and spring preplant tillage.
Lowell Georgia/USDA 89BW1230-33

Madison site, the differences were smaller.

- In view of consumer concerns over pesticide residues on fruits, scientists in Georgia and Virginia developed alternative methods of controlling fungus diseases and insect pests. Instead of relying on heavy preventive spraying to control the fungus diseases sooty blotch and flyspeck, these scientists developed a post-harvest technique for dipping the fruit in a household bleach solution. Sooty blotch was completely removed, and flyspeck was reduced by 73 percent. When sprayed fruit is dipped in bleach solution, virtually all the residues of fungicides are removed. Growers have also found that major insect pests are effectively controlled by pheromone disruption plus a single well-timed spray. Alternative-row spraying and ground cover management help conserve natural enemies of the pests and reduce the need for sprays. The overall pest control system developed in this study achieved equal or better control of insect and disease injury compared with SCS Georgia Technical Field Guide recommendations, while reducing the number of sprays from 19 to 9.5, and reducing pest control costs from $247 to $99 per acre.
- In an effort to reduce the environmental impact and lessen water quality risk associated with control of corn rootworm, Agricultural Research Service scientists in South Dakota devised a bait that is a starch crystal containing about 2 teaspoons per acre of the insecticide carbaryl. While this is only about 2 percent of the normal dosage, tests in the laboratory and in field cages under controlled conditions have found that the bait kills up to 94 percent of the adult corn rootworms, with no harm to nontarget species. The bait contains two kinds of semiochemicals (behavioral modification chemicals). The first is an attractant that lures the adult corn rootworms (both males and females) to find the starch granules scattered about the field. The second semiochemical is a feeding stimulant made from a bitter herb that is delicious to the corn root worm but repugnant to most nontarget species such as birds. Full-scale field tests of the bait under actual farming conditions are underway in several States.
- Some farmers have found that when they adopt lower input methods, including careful management, gross returns decrease slightly but net returns increase. For example, a study of Illinois farmers covering 6 years (1982-87) found that

farmers using the highest amounts of purchased inputs per acre harvested more bushels—but earned less profit per acre—compared with farmers using less purchased inputs per acre. The study examined data from a sample of 201 central Illinois farms drawn from the University of Illinois farm records system. The farms were ranked according to their per-acre expenditures for commercial fertilizers and agricultural chemicals, and the top one-fourth of the farms in this ranking were considered the "high-input" group. The quartile of farms having the lowest expenditure per acre is the "low-input" group. The net farm income per acre of farms with the lowest expenditures for fertilizer and chemicals was $121.17, whereas the net farm income per acre of farms at the high level was $94.65. Results for central Illinois farms are in figure 1.

Figure 1. Farm income vs. fertilizer & chemical costs for sample of 201 central Illinois farms



*Source: "Farm Profitability and Input Use," by Kevin W. Koenigstein, Robert H. Hornbaker, and David A. Lins, University of Illinois, 1990.

Whether a specific farmer could enhance profits while reducing pesticide and fertilizer inputs is a complex question. The answer depends on the farm's crop history, soil productivity, previous input use, management ability, weather, and a variety of other factors such as weed and plant population.

In southern Illinois, by contrast, the category of farms with higher fertilizer and chemical inputs had the greater net return. This situation readily points out the need for site-specific information.

The Challenge Ahead

What USDA is doing to foster sustainable agriculture, in fact what most agricultural institutions are doing, is but the start of a process that will have no end.

Sustainability is an ideal, a goal, whose pursuit requires a substantial change in the way we think about farming. It calls for new interactions and new associations. The continuing search for a sustainable agriculture will never be easy. But the importance of that search will always overshadow the difficulties and disappointments encountered along the way. ■

Soil and Water Conservation: A Worldwide Goal

25

by Liu-Hsiung Chuang, Agricultural Economist; Peter Smith, Director; and Thyrele Robertson, Senior Staff Analyst, Strategic Planning and Policy Analysis Staff, SCS, USDA, Washington, DC

Accelerated global population growth is generating ever-increasing pressure on natural resources. The exploitation of resources for economic development, especially since World War II, has led to great degradation of the environment in certain areas of the world. Soil erosion, salinization, deforestation, species extinctions, contaminated water, polluted air, increased atmospheric carbon, potential global warming, and the human suffering that results—all are becoming too obvious and serious to be ignored by passengers in our green spaceship.

Over the last four decades, the environmental movement has gained great support in the developed countries, including the United States. In the 1980s,

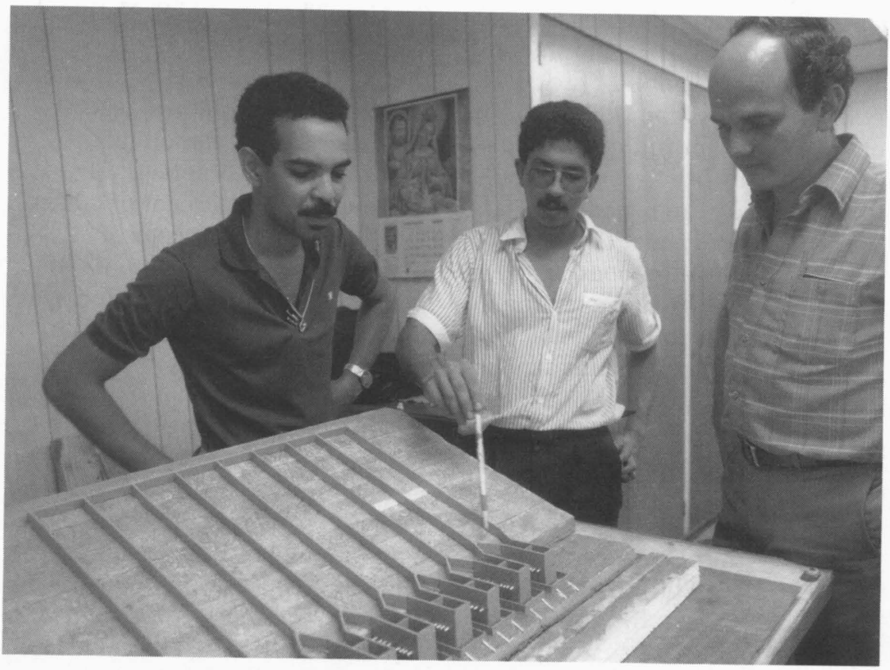
Soil and water conservation efforts aim to increase productivity, improve living conditions, and ensure sustained agricultural productivity for future generations.
Ron Nichols/USDA 88BW0508-7

people became concerned about long-term protection of the environment via sustainable use and development, and about incorporating that concern into an overall economic development plan for developing countries.

Most of the developed countries in the world, including the United States, have invested significantly to correct past errors and strengthened their efforts to protect and enhance their resource bases. Many developing countries, however, are very much behind in their efforts toward sustainability because they do not have the necessary knowledge, capital, and strength of purpose—for this last must be supported by widespread public concern.

Sustainable Development

In 1987, the World Commission on Environment and Development defined sustainable development as that which "meets the needs and aspirations of the present without compromising the ability of future generations to meet their own needs."



Conservationists from SCS and the Dominican Republic work on an erosion test plot model. Obtaining hard data from these sites helps conservationists determine ways to control erosion.
Ron Nichols/USDA 88BW0494-32A

Sustainable development intersects and interrelates the physical, biological, social, political, institutional and economic spheres. Preservation, protection, and enhancement of natural resources—including soil, water, air, plants and animals—are key items in the physical sphere of sustainable development.

Another important objective is to preserve biodiversity, which means far more than the preservation and protection of endangered species and may entail the protection of entire ecosystems. Protecting the gene pools of important agricultural crop plants is a major task of sustainable development.

To improve the lot of the rural poor, to reassess the sustainability of "primitive" or indigenous cultures, and further to preserve cultural diversity are primary social-political-institutional objectives of sustainable development.

Another key goal of sustainable development is to provide technical and financial assistance to less developed countries, regions, and sectors and thus to promote long-term, transgenerational economic benefits.

Soil and Water Conservation

Controlling Soil Erosion. Key activities in controlling soil erosion include: use of sustainable cropping practices such as crop rotation systems, conservation tillage systems, strip cropping, and contour cropping; establishment of grass and trees as ground cover and of windbreaks and shelterbelts; construction of terraces, grass waterways, checkdams, irrigation canals, ponds, and watershed protection systems.

Many success stories of applying soil erosion control in developed countries and some developing countries have been printed in international reports and journals. In the United States, a vigorous and consistent erosion control program has been established since 1935 under the leadership of the Soil Conservation Service. The latest U.S. National Resource Inventory (1987) shows that 37.3 percent of U.S. cropland is adequately protected against erosion, as is 44 percent of pastureland, 25.5 percent of rangeland, 28.7 percent of grazed forest land, 46.3 percent of ungrazed forest land, and 83.3 percent of other land. Nationwide, 38.2 percent of nonfederal rural land is adequately protected.

Although more than 50 years of erosion control efforts in the United States have brought the average annual water and wind erosion on cropland below 5 tons per acre (3.8 tons per acre of sheet and rill erosion and 3.3 tons per acre of wind erosion in 1987), there are still 123 million acres of U.S. cropland estimated to be highly erodible in 1987.

Protecting Water Quality. The soil erosion control practices already mentioned all help to reduce sediment delivery to waterways. Other activities include reduced use of pesticides, herbicides, and nutrients; organic waste management; and special precautions to protect wellhead, filterstrip, and sinkhole areas. The wetland reserve, environmental easement, and integrated farm management programs of the 1990 farm legislation, when implemented, should help to improve the safety of the Nation's food and drinking water. The 1990 farm bill also seeks to encourage sustainable agricultural practices. Protection of wildlife habitat is an important soil and water conservation activity that contributes to sustainable development.

Increase in Income and Employment

One important feature of sustainable development is the generation of income and employment for the economy. The investment in soil and water conservation will increase the level of national expenditure and thus create an effective demand for labor and other economic resources produced in various economic sectors. This tends to generate direct and indirect expansionary effects on an economy. The speed and realization of the chain reactions of the expansionary process in an economy will depend upon the structure of the economy. The resulting output and employment increase will depend on the

Terraces and grassed waterways are basic techniques used in sustainable cropping. Planting lemon grass is one way to help stabilize a newly created terrace.
Ron Nichols/USDA 88BW0497-24

amount of initial investment and the linkage effects among the sectors of the economy.

SCS Activities

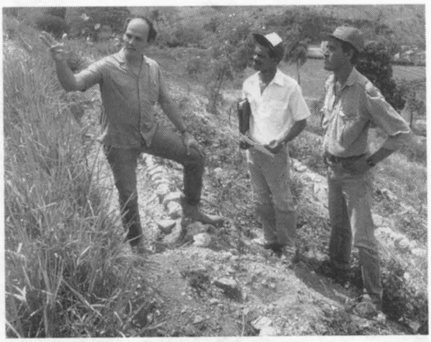
Since 1935, the Soil Conservation Service has been providing technical assistance and limited financial assistance to land users in their implementation of soil and water conservation measures. These cover the development and implementation of conservation plans; identification, development and distribution of grass species for soil protection; assistance in watershed planning for flood prevention; technical and financial conservation assistance to the Great Plains area, the part of the United States most vulnerable to wind erosion; development and conservation of rural resources; and reclaiming rural abandoned mine areas.

SCS also conducts soil surveys, annual snow surveys, and river basin surveys, which serve in part to support its activities in conservation and resource protection. Since 1960, annual expenditure in SCS conservation activities has been maintained at over $600 million in 1982 dollars. The income and employment effects of investing 1 dollar in conservation in the United States are estimated to generate one-third more than the initial investment to the U.S. economy. Thus, investment in soil and water conservation would contribute to economic development of an economy.

Prevention of Productivity Loss

Investment in soil and water conservation maintains the sustainability of soil productivity by preventing or at least retarding the loss of soil productivity. Further, it reduces off-site damage and ensuing maintenance cost, and improves safety for humans and other species, thus contributing to the sustainability of the entire ecosystem.

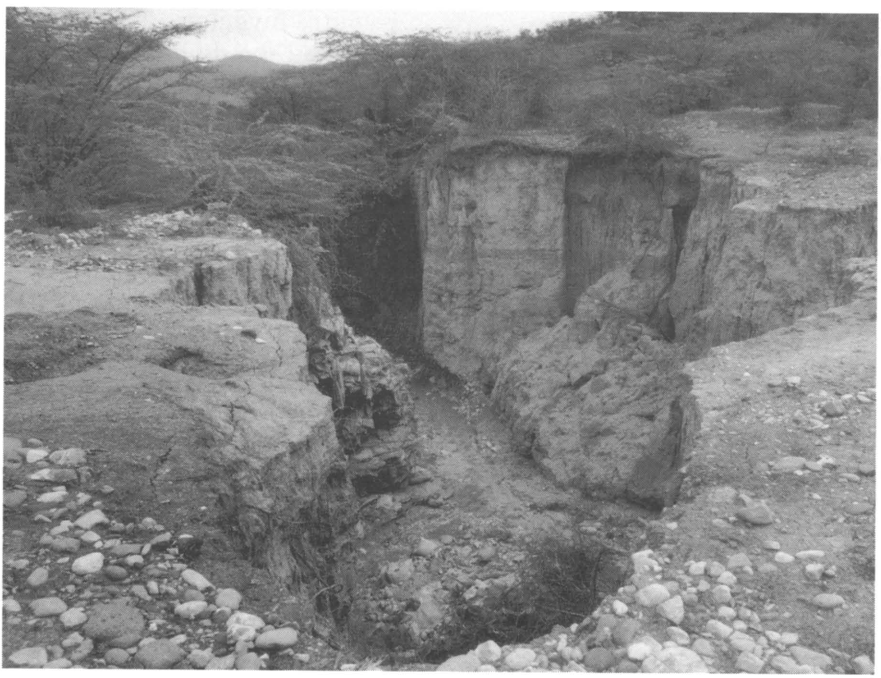
The seriousness of erosion's threat to soil productivity can be shown in a report by Walter V.C. Reid, who says, "[Forty] percent of the productive capacity of Guatemala's land has been lost to erosion; in Haiti, the loss has been so great that no top quality soil remains. In Africa, without conservation measures, 16 percent of the



By working with landowners and officials of the Dominican Republic, SCS helped reduce erosion and improve water quality throughout that country.
Ron Nichols/USDA 88BW0504-36

rainfed cropland of 1975 will be lost to erosion by the end of this century. . . . As soil productivity declines, the pressure to exploit remaining resources mounts, and further decline in productivity follows. Worldwide, more than half of the forest land cleared annually can be attributed to replacement of degraded agricultural soil." Throughout much of the Tropics, forest land converted to agricultural and livestock uses loses its productivity extremely quickly, in 1 to 3 years.

Using the Erosion-Productivity Impact Calculator (EPIC), a simulation model developed in the U.S. Department of Agriculture to measure the effects of soil erosion on productivity, and data from all major U.S. land resource areas (defined as areas with similar climate and soil regimes), it is found that even under current conditions of erosion control for a 100-year period, at the national level the loss in productivity over the next 100 years is projected to be less than 5 percent. However, a broad, elongated strip along the Pacific coast, which is currently extremely productive, is projected by the model to lose much of its



The seriousness of erosion's threat to soil productivity is strikingly apparent in these huge gullies carved through the landscape.
Ron Nichols/USDA 88BW0506-29A

productivity—in one area, more than 60 percent—while nearly all of the eastern half of the country is projected to lose between 0.1 and 9.9 percent, and in some areas considerably more, of its productivity.

Continuous investment in soil conservation nationwide is crucial, particularly in regions that are vulnerable to potential soil loss.

Recommendations for a Better World

Severe global degradation of soil and water resources evoked questions about the eventual sustainability of the Earth's entire ecosystem. Soil and water conservation has been effectively practiced by many cultures in many parts of the world throughout human history. Nonetheless, we find that the decline of many cultures was closely associated with the erosion of their resource bases.

In recent years, international technical cooperation and assistance have demonstrated that great advances can be achieved in agricultural, forest, and range productivity in all developing countries at extremely low capital costs through soil and water conservation techniques such as conservation tillage, windbreaks, terraces, and contouring; intercropping agroforestry, and use of green and organic fertilizers. Application of these practices certainly could serve as the starting point. However, to make sustainable development an achievable goal, more attention should be paid to projected population growth.

Ideally we should seek to take the following measures:

- Make soil and water conservation an ethical imperative in every human culture.
- Focus on the development of an environmental data base, such as soil surveys, water resource inventories, watershed and river basins, species inventory, gene pools, seed banks, water quality data, use of nutrients and chemicals, and natural resource inventory. The data collected should be fully compatible, so that trends can be detected over a period and geographic differences compared. These data should help reveal the seriousness of the resource degradation problems, and highlight the needed areas for action.
- Foster global cooperation and coordination on environmental policies and practices and try to make them at least equally as if not more important than other national policies such as commodity and trade policies. The currently much-talked-about "debt-for-nature swaps" are a good example of creative thinking and public-private cooperation in policy.

The "debt-for-nature swap" is an approach that is being used by environmental groups to buy up foreign debts with privately contributed donations, and to trade the right to collect these debts from the financially troubled debtor countries in exchange for commitments from these debtor countries to acquire parks, protect tropical forests, and conserve environmental resources. "Debt-for-nature swaps" have been applied in such countries as Ecuador, Costa Rica, the Philippines, Madagascar, Zambia, the Dominican Republic, and Poland.

In 1990, President Bush included debt-for-nature swaps in his "Enterprise for the Americas" initiative, and Congress authorized swaps for some $1.7 billion in third world debts.

Resources for You

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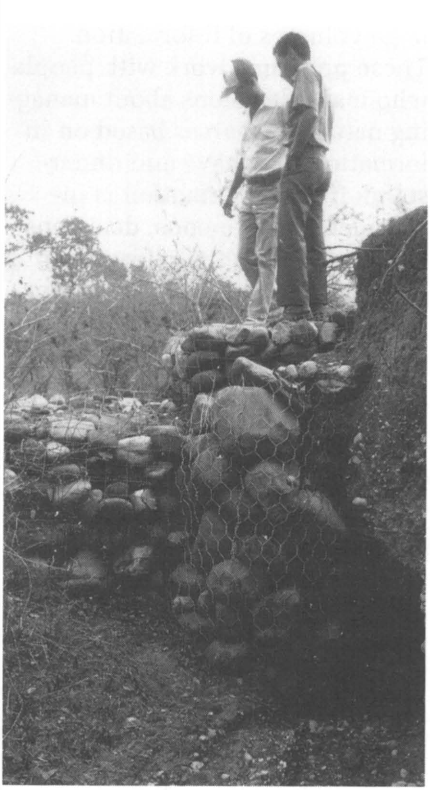

Attempts to control the erosion are often in vain due to farming practices upstream.
Ron Nichols/USDA Photo 88BW0501-29A

Integrating Sustainable Agriculture into SCS Conservation Programs

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by Marc Safley, Assistant Director, Ecological Sciences Division, SCS, USDA, Washington, DC; and Linda Oyer, Conservation Agronomist, Midwest National Technical Center, SCS, USDA, Lincoln, NE

Conservation programs require large volumes of information. These programs work with people who make decisions about managing natural resources based on information they have and understand. If that information is incomplete or erroneous, decisions will be faulty. If the information is complete and accurate, decisions are less likely to be faulty. Although this sounds simple, placing good, technically and biologically sound resource information in the hands of decision-makers requires careful planning and coordination among many specialists.

Sustainable agriculture presents a challenge to conservation programs. This chapter describes some goals of sustainable agriculture, and some ways the Soil Conservation Service (SCS) system delivers new technologies to help implement sustainable agricultural farming methods.

Although there is no strict definition of sustainable agriculture because of ongoing debate concerning agriculture and the environment, there is a growing consensus about its goals. Sustainable agriculture must be made up of farming and ranching systems that can maintain productivity and protect the environment indefinitely. Sustainable systems must be resource conserving, socially supportive, commercially competitive, and environmentally sound. A sustainable agriculture reduces adverse effects to on-site and off-site environments, while providing a sustained level of production and profit. Sustainable agriculture should be considered a goal, not a practice. Sound resource conservation is an integral part of sustainable agricultural systems.

Good Information To Support Good Decisions

SCS uses many avenues to provide natural resource information and management technology to its field personnel. These methods include specific handbooks, manuals, and the SCS *Field Office Technical Guide*. This guide is used by the SCS field office staffs as the general reference document for technical assistance. SCS technical specialists modify each *Field Office Technical Guide* to accurately address local cultural and natural resource conditions.

Each *Field Office Technical Guide* has five sections:

1. General Resource References
2. Soil and Site Information
3. Conservation Management Systems
4. Practice Standards and Specifications
5. Conservation Effects

The goal of SCS conservation programs is to provide planning assistance to decisionmakers. This assistance enables these decisionmakers to implement systems of conservation practices and management that protect natural resources. The systems prevent degradation and permit sustainable use. In 1991, SCS is revising procedures and criteria to offer sound planning alternatives by placing criteria for conservation treatment of soil, water, plant, animal, and air resources in each *Field Office Technical Guide*. These criteria will allow SCS to measure attainment of nondegradation goals and other acceptable levels of treatment.

In a Maryland cornfield at the mouth of the Patuxent River, Janine Baratta (left) and Mitch Woodward (right), University of Maryland nutrient management specialists, apply various rates of nitrogen fertilizer to determine the best rate that avoids overfertilization.
Charles Phillips/USDA 90BW1112-21

Section four of the guide contains standards and specifications for more than 100 conservation practices. These are the building blocks of conservation management systems and form the basis for creating sustainable systems. Practice standards set forth the minimum level of acceptable quality for planning, designing, installing, operating, and maintaining each practice. Practice specifications state technical details and workmanship necessary to install the practice properly. As new technologies are discovered or developed, they are incorporated into this section of the guide.

SCS field personnel and technical specialists record expected and observed effects of conservation practices in section 5 of the *Field Office Technical Guide.* Landowners and land managers are shown these effects to allow them to assess the impacts of conservation alternatives. This will improve the ability of farmers and ranchers to understand the probable effects of their management options and to make better, more informed decisions.

Sustainable Technologies

Within the philosophical framework of sustainable agriculture, the type of agriculture that emerges is not low-input or "low-technology." It is an agriculture that allows for the integration of several sophisticated technologies to produce a more efficient and environmentally responsible agriculture. For example, technologies such as genetic engineering, remote sensing, and field-level chemical testing all play a role in improving sustainability. Plants bred for increased photosynthetic efficiency, improved nutrient efficiency, nitrogen fixation, and improved pest resistance provide producers with opportunities to decrease expenditures for fertilizers and pesticides. Remote sensing of pest populations also will aid in improving pest management. Tissue testing in the field will allow more efficient fertilizer application with less likelihood for pollution of surface or ground waters.

Some older technologies also apply to sustainable agriculture. These older technologies include practices and systems that have proved useful in managing soil erosion, water movement, and pest management. Practices which break steep slopes into less steep and less erosive surfaces (such as constructed terraces, diversions, hillside ditches, and vegetative bench terraces) are important. Conservation tillage practices such as minimum tillage, ridge tillage, and no-till offer options to producers to manage their lands more efficiently with less adverse environmental impact. Crop rotation, contour cultivation, strip cropping, windbreaks, and windstrips are also basic management tools that contribute to agricultural sustainability.

Sustainable agriculture, in practice, must be considered as a system—a system that addresses unique environmental, economic, and social needs and conditions, and a system that exists in a larger context of varying local, national, and even international conditions. These systems must not be defined only by the innovative practices and methods they include, or by any "low-input" facets to their operation. Instead, they are defined by the balanced, systematic integration of technologies, management strategies, and methods which have been selected to meet the environmental, economic, and social criteria of sustainability. Agricultural options will complement each other and interact with existing systems on adjoining management units.

Near Weslaco, TX, entomologist Don Hendricks (right) and Technician Carlos Perez test infrared sensors used to count flying insects lured into this wire mesh cone by a sex pheromone. A high signal count indicates that insect populations may be threatening crops.
Tim McCabe/USDA 0387X0162-19

Within SCS conservation programs, sustainable agriculture is an idea that works. Resource-conserving, farm planning assistance is provided based on local social, economic, and natural resource conditions. Sustainable agriculture calls for more grassroots information sharing and resource concern.

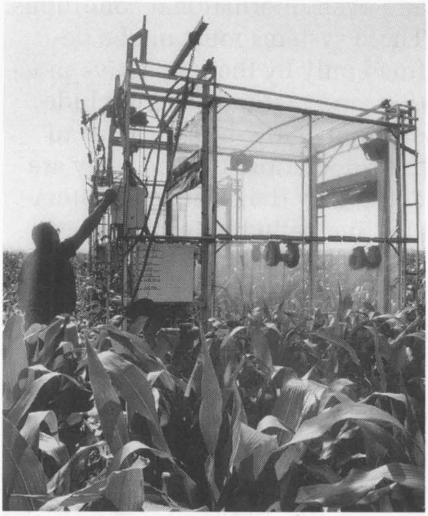
Planning a Sustainable Agriculture

Through its conservation programs, SCS is integrating the following principles of sustainable agriculture into the planning process:

- First, conservation planners must think in terms of natural resources as an ecosystem. They must place the agricultural ecosystem into its economic and sociologic context as well. Planners look carefully at each resource condition and consider how it relates to the management unit as a whole. Planners also must consider how management options will complement each other and interact with existing systems on adjoining management units.

- Second, conservation program planners actively involve the producer at all steps of the planning process. Development of effective management systems requires participation by and consideration of people throughout the planning process. Effective planners recognize that the producer has knowledge, skills, and abilities that are complementary to those of the planner.
- Third, effective application of sustainable agricultural systems requires that the planner look beyond resource problems. While examining the whole operation, planners will be alert to potential resource uses that may exist on the land.
- Fourth, planners must think in terms of resource efficiency. Effective planning for sustainable agriculture seeks to use locally available resources as production inputs and reduce use of external or remote resources. This promotes reduced input costs and improved efficiency of resource use.
- Last, planners and producers must consider both on-site and off-site effects of conservation management systems, in order to reduce adverse effects to the environment.

It is important for the planning tools to be up-to-date and accurate. The *Field Office Technical Guide,* along with specific handbooks and manuals, forms the foundation for planners who are building sustainability into conservation programs. ■



A technician throws a switch on a mobile field chamber capable of measuring the rate of photosynthesis in experimental corn plots.
Tim McCabe/USDA 0687X0697-20

Sustainable Agriculture in Developing Countries: Challenges and U.S. Role

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by Hari Eswaran, National Leader, World Soil Resources, Soil Conservation Service, USDA, Washington, DC

Sustainable agriculture demands new efforts in research, development, and implementation. Dedicated stewardship is the first step toward sustainable agriculture. There must be a commitment at the highest levels of government, and this must be coupled with an action program that addresses the needs of farmers in the context of the environment.

What is Sustainable Agriculture?
Sustainable agriculture has different meanings for different people. For some, it means continuing present farming methods; for others, the focus is on ecological integrity at the expense of any other concerns.

According to C.A. Edwards of the U.S. Agency for International Development, "Sustainable agriculture is a management system for renewable natural resources that provides food, income, and livelihood for present and future generations while maintaining or improving the economic productivity and ecosystem services of these resources."

Most definitions of sustainable agriculture include the following institutional values:

- Discriminating use of land resources
- Resource conservation and enhancement of environmental quality
- Economic viability
- Increased and stabilized productivity
- Enhanced quality of life
- Intergenerational equity
- Buffer against risks

In many developed nations, the concept of sustainable agriculture blends basic economic concerns, conservation, and maintenance or improvement of the resource base. The motivation is derived primarily from environmental and ecological concerns.

In developing countries, farmers' immediate concerns include improving crop yield, increasing crop diversity, and increasing income. Even in these countries, however, the visionary segment of the population and the institutional values of the culture may also focus on efficient cropping systems, pest-control methods, potable water supplies, support for agriculturally based industries, and related infrastructure.

Consequently, it is important to define the concept of sustainable agriculture in the context of the society in which it exists. An elementary aspect of the concept is that it be based on the value systems of social, political, economic, religious, and other institutions. As the idea of sustainable agriculture expands, however, these institutional values may come into conflict with the values of the individual farmers called upon to practice it.

In the last few years, sustainable agriculture in its broad sense has sought primarily to improve the quality of life in the context of an environmentally sound approach to farming; therefore, the resource base is maintained or enhanced for future generations.

The concept of sustainable agriculture is also a function of the scale of operation—ranging from a single farmer's field, a farm, or a watershed to an ecosystem, a country, a continent, or the Earth as a whole.

Factors of Sustainable Agriculture

To be effective, sustainable agriculture must include a concept of stewardship. In addition to institutional values that provide the framework for governmental action, the success of sustainable agriculture requires active stewardship on the part of individuals and groups.

Different technologies may be needed and each technology can be assessed to evaluate its appropriateness under specific conditions.

Sustainable agriculture is a function of the following factors, which apply in developed as well as developing countries:

- The economic viability of the enterprise; profitability is the fuel which drives the system, regardless of its size.
- The manageability of the system; it varies from individual farmers and their farms to the policymakers of the country.
- The political desirability of the system; attitudes range from indifference to centralized control.
- The physical resource base; the nature and properties of the land are manipulated through management.
- The applied technology; the response depends on the kinds and levels of inputs. Changes in sustainability are not progressively positive; rather, they tend to advance in fits and starts.
- A dynamic process; the results at any one time become the basis for the next phase of development. The level of sustainability at any one time or place determines the pace of progress.
- The social acceptability; this is determined by the compromise

between individual, cultural, and institutional values.

- The environmental integrity of the system; acceptable levels of both on- and off-site damage resulting from practices must be included in the system.
- The intergenerational equity guaranteed by the system.
- The flexibility of the system to respond to episodic events such as soil erosion, extremes of weather, and fluctuating world markets.

Constraints To Implementing Sustainable Agriculture

National and international agricultural research centers are stepping up their efforts to improve the productivity of subsistence farming. Emerging technologies—such as agroforestry, alley and multiple cropping, improved genetic material, nitrogen-fixing trees and crops, and biotechnology—hold much promise. New farming systems are more likely to succeed if they accommodate the existing variability in soils.

Several constraints often lead developing countries to resist adopting the concepts and practices of sustainable agriculture.

The overriding constraint may be the absence of economic incentives from the government policymaking level to that of the farmer. Reduction in soil loss or long-term environmental degradation are not tangible inducements for small farmers to adopt sustainable agriculture practices when their immediate concern is simply feeding their families. There are, however, exceptions. A good example is the success of social forestry in India. But even there, farmers' contributions are secondary to their family concerns.

A second constraint is lack of awareness, not only at the farm level but also at higher levels in the society. Even if the farmers are willing and able, extension services are poor or nonexistent in most developing countries.

A third major constraint is that no system becomes operational if it is not institutionalized. In many developing countries, particularly in Africa, research and development in agriculture are inadequate and suffer from lack of trained personnel, facilities, and motivation. In many African countries, donor-supported research is still the rule. In this situation, it is difficult for a country to build satisfactory research traditions and local expertise; consequently, the benefits are limited to individual projects.

A fourth constraint relates to the information base. Implementing sustainable agriculture assumes that (1) reasons for nonsustainability are known, (2) there is sufficient information on the resource base to target activities that will foster sustainability, and (3) the resource base can be monitored to evaluate sustainability. In practically all developing countries, these three conditions are uncertain.

In the past three decades or more, international donor support for agricultural research and development focused on improving the genetic potential of crops and related management practices to improve yields—a spinoff of the Green Revolution. Few developing countries have a systematic, detailed soil resource inventory program. Agronomic research programs, including those by western expatriates, have been conducted and are still being conducted on soils about which little is known. In the absence of information on the resource base, it is usually a waste of time and effort to try to institute sustainable agriculture.

A fifth constraint to implementing sustainable agriculture is that appropriate research methodology is not readily available in developing countries. Until recently, not even the basic principles and concepts had been enunciated. Fundamental questions—such as how long should an experiment be conducted, what are the treatments, what are the measurements, and how can the data be analyzed—have yet to be answered.

Reversing the Trends

There are many hurdles to be overcome before a significant number of developing countries have sustainable agriculture programs in place. N.S. Jodha, working in the mountain areas of Asia, reports "a persistent decline in crop yields in many areas. Mining activities have destroyed mountain flora, caused landslides, and choked water channels. In Tibet and Pakistan, highland pastures are overgrazed. High-potential grazing areas are disappearing and cattle are being replaced by small ruminants. The increasing scarcity of fuel and fodder is reflected in the longer distances and time involved in collection. Finally, there is an increasing dependence of people on government subsidies and inferior options."

Jodha recommends that a reversal of these negative trends should be the primary focus of agricultural development in mountain areas—and this recommendation applies to most tropical ecosystems as well. The responsibilities rest not only with the countries themselves, but also with the international community, particularly donor countries.

Challenge for the Future

The challenge of enhancing productivity while maintaining environmental soundness and attaining intergenerational equity is enormous for the low-input, resource-poor farmers of developing countries. Sustainable agriculture calls for educating farmers; emphasizing the long-term consequences of their traditional methods of agriculture; and helping them develop and implement innovative, appropriate farming practices. Appropriate incentives are essential.

Without intensified financial and technical assistance, sustainable agriculture in developing countries will be untenable in the immediate future. This essential support could be considered an investment to ensure food security and social stability in the world.

The stability of the global ecosystem requires an unequivocal commitment to long-term support of sustainable agriculture. The alternative to sustainable agriculture is degradation of the resource base, loss of biodiversity, environmental pollution, reduction of the population-supporting capacity for humans and animals, and a general decrease in the quality of life for all living things on this planet.

Because sustainable agriculture cannot be achieved overnight, institution building takes on added significance. Many developing countries still do not have detailed information on the resource base; consequently, data bases must be developed and techniques instituted to monitor resources. Likewise, a cadre of highly trained professionals backstopped by adequate facilities is needed to conduct effective resource inventories.

Equally important is the creation of awareness. Private organizations are generally equipped to provide such services but must have funds to carry out their activities.

As the world population increases, additional land will have to be cultivated, and this gives added importance to sustainable agriculture. Major causes of land degradation—overgrazing on rangeland, overcultivation of cropland, waterlogging and salinization of irrigated land, and deforestation—all result from poor land management and should, therefore, be able to be controlled.

Although effective technologies that prevent or reduce land degradation either exist or are being developed, their application is still constrained by institutional and societal barriers. Lasting solutions can be rooted as much in social and economic reform as in effective technologies. In the Tropics, as elsewhere, the current prospects for institutionalizing development strategies for sustainable agriculture are unique challenges awaiting creative and committed solutions.

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International Cooperation To Protect Our Productive Environment

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by Julia M. Morris, Program Coordinator for Africa, Forest Service, USDA, Washington, DC

In recent years, people around the world have come to acknowledge the importance of our natural environment and its sensitivity to the effects of humans' actions. Holes in the ozone layer over Antarctica, spreading deserts in Africa, acid rain in eastern Europe, and deforestation in Brazil—all are subjects many Americans hear of daily. At the same time, we are learning that productive agriculture and forestry are necessary for the development of strong economies in all countries.

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As global environmental changes cause critical ecological, economic, and social consequences, USDA is increasingly called upon to apply its experience around the world. As political barriers disappear, international networks of scientists are emerging to support the development of a sustainable global agricultural system—a system that will produce enough to feed the world into the future, yet that will not destroy the land and its fertility that make such production possible.

Cooperation: A Two Way Street

The U.S. land-grant colleges, in existence since 1864, and the National Forest System, observing its Centennial in 1991, reflect a rich national tradition in agriculture and natural resource management which the United States can offer to neighbors around the world. This unique U.S. capacity can contribute to international agricultural research, education, and development projects of institutions and agencies in other countries.

U.S. participation in international activities contributes not only to global knowledge, but also to our own domestic programs. At the same time that our resources and experiences benefit programs overseas, the lessons we learn in tackling new problems and different situations elsewhere help us find creative solutions to challenges right here at home. Opportunities to combine research efforts, gain new technical experience in the field, and participate in innovative training programs allow U.S. scientists to improve how they manage the forest and farm land in the United States.

As the Earth experiences an ever-growing demand for goods and services from a limited resource base, the need to share knowledge and skills in meeting that demand grows. Sharing professional expertise and scientific talents with colleagues around the world will contribute to the development process in all countries, including our own, by improving people's health and nutritional status, fueling economic growth, and political stability.

International cooperation and assistance fall into several categories, including government discussions on policy, cooperative research, scientific and technological exchange, training, and technical assistance. In each area, USDA has a long history and valued expertise in linking technological development to field application, in managing natural resources by interdisciplinary approaches, and in exercising the general management skills necessary to run a national agency. This USDA expertise represents a valuable resource for colleagues abroad.

Soil Conservation in The Gambia

For over 10 years the USDA Soil Conservation Service, working through the USDA Office of International Cooperation and Development, has helped to develop the Soil and Water Management

Unit of the Department of Agriculture of the tiny West African nation of The Gambia.

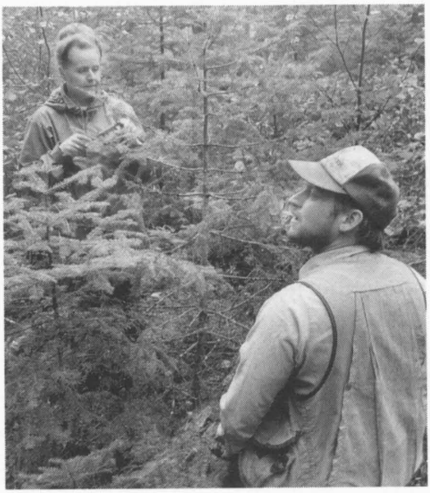
In a country dependent on agricultural exports for three-quarters of its foreign exchange earnings, greater population pressure and increasingly irregular rainfall patterns threaten the long-term sustainability of the agricultural production systems. SCS has helped train government extension agents and rural farmers to manage valuable water resources.

Through the design and construction of small earthen dams, the Gambian Soil and Water Management Unit has helped to reclaim thousands of acres of rainfed rice fields, previously abandoned because of contamination with salts. These fields, traditionally farmed by women to produce the staple of the family diet, will help to ensure the survival of the rural household. On the men's upland millet and peanut fields, SCS staff and their Gambian counterparts have incorporated soil erosion controls into the traditional farming system, preventing the precious topsoil from being washed away.

The Soviet Union—Valuable Scientific Exchange

The Soviet Union has 2.3 billion acres of forest—one-third of the world's total. Dozens of forest research institutes are found across this mammoth expanse of forest, along with many excellent forest scientists. This combination of natural and human resources offers exciting opportunities for U.S. forest scientists and forest managers to expand their understanding of forests of temperate and subarctic zones. Interaction between U.S. and Soviet foresters builds networks that can also foster private sector cooperation. For example, imports of Soviet timber into the United States are being actively sought by U.S. forest products companies. These can offset reduced harvests in this country and keep mills operating at efficient levels.

Recognizing the benefits that the United States will gain by cooperating with the Soviet Union,



Soviet Forest Ministry scientists performing climate change research in the Boundary Waters Region of the Superior National Forest, MN.
Bernie Yee/USDA 90BW1699-9

the USDA has signed an agreement with the Soviet Union creating a working group on forestry, which is administered in this country by the Forest Service.

Among the activities carried out through this agreement were exchange visits by four teams of U.S. forest scientists who went to the Soviet Union in 1990. One team of scientists investigated ways to reduce the dangers of encounters between people and bears in forests, including the use of specially trained dogs to chase bears away from areas where people are present. The Soviets have pioneered this way of managing bears near human habitation.

Another team studied Soviet windbreaks that are designed to control erosion and improve crop yields. A third team carried out research on the importance of small animal predators in controlling gypsy moths, a moth which has damaged forests across the Eastern United States. The fourth team joined with the Soviets to establish research plots north of the Arctic Circle. The research plots will help scientists detect changes in the tundra forest that may be due to global climate change.

The U.S. scientists have also welcomed visits to this country. After the research plots were established north of the Arctic Circle in the Soviet Union, the Soviet scientists followed the U.S. team back to the United States for further cooperation. A second Soviet team also came to the United States—this one to learn about different methods of forest fire control.

Honduras—Applications of Technical Experiences

In the Central American nation of Honduras, the agricultural sector accounts for nearly half of the total gross domestic product. In spite of low technology levels and relatively poor productivity, Honduran agriculture, forestry, and fisheries consistently provide around 75 percent of national export earnings.

In this context, the USDA Forest Service and the Honduran Forest Development Corporation (COHDEFOR) are working together to implement a principal component of the Honduran Forestry Development Project. Their goal is to increase sustainable yields of timber production and improve management of the country's natural pine forests. Activities will focus on the reorganization of COHDEFOR; pilot forest management programs demonstrating soil conservation, range management, and agroforestry practices for local populations; and encouragement of more private sector forestry enterprises.

Through the activities of the project, farmers will reduce their dependence on extracted products of the natural forest and increase their farm yields and income. At the same time, the sustainable productivity of the timber industry will be improved by a variety of project activities. These include: new timber sales systems, standards for grading timber products, privatization of industries, and application of more efficient processing technologies. The project has sponsored visits to the United States by members of public and private sector forest industries to expose the participants to cost-effective management and technologies and to initiate dialogue within the Honduran industrial sector.

The Global Environment—Drawing Closer

USDA's participation in international agricultural, environmental, and natural resource management activities is increasing. In addition to a range of projects such as those described above, USDA also contributes to policy decisions of international organizations and to the formulation of U.S. policy on global change topics.

USDA's involvement has many positive effects, not only in the foreign countries where we work but within our own country as well. As we provide ideas to organizations that decide international policies, we also shape our own.

The friendly international atmosphere created by this kind of scientific and technological exchange, and the skills and knowledge gained by U.S. scientists, increase the chances of resolving some of the major environmental challenges that confront human beings and the Earth. ■

Geographic Information Systems for Managing Resources

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by Gale W. TeSelle, Director, Cartography and GIS Division, Soil Conservation Service, USDA, Washington, DC

Assisting the private landowners and land users in the wise management of their natural resources (soil, water, air, plants, and animals), is the primary mission of the Soil Conservation Service (SCS). Helping land users implement the best management practices to minimize off-site impacts of their agricultural activities, particularly the effects of nutrients and pesticides on ground and surthe same time, the sustainable productivity of the timber industry will be improved by a variety of project activities. These include: new timber sales systems, standards for grading timber products, privatization of industries, and application of more efficient processing technologies. The project has sponsored visits to the United States by members of public and private sector forest industries to expose the participants to cost-effective management and technologies and to initiate dialogue within the Honduran industrial sector.

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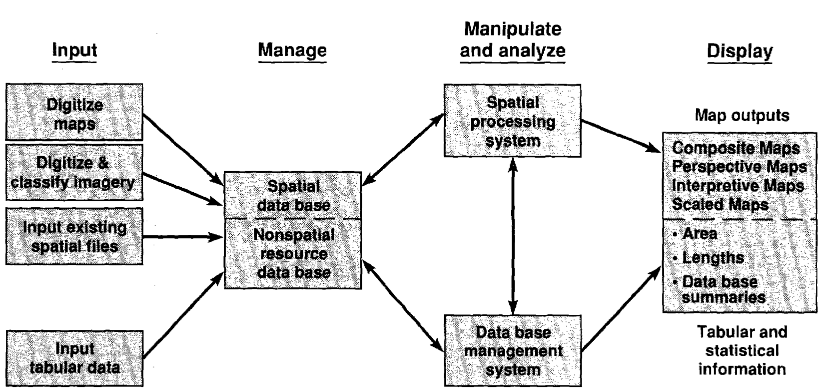
Unfortunately, assessing and predicting off-site impacts of various agricultural practices are very complex tasks, and require more sophisticated analyses than we have used in the past. Resource management experts are revising and improving existing procedures and developing new models that can more accurately predict soil erosion and the movement of water and chemicals at the surface and down through the soil.

Fortunately, a technology called Geographic Information Systems (GIS) is emerging as an important and useful computerized information management tool to support such resource management applications. The GIS allows resource managers to input, manage, analyze, manipulate, and display geographic data (fig. 1). It uses traditional tabular data and data base management system techniques, as well as geographic data bases and powerful analytical software programs that model space in two or three dimensions.

In helping land users manage the Nation's land and water resources, SCS conservation specialists frequently use geographic information such as maps and aerial photography for planning and decisionmaking. Basically, soil and water conservation resource concerns are spatial, and they involve complex interrelated processes. The GIS deals with large spatial data bases, and it displays results in a way that makes relationships, trends, changes, and proposed solutions easily understood. The Soil Conservation Service's interest in developing and implementing a GIS is a logical and natural outgrowth of its resource management planning responsibilities.

Figure 1. A GIS schematic

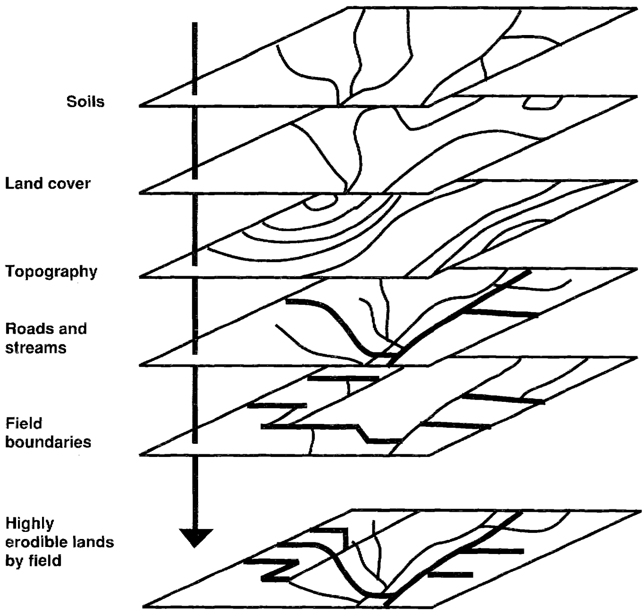


Applications

GIS is a comprehensive technology which includes aspects of surveying, mapping, cartography, photogrammetry, remote sensing, landscape architecture, and computer science. However, GIS is most closely associated with the discipline of geography, which is the study of the meaning of spatial relationships of the environment and human activities. Thus, GIS can be used for such broad applications as land use planning, economic analysis, urban planning, social and cultural evaluations, environmental analysis, and natural resource planning.

A project can be large in scope, such as the analysis of global information to identify potential causes of global change, or can involve the analysis of one field in a farm to recommend a conservation practice. It may analyze one element at a time—such as the

Figure 2. GIS maps



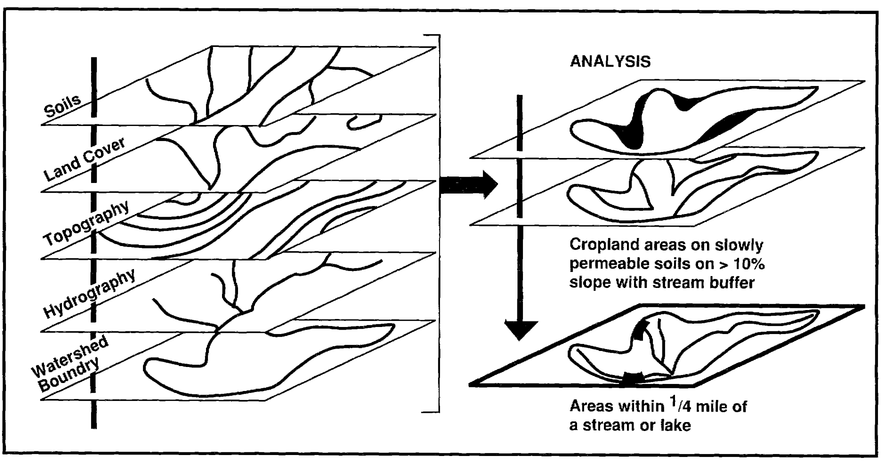
Spatial information portraying such themes as soils, land cover, topography, roads, streams, and field boundaries are among those data layers typically used in a Geographic Information System (GIS) to produce interpretive maps and their related tabular data. Through an ANALYSIS function, the GIS creates a map depicting the highly erodible cropland areas.

soil resource within a watershed. It may also analyze the relationships among many elements in the watershed, such as the soil, land cover, topography, hydrography, and the watershed and ownership boundaries, all at once in an integrated fashion (figures 2 and 3).

In SCS, GIS technology is being used to support project planning; water quality analysis; planning for resource conservation and development; natural resource inventories and analysis at the county, State, regional, and national levels; soil interpretations and delivery of soils information to the public; farm and ranch conservation planning; cultural resource analysis; workload analysis and priority setting; and national-level strategic planning.

Two examples that further describe SCS GIS applications are conservation farm planning and national-level strategic planning. In farm planning, the planner would key in the farmer's name. The computer would find the farmers' areas in the field office geographic data base files (see fig. 4). The farmer's field would be displayed, along with the soils, roads, and streams. Soil interpretations would be generated for each field, identifying highly erodible land and acreage by field. Soils that are suitable for terracing would be displayed and overlayed by field. Several analyses would describe erosion loss or pesticide runoff, predicting the probability of it reaching the stream or ground water. Conservation plan maps and alternative conservation

Figure 3: The GIS can create a map depicting the cropland areas in the watershed with slowly permeable soils on slopes greater than 10 percent within 1/4 mile of a stream or lake.

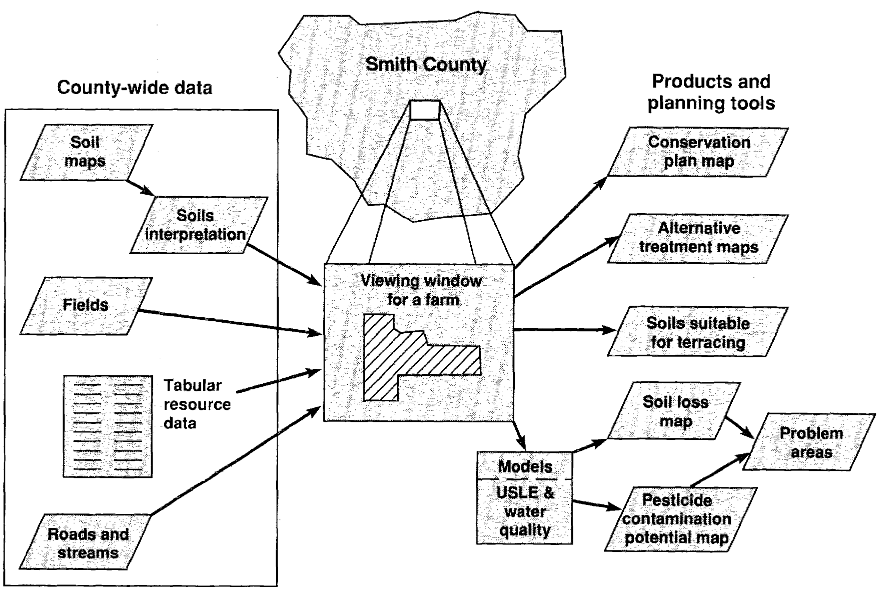


treatment maps would be generated from the GIS to help the landowner and conservation planner find new methods for improvement.

At the national level, a policymaker or program manager might want to analyze some component of the implementation of the conservation provision of the farm bill—for example, the use of conservation tillage as a practice for complying with erosion control measures in the conservation plan. From the national data base, one would call up State and county boundaries and the conservation tillage information showing existing tillage practices by county. The National Resources Inventory data, along with the soil interpretation data, would be used to identify all the cropland with soils suitable for conservation tillage for each major land resource area in the country. National conservation tillage planning information could also be displayed and a resultant map created showing opportunities for the additional use of conservation tillage practices.

Other USDA agencies use GIS to help track the spread of diseases in animals and to analyze the relationships among the Nation's water quality problem areas, natural resources, and human

Figure 4. Example scenario using GIS for conservation planning



activities. It is being used in land and water resource management research to determine the spatial variability of surface and ground water resources, and to study the transport of pesticides and other chemicals into the ground water. The Forest Service has many GIS applications in support of forest pest management, wildlife habitat management, and fire management.

Components of a GIS

A GIS consists of five key components: hardware, software, data, applications, and people. With the advances in computer science, powerful desktop computers with mass storage are now available and affordable for nearly every work environment. The UNIX operating system and graphic workstations are the computers of choice for running GIS software.

Today GIS users have many choices. Some GIS software packages are designed to handle the

SCS Soil Conservationist Nell Bednarz measures land contours for terrace construction and input into the geographic information system.
Gene Alexander/USDA TX-51312

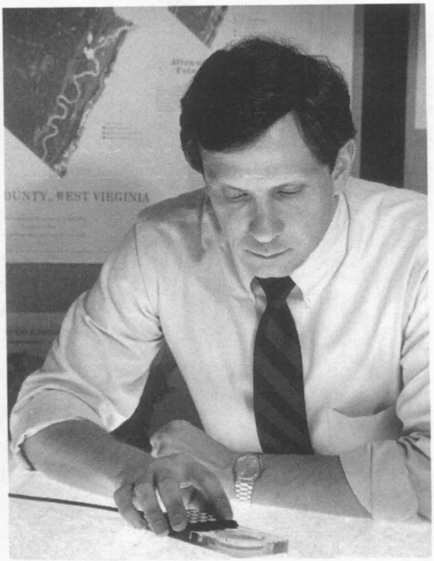
single-purpose application, while others can handle the multi-purpose, very complex applications and present many alternative methods to problem solving. Selecting GIS software involves a careful evaluation of application requirements and the GIS software capabilities. GIS software packages range in price from $1,000 to $100,000 with the median being approximately $20,000.

Data is probably the most important component of GIS as this technology is fueled by digital data bases. Geographic information such as soils, land cover, topography, geology, roads, streams, ownership, and field boundaries are examples of the kinds of data used in natural resource GIS applications (fig. 2). Both the spatial data (the x, y, z coordinate information of geographic features) and the nonspatial data (the attribute data describing the characteristics of the geographic features) are stored and managed as part of a GIS. Recent significant investments by many Federal, State, and local government agencies have helped to develop large digital geographic data bases which are being made available to other agencies and the public. This has stimulated the growth of GIS technology.

The GIS also needs a trained person to operate the system. People using GIS need to be knowledgeable about the capabilities of the hardware and software, the characteristics of the data, resource conservation, resource problems, and how to apply GIS technology to help solve these problems. However, specially designed new software interfaces are making the task of system operation easier and more effective than in the past.

Models

Environmental models are increasingly being used to predict the effects of human activities on the Nation's land and water resources. Models such as the Universal Soil Loss Equation (USLE), the new Water Erosion Prediction



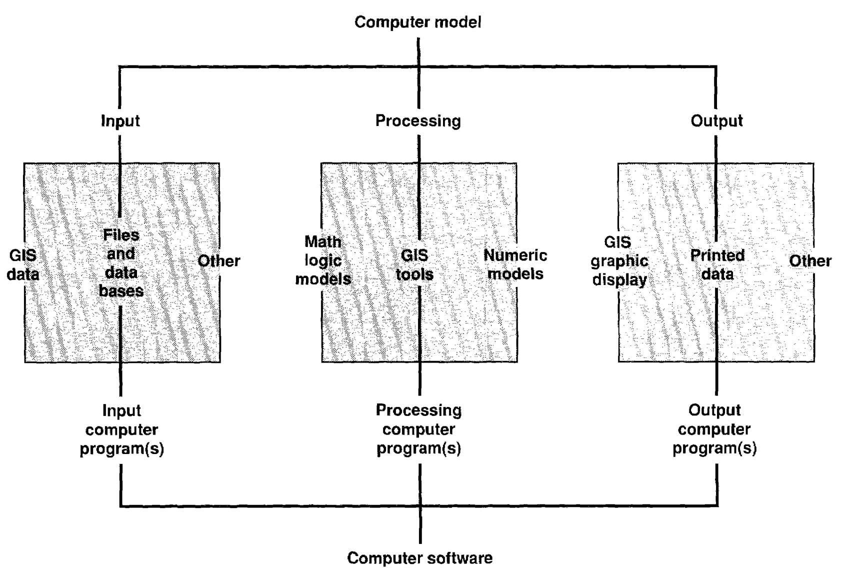
Lane Price, SCS National GIS applications leader, uses a digitizing table to convert a map into digital form for input into the automated geographic information system.
Ken Hammond/USDA 91BW0637-37

Program (WEPP), Chemical Runoff and Erosion from Agricultural Management Systems (CREAMS), Agricultural Nonpoint Source pollution program (AgNPS), Erosion Productivity Impact Calculator (EPIC), and many others are being used to describe and predict soil loss in a field, chemical and sediment runoff in a field, and pesticide and nutrient runoff in a watershed, as well as erosion's impact on agricultural productivity.

These models require large amounts of geographic information and geographic analyses. In the past, this type of information has not been available in a useful, organized structure, nor were the spatial geographic tools available. As a result, geographic parameters were often just lumped in the model, making the model less accurate and less useful. Many excellent models have been used only in a research environment due to the lack of accurate and available geographic data.

GIS technology provides a major new environment for the operation of such environmental

Figure 5. GIS input, processing, and output



models since GIS can be used to collect and manage the geographic data bases necessary for these models, execute mathematical model calculations using the GIS analytical tools, and then display the results graphically (figure 5).

The Vision

A USDA strategy for improving our assistance to farmers is the increased use of automated technology. Using GIS technology, a multi-agency integrated joint data base approach can be taken for sharing and maintaining information as part of a planning process with the farmer.

To accomplish this, we need the USDA field offices geographic resource information, for example on fields, soils, wetlands, roads, and streams, to be mapped and organized on accurate photo-image base maps called orthophotoquads. An orthophotoquad serves as the catalyst for integrating these various geographic resources. Tabular records of the farmer's operations would also be linked to the geographic data bases. These data bases would be created electronically and maintained jointly, primarily by the Agricultural Stabilization and Conservation Service (ASCS), the SCS, the Farmers Home Administration, and the Federal Crop Insurance Corporation. The data bases could be accessed directly by the farmer's computer, using a password-protected security technique. Such an effort, jointly supported and operated using GIS technology, would be a means for USDA agencies to cooperatively and effectively work together to meet the needs of the Nation's farmers and ranchers.

Conclusion

The SCS and other USDA agencies have begun to tap the benefits of GIS, a technology that shows much promise. The GIS provides the structure and environment for organizing and analyzing our resource data in the computer. It enables us to use a wealth of resource information in an integrated approach to help solve the complex resource management problems we face. It greatly facilitates the sharing of information resources among Federal, State, and local governments in order to avoid the costs of duplicating data collection, analysis, and management. Most important, GIS takes us one step closer to being able to create customized total resource management plans for farmers and ranchers and our many partners in soil and water resource management. ■

Science, Social Science, Policy, and Environment

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by Mitch Geasler, Associate Administrator; and Janet Poley, Director, Communication, Information, and Technology, Extension Service, USDA, Washington, DC

The flow of new technology has not been matched by adequate investments in the . . . institutional and human capacities necessary to use and control these technologies effectively. We now face needs for technology assessment, new institutional innovations and related human capital, and research on ethics and values. (Social Science Agenda Project, Michigan State University, March 1988)

Today, the mass of scientific knowledge and its availability to the public are increasing exponentially. However, data from most academic testing programs document that, in general, scientific literacy is low, and the general public does not have a deep understanding of the biological and physical sciences.

There is an old Chinese curse that says, "May you live in interesting times." Whether the interesting 1990's are recorded in history as a time of curse or promise depends on science—and the public's reaction to and understanding of science in the policy context.

Agricultural scientists increasingly recognize the challenges and opportunities presented in this age of environmental consciousness, increasing information, and public participation, and that recognition is giving rise to new thinking and actions.

Education of the public through the Cooperative Extension System, other institutions of youth and adult learning, and the private sector is essential. Sound long-term policy will be shaped in the United States only if the public understands the challenges that face agriculture and food systems and the potential benefits of science and technology.

Today's agricultural leadership, within USDA and across the Nation, sees that agricultural science is not an island. The Cooperative Extension System is aggressively pursuing an issues-based programming approach, including a strong emphasis on environmental issues. New partnerships are being created between governmental and private stakeholders with immediate and long-term interest in learning about and solving problems.

Charles Hess, Assistant Secretary of Agriculture for Science and Education, has said that agriculture must go beyond a simple preoccupation with the biological and physical sciences. According to Hess,

Powerful outside forces often have both positive and negative effects on agricultural research and its use. These outside forces affect not only the way in which we do our work, but what work we decide to do. Research and production policies are not formulated in any pure and solitary test tube. They spring from the messy and often disorderly real world of conflicting demands and unclear choices. We no longer operate—in fact, we probably never really did—in isolation from an increasingly concerned public. Our course is continually influenced by the changing winds of public opinion and national and agricultural policy.

Social scientists are bringing new and important understanding about human behavior, beliefs, and values to the agricultural science community. The Cooperative Extension System is well positioned to listen to local concerns, bring research-based information to bear on problems, and help communities solve environmental issues.

Today's agricultural researchers and educators are just as likely to be surveying consumers about their perceptions of food safety or water quality as they are to be concerned about questions of production. Through application of social science research methods, USDA and the land-grant community are developing more effective and meaningful ways to present complex, technical, and sometimes ambiguous information to the various publics they serve.

Nils Hasselmo, President of the University of Minnesota, had this to say about the challenge of change:

We stand on the dividing line between two decades. Between a decade of questions and what must be a decade of answers. Between a decade when the world and the Nation realized that change was coming, that change was necessary, and that change was possible, and a decade that must deal with the consequences and opportunities of change.

Science is essential to finding these answers. Webster defines science as "knowledge obtained by study and practice." Scientists are concerned with observing and classifying facts leading to the establishment of verifiable general laws. Few would argue that science or scientists are perfect, but the notion that knowledge can be obtained without systematic study and practice seems ludicrous.

Public Understanding of Science

According to the American Institute of Biological Sciences (AIBS), by last count the tree of biology had more than 60 named branches. Each branch is growing vigorously in its own direction, each with its own agenda and goals.

In one sense, this can promote healthy diversity and growth; in another it is an open invitation to misunderstanding, confusion, and rejection of biology and its work on the part of the U.S. public.

Paul Ehrlich of Stanford University, a recent president of AIBS, had this to say about the role of science and scientists in relation to pressing environmental issues facing our society:

Biology is intrinsic to the sustainability and survivability issues of a global nature that now greatly impact whole organisms, populations, and their ecological settings. These range from the loss of biological diversity, spread of rogue pathogens, global warming, desertification, population growth, ozone depletion .... Yet today, there are vastly more lawyers, economists, sociologists, and even accountants working on these problems than trained biologists. Is it any wonder that many citizens in general have no appreciation of the highly skilled work of professional biologists?

Our Information Society

Adding to the complexity of the issues is the explosion of information, including computer and global satellite communication, which exposes all segments of society to a much broader array of data. In the privacy of our homes, people watch the events of the day, including frightening messages of environmental doom.

James Moseley, USDA Assistant Secretary for Natural Resources and Environment, has said that this constant media barrage affects people, influencing them to question and, in some instances, no longer trust government, business, and institutions of higher education. "The result," as he sees it, "is that people come to rely on 'we-trust-what-we-know' and 'less-is-better' attitudes."

Assistant Secretary Moseley sees more and more citizens demanding and getting a greater voice in the issues that concern them. He believes that these trends mean that people want a voice in the decisions that affect their daily lives. And if long-standing institutions don't give them immediate and satisfactory responses, citizens will respond. He compares the amount of public involvement in development of the 1990 food and agricultural legislation, as contrasted with the relatively limited involvement in 1985:

Agriculture clearly was not the only player in writing farm legislation. Environmental groups concerned about agriculture decided they needed not only to participate in the writing of the legislation, but to drive the process as well.

Listening to the Public

Daniel W. Bromley, Anderson-Bascom Professor of Agricultural Economics at the University of Wisconsin-Madison, concluded an article in the July 1990 "Economic Issues" by stating two alternatives for dealing with public concern over science and agricultural research.

He said that scientists can "hunker down" and denounce that the public interest in science is an unwarranted intrusion into the halls of academe. He states that down this road lies ruin, since public funds are used to support research.

Bromley suggests that a more promising route is to accept a legitimate public interest in research and technology. This route requires the research establishment to admit the collective interest in its activities and take steps to incorporate these interests into its agenda.

According to Leon Kass, Luce Professor at the University of Chicago,

Politics is always about moral questions. We're always trying to figure out what the better or just or right or decent thing to do is. For better or for worse, in a liberal democracy, these expressions of the beliefs and practices and values of the community are best expressed through serious discussion with the populace in the legislature and in local communities.

David Meeker, of the National Pork Producers Council, argues that while the scientific community is generally highly regarded today, it must do a better job of communicating. He asked that principles be stated in understandable terms and that predictions of the impact of new developments be realistic. He urged treating the public with respect, addressing their concerns, and answering their questions.

S.K. Harlander, Professor of Food and Nutrition at the University of Minnesota, says that it is important to bring together groups with divergent opinions even though the process may be painful. He states that these groups do not need to control the research agenda, but their input should be actively sought and acknowledged.

He goes on to suggest that not all scientists and administrators need to participate in this process. "Individuals who are compassionate, sensitive to the needs of people, and unafraid of being challenged should be encouraged to participate."

Thomas Hoban, sociologist at North Carolina State University, says that decisions about research goals, clients, Extension efforts, and farm commodity policy must now be made with an eye toward the larger public, both rural and urban. "Consideration of these effects, and these nonfarm publics, must increasingly be a part of the agenda for decisionmakers from USDA down to the bench science level."

Studying Attitudes and Beliefs

Recent work at Colorado State and Cornell Universities highlights the importance of understanding the varied values, beliefs, interests, and attention spans of different audiences.

This work cautions scientists and educators, convinced of the logic and importance of their messages, against trying to convey a single version of a message to a perceived homogeneous, faceless public. Urban consumers as an audience may pose special communication challenges to agricultural scientists and educators.

In the National Research Council publication *Improving Risk Communication,* the authors challenge the view that risk communication is successful to the extent that recipients accept the views or arguments of the communication. Rather, they define risk communication as being successful when it "raises the level of understanding of relevant issues or actions for those involved and satisfies them that they are adequately informed within the limits of available knowledge."

P.M. Sandman, writing for the Environmental Protection Agency, stresses that the ultimate goal of risk communication should be to develop a public that is alert to the issues and rational in its approach to them. He indicates that the public sees risk as much more than the probability of a loss. Qualitative factors such as the fairness of the risk, the level of control one has over the risk, and the degree to which the risk is voluntary must also be considered. He describes these factors as "outrage" factors. When the public pays little attention to the strict probability of a hazard, and the experts ignore outrage, then it should come as no surprise that the two groups rate risks very differently.

Public Participation in Technology Transfer

As the public participates more broadly in shaping policy, it becomes even more essential to understand the various stakes individuals and groups hold relative to the issues. Who benefits and who is affected—small and large producers, private sector companies, consumers.

Most members of the research and education community believe that discussions should be grounded in science. But, as we have suggested, these questions are as much social and political as they are about scientific research and information alone. The political perception and value dimensions of the issues are critically important in understanding public reaction.

Multidisciplinary Cooperation

Researchers and educators in the various science disciplines continue to respond to this broadening of public participation and the need to provide accurate and effective information to the public. Increasingly, USDA and the land-grant community are creating new structures and incentives to encourage cooperation between the natural and social sciences.

The Experiment Station at Michigan State University began an initiative in 1990 to do just that. Robert Gast, director of the Michigan Agricultural Experiment Station, indicates that social scientists must become more involved with their biological and physical science colleagues to solve far-reaching environmental problems, such as those related to ground water quality, food safety, solid waste management, and pesticide residues.

Kenneth Corey, dean of Michigan State's College of Social Science, believes in a bold approach, given the quickening pace of society. He says:

We can sense problems quicker, we can analyze data quicker. Problems are more urgent now, and we have to think with a sense of urgency. We need more linkages like this between institutions, between governments, and between institutions and governmental officials. We need to mine the richness of people's experiences to make our teaching and research that much richer. This is not business as usual.

As researchers and teachers from various disciplines work together to deal with complex issues of society, and as communication improves, we must be able to apply technology for the betterment of all people. ■

Part V
Food Safety

Introduction by
Jo Ann R. Smith,
Assistant Secretary,
Marketing and Inspection Services

Today, American agriculture can be proud of its concern for the environment that provides food and water for life, as well as the natural beauty we appreciate so much.

Agricultural Leadership. Historically, American farmers have been leaders in nurturing the land so it would remain productive for agriculture. Crop rotation, terraced farming, and irrigation are just a few examples of the accepted practices that conserve agricultural land and keep it a renewable resource. Progress in animal production, vaccination, and good feeding and sanitation practices has helped ensure healthy livestock and poultry for American consumers. We often forget the continuing importance of this progress in providing our abundant and safe food supply.

Yet today, American agriculture has extended its leadership far beyond those accomplishments. Most farmers and animal producers today know that their responsibility isn't only to preserve agricultural land so they can produce food and fiber and preserve their own livelihoods. They know that they also have a responsibility to help protect the environment for all Americans. This has led an increasing number of farmers and animal producers to take a closer look at their own management practices and to improve them wherever possible.

Biosecurity is one way to do just that. Biosecurity protects not only the health and sanitary environment of livestock and poultry, but also the public that enjoys meat, poultry, and egg and dairy products.

The Animal and Plant Health Inspection Service (APHIS) says that every year they hear from more animal producers who want to learn about biosecurity—and we're pleased at this trend. It can help us solve the Salmonella enteritidis problem and prevent others.

The Agricultural Community. Second, the very definition of American agriculture has expanded. Agriculture will always mean farmers and animal producers, but it also includes the merchant who sells feed grain, the veterinarian who advises the animal producer, the researcher who studies Salmonella, the food processor who converts the harvest into safe and nutritious packaged foods, the retailer who keeps the shelves stocked with an amazing array of the foods Americans need and want, the exporter who seeks new markets for American goods, and the expert on USDA's Tollfree Meat and Poultry Hotline who answers consumer questions about safe food handling. And yes, agriculture also includes the consumer who dines on the products of agriculture and the regulators who protect the public interest and ensure fair industry practices.

A great deal of critical thinking and good science go into developing the regulations that protect the American public. Agricultural chemicals are a key food safety concern today, and you will learn in this Yearbook how their actual risk is determined, how the strict legal limits on residues are set, and how an extensive "safety net" prevents unsafe residues from entering the food supply. You will also learn about the comprehensive Pesticide Data Program, a cooperative effort of a number of USDA agencies. This initiative will provide us with even more solid, objective data that can be used to prevent illegal or unsafe residues. We hope you will become much better informed about what your Government is doing on this issue.

Most Americans are becoming more confident that their food is safe. If the information presented here does not answer all your questions, however, I hope you will continue to seek balanced information from responsible sources, and I hope you will continue to raise questions. That is the right of all Americans, and it is Government's duty to listen.

The Food Safety and Inspection Service (FSIS) has been doing a great deal of listening over the last year. FSIS has revolutionized its communication program as it has developed its implementation study on the Hazard Analysis and Critical Control Point System (HACCP). HACCP is a preventive, logical, "systems" approach to preventing problems in food production from farm to table. Underlying HACCP is the idea that by controlling the process, one actually has better control over the product. The agency has held five public hearings and more than 100 meetings, reaching more than 3,000 people. The agency firmly believes that "active listening" has generated many useful suggestions from employees, consumer groups, and industry. FSIS also believes environmentally sound approaches such as HACCP will be key to reducing the microbial contamination that can lead to foodborne illness.

Because consumers are also part of the agricultural community, careful handling of food is a very important aspect of ensuring food safety. Most outbreaks of foodborne illness probably would not have occurred if a few simple mistakes such as undercooking, inadequate cooling, or unsafe handling had not been made. We at USDA are extremely proud of the accomplishments of our tollfree Meat and Poultry Hotline, which answers the food handling questions of tens of thousands of consumers and professionals each year.

It's a Small World. Finally, other countries are a part of the agricultural community. We need international standards to ensure human, plant, and animal health, and to ensure that the progress we are making will continue. Today, we realize that American agriculture must be able to compete more effectively in the global marketplace on the basis of fair rules based on science. We have been working toward this goal for many years, but today we see new vitality and new determination in those efforts among many of our trading partners the world over.

Together, we will reach the goals of even safer food and fairer international trade. These are environmental issues that touch the lives of all Americans.

Agricultural Chemical Residues In Food: Evaluating the Risks

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by Richard A. Carnevale, Assistant Deputy Administrator for Scientific Support, FSIS; Wesley A. Johnson, Veterinary Staff Officer, FSIS; Craig A. Reed, Director, Science Division, AMS; and Alan Post, Research Liaison, AMS; USDA, Washington, DC

The past 40 years have seen a remarkable scientific revolution in agriculture, in which chemical technology has played a major role. Yet improper use of agricultural chemicals can pose environmental and health risks to farm workers and consumers. Many Americans would like to know more about how these risks are identified, evaluated, and managed. This chapter will seek to answer some of those questions.

What Are Agricultural Chemicals?

Agricultural chemicals include a broad range of compounds used for fertilizing crops, controlling pests, enriching feed, and promoting the health and productivity of livestock and poultry. Agricultural chemicals have helped develop a highly successful domestic farm system, ensure an abundant and wholesome food supply, and build U.S. economic strength. Yet these compounds are not a panacea. For example, today pests destroy 30 percent or $20 billion worth of all food and fiber produced in this country each year.

Which Agricultural Chemicals Most Concern Consumers?

Most Americans are concerned about pesticides, specifically their impact on the environment and public health. This long-running concern helped stimulate the formation of the Environmental Protection Agency (EPA) and stricter laws on pesticide registration and use in the early 1970's.

One healthy outcome of this public concern has been a new emphasis on responsible agricultural management of pesticides; for example, more pesticide applicator training programs and increased use of integrated pest management techniques—IPM.

In the past decade, several food contamination incidents—such as ethylene dibromide in grain products and heptachlor in milk and poultry—have drawn considerable media coverage and centered public concern on the health risks of pesticides. Most citizens appear to have some concerns about possible links between the consumption of pesticide residues in food and an increased risk of cancer. Therefore, because of limited space, this chapter will spotlight pesticide regulation. Readers should know that most new agricultural chemicals, including animal drugs, are regulated in a strict fashion.

What Are the Health Hazards?

Any harmful health effects of pesticides are usually associated with the amount or "dose" of the pesticide. For example, a chemical worker who accidentally comes in direct contact with large amounts of a pesticide harmful to humans during manufacture of the pesticide could face serious injury. Yet because the danger is so great, strict safety requirements have been set to drastically reduce the likelihood of such an industrial accident occurring.

Another type of hazard is faced by those who repeatedly misuse pesticides in an agricultural setting, or are themselves the victims of misuse. For example, a farmer who ignores pesticide label warnings time and time again, or a farmworker who is repeatedly sent into fields too soon after spraying, may face long-term health risks. The public health community is still learning more about the health risks to agricultural workers from repeated exposure to pesticides through misuse. However, experts believe this is a far bigger risk than dietary exposure, simply because the exposure to pesticides is greater.

Ironically, public concern appears to be greatest about the situation that exposes citizens to the *least* amount of pesticides—residues in food. Also, more is known about dietary exposure and its risks than about any other exposure to pesticides. USDA does not dismiss public concern about pesticides in food as trivial, yet believes many Americans may be unaware of the strict framework already in place to protect consumers against unsafe pesticide residues.

Regulation of Agricultural Chemicals

Three Federal agencies—the Environmental Protection Agency (EPA), the Food and Drug Administration (FDA) and the Department of Agriculture (USDA)—share responsibility for regulating agricultural chemicals in the food chain.

Pesticides are governed primarily by two laws, the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food Drug and Cosmetic Act (FFDCA).

Pesticide Registration, Labeling, and Legal Residue Limits

The pesticide law, FIFRA, assigns Federal oversight responsibility for registration and labeling of pesticides to EPA. Before a new pesticide can be registered, sold, or used, it must undergo thorough testing to prove it is safe for its intended use. The burden of proof falls on the pesticide manufacturer.

The data requirements are extensive, requiring from $10 to $40 million and 6 to 10 years to complete for each pesticide. The information required for pesticide approval covers a wide spectrum of health and environmental criteria, including environmental breakdown, potential for spray drift, cancer-causing properties, product composition, aquatic and wildlife toxicity, genetic effects, and animal health and safety. EPA evaluates this information before making a determination that a pesticide is safe for use.

Under the major food protection law, the FFDCA, EPA is also responsible for determining the amounts of pesticide residues that can be safely and legally permitted in human food.

Determining Safe Residue Limits

There may be several different tolerances or legal residue limits for a given pesticide. For example, one limit might apply to residues on fresh tomatoes and another to residues on lettuce. Still another limit might be set for residues in canned tomatoes, because the law currently treats pesticide residues on raw crops and processed foods somewhat differently.

Determining safe, legal residue limits is an exhaustive process that includes analyzing (1) the human health hazards of the pesticide and (2) consumption of foods that might contain residues of the pesticide.

Assessing Health Hazards

A scientific evaluation of the potential hazards of a compound to human health is called a risk assessment. Usually, regulators do not have direct evidence of risks to humans from exposure to a chemical. Medical ethics prohibit experimenting on humans to gather such data, and so potential human health effects are *predicted* on the basis of the most accurate and meaningful information available. Usually, that will be carefully analyzed results from studies of test animals exposed to the chemical. The science of risk assessment is always improving and becoming more precise.

Translating Scientific Information

For information from animal studies to be meaningful, it must be translated or extrapolated into information that is useful for assessing human health risks. Two differences that must be taken into account are *dose* and *species*. Test animals are exposed to much higher levels of chemicals than a human potentially would be, and test animals are different from humans in many ways that could affect their reaction to a chemical.

Two types of calculations are used to make animal test data useful for assessing human health risks. The traditional Safety Factor approach, in use since the 1950's, is used for most chemicals that do not appear to cause cancer in test animals. The newer method, mathematical modeling, is increasingly used to assess the risk of some health effects—such as cancer—for which any increase in risk must be very slight, or negligible.

Determining Safe Intake

In the Safety Factor approach, the first step is to determine the highest level of the chemical that does not cause *any* observable harm or other health effect to *any* animals in any of the tests. This level is called the no-observable-effect-level (NOEL). Next, the NOEL—the safe residue limit for animals—is divided by a safety margin of 100 or even 1,000 to arrive at a residue amount that is known as the Acceptable Daily Intake (ADI) or Reference Dose (RFD).

The ADI is the amount of pesticide residue in food a human could safely consume each day, over a 70-year lifetime. It can be used to calculate a lifetime safe intake, and it includes a wide margin of safety between the observed safe dose in animals and the lifetime safe dose for humans, even accounting for individual differences in people.

In the mathematical modeling method, scientists construct a "mathematical model" of the toxic response (such as cancer). The mathematical model is used to extrapolate theoretical human risk from the animal studies. The number that results from this calculation reflects a range from zero additional cancers to the extrapolated number of additional cancers. Again, safe intakes are determined in terms of any potential increase in the lifetime risk of experiencing the cancer. Ordinarily, no increase in the range of mathematically established risk of greater than 1 cancer in 100,000 lifetimes to 1 cancer in 1 million lifetimes would be permitted. This compares to a mathematically calculated risk of 1 cancer in 10,000 in chemically purified tap water.

Assessing Exposure

The second major step in determining a legal residue limit is to determine the likely dietary exposure to the pesticide residue on the crop in question. In estimating potential human exposure to a pesticide from eating a crop containing this residue, EPA's process normally makes three assumptions: that all of the crop is treated, that the residue is present at maximum levels (the proposed legal limit), and that all consumers eat a certain fixed percentage of the commodity in their diet for 70 years.

These are all very conservative assumptions. EPA also measures the pesticide levels at harvest time, and the levels could be lower by the time the food reaches the consumer.

Combining Hazard Data and Exposure Data

The third and last step in setting legal residue limits for a pesticide is to combine the information on dietary exposure with the information on safe residue intake. If exposure calculations show that intake is less than or equal to the safe intake level, a residue limit can be set for the pesticide on a particular crop. However, the total human exposure to a pesticide from residues on all crops (or processed foods made from that crop) must be less than the safe intake calculated earlier.

Enforcing Residue Limits in Food

Under the FFDCA, FDA enforces legal residue limits in most foods, including fruits, vegetables, and shell eggs. However, USDA's Food Safety and Inspection Service enforces legal limits for pesticide residues in meat, poultry, and processed meat and poultry products. FSIS carries out these activities under the Federal Meat Inspection Act and the Poultry Products Inspection Act. USDA's Agricultural Marketing Service enforces the legal limits in egg processing facilities, under the Egg Products Inspection Act. The meat, poultry, and egg inspection laws complement the FFDCA.

FDA and USDA conduct sampling and testing programs to determine the levels of chemical residues that are actually occurring in the food supply. This information is important both because it helps ensure that agricultural chemicals are being used properly and because it helps FDA and USDA ensure the safety of the food supply.

Sampling and testing for residues can be conducted at several points: on the farm, at meat and poultry slaughtering plants, at food processing plants, and in retail food establishments. In addition to Government sampling and testing programs, USDA and FDA encourage the private sector to conduct residue testing as a good business practice.

Sampling and testing must be conducted according to a statistical random sampling plan developed by experts in the field in order for the information to be useful for making broad conclusions about the food supply.

FDA Testing

FDA's general commodity monitoring program involves sampling, on an "as shipped" basis, of raw agricultural commodities, animal feed, and processed foods other than meat and poultry.

Past FDA monitoring efforts have shown that pesticides seldom appear in food at levels above legal residue limits, which include a margin of safety. Of all the samples tested by FDA under the commodity program in 1989, more than 99 percent had no violative residues (61 percent of all the samples had no detectable residues at all).

In FDA's Total Diet Study, a market basket of food samples is collected four times a year from each of several geographic regions of the country.

The commodity monitoring program involves raw foods; in the Total Diet Study, food is analyzed for residues after it has been prepared for eating. The Total Diet Study is used to estimate the dietary intake of selected pesticides by various age and gender groups. The 1989 total dietary intakes of pesticides for all age and gender groups—infants to senior citizens—were well within safe intake limits established by both EPA and the United Nations Food and Agriculture Organization and World Health Organization.

USDA Testing

USDA's Food Safety and Inspection Service monitors domestic and imported meat and poultry for residues of pesticides.

The FSIS routine monitoring program is intensive enough to provide an indication of residue violations in specific animal populations, such as hogs or chickens, on a nationwide basis. Generally, enough samples are tested to detect one violation if 1 percent of the specific animal population carries illegal residues; monitoring also highlights potential problem areas where more testing may be needed to protect consumers. By itself, monitoring is not effective in preventing all illegal residues.

FSIS surveillance or enforcement testing is designed to investigate and control meat and poultry products adulterated with illegal residues.

The National Residue Plan began as a "spot-testing" program in 1969, when safety concerns were raised about pesticides such as DDT. Today, USDA inspectors and laboratory technicians use tests that detect more than 130 animal drug and pesticide residues. The program tests about 500,000 samples of meat, poultry and egg products from domestic and foreign plants, and it includes in-plant rapid testing as well as laboratory testing. Altogether, about 1.5 million test results are collected each year for food protection.

Over the past 20 years, the overall violation rate for residues detected in animals presented for slaughter has dropped dramatically. Only about 3 of every 1,000 samples routinely tested for residues exceed the legal residue limit—and only slightly. Almost all violations detected in routine testing are illegal levels of approved animal drugs; last year, only two pesticide violations were detected in routine monitoring.

What's Ahead

In 1991, USDA's Agricultural Marketing Service began a cooperative Federal-State program for nationwide pesticide residue monitoring of fruits and vegetables. The new testing program will provide regulators with even more information on actual pesticide levels in food as close to the consumer level as possible.

The goals of the Pesticide Data Program (PDP) are: (1) to provide Federal regulators with nationwide statistically reliable information on pesticide use, exposure, and the level of pesticides in the food supply, and (2) to assist in communicating food safety information to government agencies, the consumers, and our international trading partners.

Three Federal agencies—USDA, EPA, and FDA—determine the information needed on pesticide residues in selected food commodities. AMS develops a specific testing plan, and the States actually collect the data. The program focuses sampling on high-volume domestic and imported produce collected at major produce distribution centers.

The new testing program will increase the ability of the food protectors—at Federal and State levels—to protect Americans from illegal residues.

The Challenge to Agriculture

Today, the regulation of pesticides in the USA is a rigorous, scientifically based process, extremely protective of public health. Current food residue testing programs provide persuasive evidence that the system is working well in controlling the exposure to unsafe residues. New data will help make it even stronger.

Pesticides have benefits as well as risks. The health risk to society could be significantly greater without some agricultural chemicals such as fungicides, which prevent mold from contaminating stored grain. Our plentiful food supply and its cost could also be affected.

Nevertheless, USDA, FDA, and EPA believe the search for safer pesticides and improved methods of managing pests must continue. They also believe that health risk assessments for dietary exposure to pesticide residues must continue to be improved and standardized. Finally, they believe Government must redouble its efforts to educate, inform, and involve the public in the regulatory process.

These steps are the surest path to the most up-to-date and scientific health protection and environmental protection possible. ■

Consumers Receive Safe Meat and Poultry

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by Catherine E. Adams, Assistant Administrator, Food Safety and Inspection Service; and Elizabeth S. Crosby, Home Economist, Poultry Division, Agricultural Marketing Service, USDA, Washington, DC

The agricultural and food manufacturing industries face a continual challenge to provide consumers with the food products they want and expect and to market those products at an affordable price. This challenge includes safety, quality, nutritional value, and price. The food industries are continuously improving the products they make available to consumers. USDA monitors the food supply, according to prescribed Federal regulations, to ensure that meat and poultry products are safe and that labels are accurate and unlikely to confuse or mislead consumers.

How Do Consumers Feel About the Safety of Foods?

Consumer surveys indicate that most consumers consider the safety of food products when

Foods inspected by USDA strengthen the consumer's confidence in the safety and quality of meat
Lester Shepard/USDA 90BW1658-14

buying food. A 1990 survey of 1,005 food shoppers by the Food Marketing Institute ("Trends: Consumer Attitudes and the Supermarket," 1990, Washington, DC) reported that 91 percent of consumers considered safety to be at least somewhat important when shopping for food. The FMI survey also indicated that consumers were more confident about the safety of food in 1990 than they were in 1989: In 1989, only 58 percent of shoppers were "mostly confident" about the safety of food products, but in 1990, 64 percent of consumers felt "mostly confident" about the safety of the foods they purchased. Fifteen percent even felt "completely confident" in 1990. Respondents to the 1990 FMI consumer survey indicated that their specific food safety concerns were "spoilage and germs" (29 percent), insecticides and herbicides (19 percent), chemicals (16 percent), improper packaging (16 percent), and tampering (14 percent). Consumers continue to be concerned about the use of agricultural pesticides and the use of antibiotics and hormones in animal production. However, shoppers were less concerned about the use of these agricultural chemicals in 1990 than they were in 1989.

How Does the Government Ensure the Safety of Meat and Poultry Products?

The Federal agency responsible for ensuring that meat and poultry products moving in interstate commerce for use as human food are safe, wholesome, and accurately labeled is the USDA's Food Safety and Inspection Service (FSIS). The agency's employees, numbering more than 9,500, inspect meat and poultry for domestic consumption and export, and check imported meat and poultry products for compliance with the same standards that apply to domestically produced products. The agency employs veterinarians, food scientists, food microbiologists, pathologists, food inspectors, and others with specialized training for the job of ensuring food safety and regulatory compliance.

Over 7,000 FSIS inspectors work in almost as many meat and poultry slaughter and processing plants across the country. The Federal inspection laws require that a USDA inspector be present in all establishments on days when those establishments are in operation. In 1990, FSIS slaughter inspectors and veterinarians inspected more than 124 million cattle, hogs, and other meat animals, and 6.2 billion chickens, turkeys, and other types of poultry. Animals and birds were examined for signs of disease or other abnormalities, both before and after slaughter. Inspectors are obliged to check each animal and each carcass, and examine further those appearing suspicious. During the manufacturing of processed products, USDA inspectors reinspect products to ensure safety and compliance with the Federal meat and poultry inspection laws. In 1990, FSIS inspectors reinspected millions of pounds of processed products (for example hot dogs, chicken nuggets, and frozen entrees) that entered the retail market.

The inspection process is not limited to observing plant operations. Additional information is gained by testing products both in the plant and in laboratories. In 1990, FSIS conducted more than 2.2 million analyses on approximately 525,000 meat and poultry samples. Some 411,000 samples were checked for residues of 133 different animal drugs, pesticides, or other chemical compounds; and 35,000 samples were checked for bacteria and parasites.

Each year, FSIS condemns hundreds of thousands of pounds of meat and millions of pounds of poultry that do not pass inspection requirements. Condemned products are marked so they cannot be used for human food. Products are condemned for many different reasons, including contamination with violative residues of animal drugs or other chemicals. With rigorous testing and scientifically based standards, FSIS found that only 0.3 percent of samples in 1989 contained residues at unacceptable levels. These results indicate the safe use of animal drugs and other chemicals for and around animals intended for food use in this country.

Imported meat and poultry must be produced under a system "equal to" that of the United States. To verify the effectiveness of foreign inspection systems, FSIS evaluates each exporting country's food inspection laws, policies, and operations; this includes physical reviews of foreign plants, laboratories, and training programs. Computer-selected random samples of meat and poultry products are reinspected when they enter the United States. Imports destined for use in processed products such as chicken pot pie and beef stew are reinspected a third time in U.S. food manufacturing plants. In 1990, 2.6 billion pounds of imported products were reinspected by FSIS inspectors.

Routine inspection activities can trigger a range of enforcement actions including product retention and a temporary halt in production until problems are corrected, intensified inspection, product recalls, and other actions. When meat or poultry products already in consumer channels are found to be potentially hazardous to consumers, FSIS asks the firm to recall the products, and consumers are alerted through a press release. FSIS investigates to be certain the recall is effective and that corrections are made so the firm distributes only safe and wholesome products.

Keeping Consumers Informed About Food Safety Is Important

An important part of USDA's mission is to keep consumers informed about food safety and to recommend methods to keep foods safe during preparation, storage, and consumption. FSIS produces millions of educational pamphlets, as well as videotape teaching kits, a quarterly magazine for food editors, and other information on safe food handling. It also operates a Tollfree Meat and Poultry Hotline that consumers can call to ask for recommendations on keeping meat and poultry products safe. The Hotline continues to grow in popularity; in fact, over 80,000 consumers called it in 1990. The Hotline number is 800-535-4555; in Washington, DC, (202) 447-3333.

FSIS also provides a variety of materials about FSIS and food safety issues. A list of FSIS publications is available from FSIS Publications Office, 1165 South Building, Washington, DC 20250.

Inspection for Safety and Wholesomeness, Grading for Quality

Meat and poultry inspection and grading are two separate USDA programs. FSIS inspects meat and poultry products to ensure safety and wholesomeness. Only then may inspected meat and poultry be graded for quality by the Agricultural Marketing Service (AMS).

Grading is a voluntary program that is requested and paid for by food processors. Graders evaluate numerous attributes of meat and poultry that are described in the official U.S. grade standards. These attributes determine the value and utility of the products and include such variables as the amount of marbling in beef (fat interspersed within the lean tissue—an attribute relating to tenderness) and the freedom from defects of poultry (such as torn or missing skin—attributes relating to cosmetic appearance).

Grading is the standardized trading language that enables food

A FSIS inspector checks meat products to ensure safety and wholesomeness.
Lester Shepard/USDA 91BW0156-11A

wholesalers and retailers to buy and sell their products across the country, sight unseen. Consumers also use grades to help them make food purchasing decisions.

Conclusion

Consumers have good reason to feel confident in the safety of the food supply. Meat and poultry products are continuously inspected and reinspected to ensure that they are safe, wholesome, and properly labeled. Food quality grading, a voluntary activity paid for by manufacturers, enables meat marketers to use a standardized language that facilitates the buying and selling of meat and poultry products; it also allows consumers to know characteristics, including tenderness and appearance, that help them decide what to buy. USDA also provides a wealth of information that enables consumers to understand more about how the safety of the U.S. food supply is protected. ■

International Standards: Promoting Food Safety and Facilitating Trade

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by Patricia Stolfa, Deputy Administrator for International Programs, Food Safety and Inspection Service; Steven Tanner, Assistant to the Administrator for Technology, Federal Grain Inspection Service; and Alejandro B. Thiermann, Deputy Administrator for International Services, Animal and Plant Health Inspection Service; USDA, Washington, DC

International standards and agricultural trade may seem to be specialized topics not of everyday concern. However, all consumers and agricultural producers are touched by trade. Making the trading system work better is in everyone's interest.

American farmers produced almost 115 million metric tons of grains and feeds for export throughout the world in 1990. During the same year, cattle producers and meat processors in Argentina, Brazil, and Uruguay supplied almost 150 million pounds of cooked beef for U.S. consumption, some in products such as TV dinners and soups. More than 57 million boxes of fresh fruit and vegetables were imported from Chile during the winter of 1989-90. So, whether Americans are producers of agriwholesalers and retailers to buy and sell their products across the country, sight unseen. Consumers also use grades to help them make food purchasing decisions.

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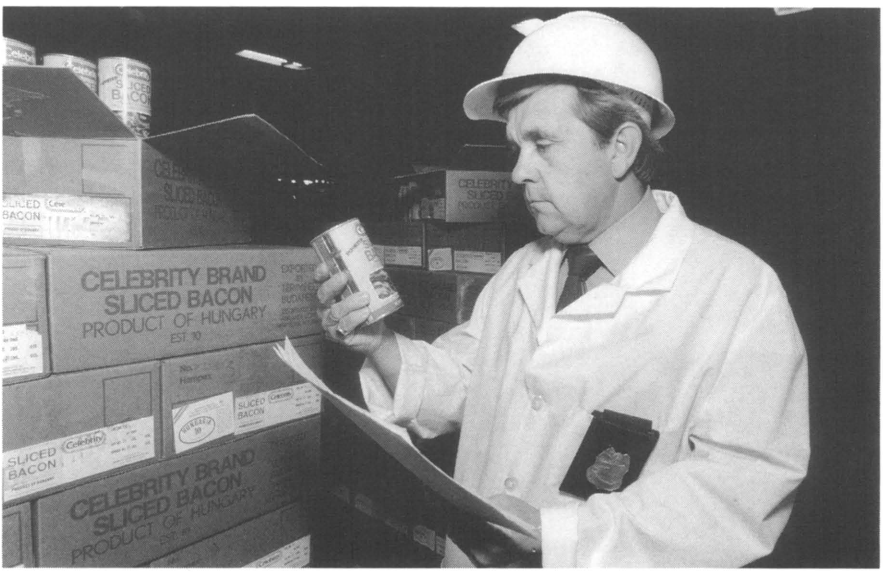
Types of Trading Rules

Many complex rules and practices affect international trade in agricultural commodities. First are those designed to protect human health or that of plants or animals. One example of such a rule is the U.S. requirement that permits importation of animals and animal products only from countries free of foot-and-mouth disease. (This requirement can also be met if meat products are cooked according to specific requirements to destroy the disease-causing organisms that could be present.) Another example is the U.S. requirement that imported poultry products be inspected under a system that imposes requirements equal to those imposed by USDA on domestic poultry products.

Several USDA agencies—the Agricultural Marketing Service (AMS), Animal and Plant Health Inspection Service (APHIS), Federal Grain Inspection Service (FGIS), and Food Safety and Inspection Service (FSIS)—are involved with the safety and quality standards that affect international trade in agricultural commodities. These and other agencies provide important benefits to U.S. consumers, who can be confident about the safety of food in the marketplace, regardless of its origin. U.S. producers can also be



A FSIS import inspector verifies eligibility of products for importation into the United States.
Lester Shepard/USDA 88BW1929-32

confident that the health of their animals and plants will not be jeopardized by inferior or unsafe imported products. Other countries have also developed trading rules to protect human, plant, or animal health.

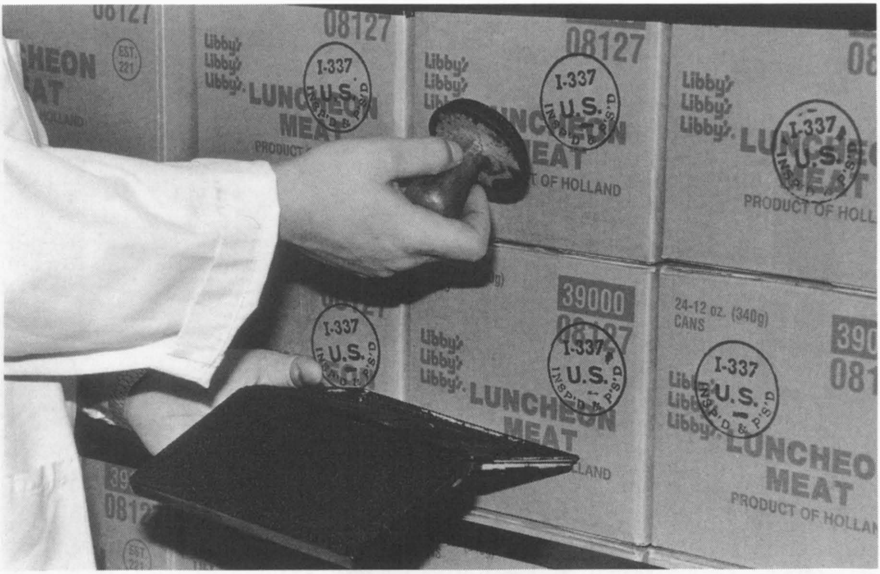
Other types of trading rules are designed to directly affect the flow of international commerce. Tariffs, or taxes on imports, are a common way to prevent too many imports that could compete with domestic products. Quotas, or restrictions on the amount of certain products that may be imported, are another common mechanism.

Who Sets the Rules?

A hundred years ago, only a few nations were major players in international trade of agricultural commodities, so other countries had to comply with sometimes very stringent rules in order to have any chance to see their goods in international commerce.

Over time, however, many more countries managed to gain a good foothold in international trade. As they began trading with more than just one or two other countries, countries gained leverage in setting the trading rules—which have evolved into negotiated agreements.

Today, so many nations are involved in international trade that



Cartons of imported products are stamped and passed after completion of import reinspection, ensuring that standards and safety quality have been met.
Lester Shepard/USDA 0483X0463-14

it is common to speak of "the global economy." Negotiated agreements determine the trading rules in the global economy. Bilateral agreements, such as the Canadian Free Trade Agreement between the United States and Canada, are one type. Another type of agreement is truly international, such as the General Agreement on Tariffs and Trade (GATT), which today includes 101 member nations. The GATT was agreed to in the post-World War II period, as a way of giving more countries an opportunity in international markets by developing fair, negotiated rules.

Problems with Trading Rules

As with all large systems, sometimes things do not work as well as they could.

Sometimes rules that were originally developed for protection have unintentionally evolved into unjustified barriers to competing products from other countries. For example, for many years the meat trading countries of the world have prohibited or severely restricted trade in ground meat products. Although the exact origins of the prohibition are obscure, it is thought that regulators were concerned that because the pieces of ground meat were so tiny, it would be impossible to determine what kind of animal the meat came from and whether the animal was healthy. Today, however, sophisticated tests permit the quick determination of species with great accuracy, and may permit the removal of regulations that now appear unnecessary.

In other instances, import restrictions promulgated in the name of health protection were actually based on other factors. One notable example is the European Community's (EC) ban on the importation of any meat from livestock that has been raised with the use of certain growth-promoting hormones. Leading scientific experts from around the world concurred with the U.S. determination that with proper controls these important compounds in production agriculture are quite safe. Nevertheless, no amount of scientific evidence was persuasive to the EC, which went ahead with its ban and effectively ended U.S. beef exports to that market.

In still other situations, when importing countries have instituted legitimate, scientifically sound regulations to protect public health, they also insisted that the exporting country regulate using exactly the same procedures. Yet the procedures are often inappropriate to the production and processing systems in the exporting country, and need not be identical to offer the same degree of protection.

This is the problem U.S. poultry processors have encountered in their efforts to export products to certain European countries. Both U.S. and European inspection systems recognize and accept the use of water chillers in slaughterhouses. However, European countries insist that the water flow in the opposite direction from the way it flows in U.S. plants. This would require U.S. plants to make costly changes in equipment and procedures. European insistence on identical procedures in U.S. exporting plants has meant that U.S. poultry sales to Europe have been substantially reduced.

Correcting the Balance

For several years, governments of many countries have been cooperating to improve and better coordinate international trading rules for agriculture because of widespread dissatisfaction about how the rules are sometimes used. In effect, countries are seeking to restore a balance of fairness in trading rules. There may be many ways to correct the balance.

The simpler disputes have been solved over the years through open and cooperative attitudes on the part of regulatory officials in trading countries.

One general regulatory policy that has favored agricultural trade has been known as equivalence. Equivalence is based on the idea that public health protection can be effectively accomplished in different production and processing settings using different sets of procedures. Two regulatory systems may be judged equivalent even though they use different techniques, as long as acceptably similar results are achieved.

Container ships carry agricultural exports from docks in the U.S. Exports have doubled over the last 20 years.
Lester Shepard/USDA 0483X0466-23A

In one case, U.S. plant health regulations allow for the importation of citrus from fruit fly-infested regions after the fruit has been fumigated with methyl-bromide. An equivalent and more environmentally sound option is to inspect—rather than fumigate—citrus imported from regions that have been certified as pest-free. In order to meet this pest-free status, the foreign government and its national inspection institutions must have a surveillance, inspection, and quarantine program in place that meets U.S. requirements and is verified by U.S. inspectors. Currently, such pest-free status has been granted to production areas in the State of Sonora, Mexico. This has been the result of persistent efforts by Mexican officials with strong support from local agriculture.

Science-based Requirements

Another approach for settling the differences in regulatory controls is to define and accept a common basis for such regulation. Scientific necessity is usually recognized as the appropriate basis for regulations designed to ensure food safety, plus protection of animal and plant health.

In the case of animal health, the United States and Canada have developed a protocol for the bilateral trade of livestock between regions with or without bluetongue virus. This livestock disease requires a mosquito for its transmission. Importation protocols were developed after considering the biological characteristics of the disease and the seasonal distribution of mosquitoes. Specific guidelines were established for regions free of the disease, regions having the disease during mosquito season, and regions having the disease during seasons without mosquitoes. This is another example of safe and fair trade between two countries, made possible only after scientific evaluation of the biological nature of the problem and full participation by regulatory officials and representatives of livestock industries.

Rethinking the Rules

Another approach to resolution of such problems is also promising. That is the adoption of internationally enforceable, scientifically based regulations that would ensure a uniform high level of health protection. These rules and measures could be agreed on in advance of trade disputes, rather than after the lines are drawn. They could originate in cooperation and scientific consensus, rather than in hostility and political tension.

Certain international organizations already formulate scientific regulatory standards and guidelines that could be a basis for new health requirements. These three international organizations deal with food safety, animal health, and plant health.

Codex. For food safety, the standards, guidelines, and recommendations are established by the Codex Alimentarius Commission (Codex). Codex was established in 1962 by two United Nations organizations—the Food and Agriculture Organization and the World Health Organization. Its purpose is to develop internationally agreed upon standards that encourage fair international trade in food while promoting the health and economic interests of consumers. Codex standards concern foods, food additives, residues of veterinary drugs and pesticides, contaminants, methods of analysis and sampling, labeling, and other matters. Codex has also developed many codes or guidelines for food production and processing—including an international code of ethics for trading in food. Codex is headquartered in Rome, Italy. Its membership includes most countries actively involved in international trade.

International Office of Epizootics. For animal health, including diseases that can be transmitted to humans, the standards, guidelines, and recommendations are developed by the International Office of Epizootics (OIE). This organization was founded in 1924 and is based in Paris, France. Its membership is composed of 114 active member countries. The OIE develops norms, standards, and diagnostic procedures for detecting, controlling, and eradicating important animal diseases. Its main mission is to ensure that international trade in animals and animal products is governed by technically justified health regulations. OIE member countries are obliged to report immediately the appearance or reappearance of any severe and highly contagious communicable animal diseases.

International Plant Protection Convention. For plant health, the international standards, guidelines, and recommendations are developed under the auspices of the International Plant Protection Convention (IPPC), in cooperation with regional organizations operating within the framework of the IPPC. This organization is also affiliated with the Food and Agriculture Organization and is based in Rome, Italy.

Successes

Many countries, including the United States, are already participating in these international organizations, and the efforts of these international groups have already benefited agricultural trade in numerous instances. The Codex process recently helped prevent a problem with wheat flour. The United States and several other countries wanted to permit certain safe additives in wheat flour to enhance and preserve the flour and make it more suitable for use in bread with a shelf life of more than a few days. Several European countries opposed allowing these safe additives in the standard for wheat flour. However, in 1989, the United States took its arguments to the Codex forum and secured acceptance of its view. In the Codex process, if new scientific information becomes available, countries may always seek reconsideration of a standard.

The Codex committee on cereals, pulses, and legumes is now developing a standard for maximum limits of aflatoxin residues in certain grains and legumes. Aflatoxin, which is produced by a particular mold that grows on corn and other crops, is recognized as a carcinogen throughout the world. Mexico has been very concerned about the safety of the corn it produces as well as that imported from the United States. Corn is a primary food source for Mexico. A Codex limit for aflatoxin will give both the United States and Mexico an acceptable standard to help facilitate trade.

The OIE also has provided an avenue for important reform which can be expected to ease trade problems. New proposals developed by the United States and Canada will serve as tools to develop import guidelines based on accurate assessments of risk and ecological conditions in foreign agricultural regions. The draft proposals were recently submitted for consideration at the OIE Commission for the Americas, where they were discussed and endorsed by all participating member countries. They will now be presented to the general assembly of the OIE, the next step in OIE approval.

The IPPC, especially through its regional affiliates, also has begun to turn its attention to international trading problems. The pest-free zones in the State of Sonora, Mexico, are being studied by the North American Plant Protection Organization (NAPPO) as a model for regionalization. If entire agricultural regions, rather than just countries, could be certified as pest-free, that would facilitate trade. This is a concept that may eventually be submitted to the IPPC for approval.

USDA and its consumer and producer constituents can look forward to improved international trade founded on public health protections that are fair and necessary. International standards will be a firm foundation for these important rules. ■

New Approaches To Control Foodborne Disease

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by Lester M. Crawford, Executive Vice President for Scientific Affairs, National Food Processors Association; and Sharin Sachs, Chief, Information Office, Information and Legislative Affairs, Food Safety and Inspection Service, USDA, Washington, DC

Foodborne illness generally isn't thought of as an environmental issue. Water quality, yes. But foodborne illness?

A look at the past 20 years suggests that viewing this public health problem from a broader environmental perspective may be the *only* way to achieve a lasting reduction in the number of human illnesses caused by *Salmonella* and other invisible, disease-causing organisms in food and water, whether in the United States or the world at large.

This aspect of food safety is an environmental issue in several ways. First, the bacteria and other microorganisms that can cause foodborne illness—pathogens—are often a "natural" part of the environment.

- Dormant and harmless *Clostridium botulinum* spores are found virtually everywhere, including in soil from farms, in forests, and in the bottoms of streams, lakes, and coastal waters.
- *Campylobacter jejuni* bacteria, which many experts believe constitute the number one foodborne threat despite their fragility, can be found in water, soil and sewage sludge, as well as in the intestinal tracts of domestic and wild animals and birds.
- *Listeria monocytogenes* bacteria are often excreted by asymptomatic humans and animals and can often be found in raw cow and human milk, improperly fermented silage, leafy vegetables, soil, and food-processing environments.
- *Salmonella* bacteria may be shed in poultry or livestock feces, spreading from animal to animal.

Foodborne illness may also be considered an environmental problem because an action—say, a mistake—at one point in the environment can have effects that ripple far beyond that point. For example, *Clostridium botulinum* spores in soil don't normally cause botulism. But under certain conditions—including the absence of oxygen—the dormant spores can transform into the vegetative bacterial cells that form the botulism toxin.

An environmental approach to solving foodborne illness problems does not necessarily mean eliminating an organism at its source point. Often, that is not possible. For example, pure-looking mountain streams can carry *Campylobacter* bacteria from the feces of undomesticated animals and birds, and trichina parasites may well be present in game animals shot in the wild.

However, an environmental approach does mean attacking the problem at many different points in the environmental cycle of the pathogen. This approach has seen some success.

Listeriosis. After one particularly serious U.S. outbreak in 1985, public health authorities and the food industry united to attack the problem on all fronts. The Food and Drug Administration (FDA) conducted a massive examination of the production processes for soft cheese and other dairy products. The trade associations for the food industry conducted their own troubleshooting and research to determine guidelines for preventing growth of the organism in the favorable climate of food processing plants.

FSIS, despite the lack of any listeriosis cases associated with meat or poultry products, began a monitoring and regulatory program to reduce the likelihood of *Listeria*-contaminated processed products reaching consumers. FSIS made its program stricter after such an illness occurred, and recalls are still occasionally necessary when *Listeria* bacteria are detected in ready-to-eat products. Today, public health authorities continue their vigilance against this disease, which causes an estimated 1,600 cases and 400 deaths annually in the United States alone.

Salmonella and the Environmental Approach

Salmonellosis. *Salmonella* has become a household word. Reducing human salmonellosis, the disease caused by *Salmonella* bacteria, has challenged the public health community for decades. Some strains of *Salmonella* cause human illness without affecting animals at all; others cause illness in animals but not humans; still others affect both. Ten strains of the bacteria cause most human illness. Foodborne *Salmonella* infections are caused when humans ingest "too many" *Salmonella* bacteria in their food. There is no minimum or maximum safe number, although usually "the dose makes the poison." That means, the more *Salmonella* bacteria consumed, the greater the risk of illness. The number of bacteria that will cause illness varies with the strain of *Salmonella* and the victim's age, immune status, and individual genetic makeup. Healthy adult volunteers have consumed millions of *Salmonella* without becoming ill; in actual outbreaks, as few as 10 bacteria have caused illness.

A 1969 National Academy of Sciences Report on *Salmonella* recommended intervening in the *Salmonella* contamination cycle at various points, including animal feed production, to reduce the potential for human illness. Yet, a 1984 international symposium on *Salmonella* concluded, "It should be candidly recognized that raw foods of animal origin are frequently contaminated by *Salmonella* and that such contamination levels cannot be expected to change greatly in the near future."

Today, such a statement would be greeted with outrage—and often is, because some are still saying it. USDA takes a much more aggressive approach. In 1981, USDA made its number one food safety research priority the control and reduction of *Salmonella*—both at the animal producer level and in the plant.

Despite their misgivings about the possibilities for reducing *Salmonella* on raw products, the 1984 expert meeting made research recommendations for the production of animal feed. USDA's Agricultural Research Service has since developed and pilot-tested an experimental steam conditioner for use in making animal feed pellets. This device shows great promise in reducing the potential for recontamination of animals through *Salmonella*-contaminated feed, if it proves to be practical and economical for the animal feed industry.

As a result of research it has performed over the past 2 years, FSIS has tentatively concluded that any inplant improvements to modestly reduce the spread of *Salmonella* from carcass to carcass will probably not have much effect on final consumer-ready products unless *Salmonella* on incoming poultry can also be reduced. Such research continues and there are hopeful signs, such as the finding that a certain complex sugar appears to reduce *Salmonella* growth in young chickens. However, a number of other promising research avenues have been inconclusive or are still being studied. One ARS researcher has said that controlling *Salmonella* is as difficult as finding a cure for the common cold. Today, almost no one expects to find a "silver bullet" that will solve the *Salmonella* problem once and for all.

Nevertheless, today the majority of scientists and public health officials believe it is possible—and imperative—to reduce microbial contamination levels as much as possible at many different points in the food chain, including the domestic animal population. What has happened to change the collective scientific mind?

One factor has been the emergence of "new" foodborne pathogens. The foodborne illness problem is no longer only a *Salmonella* problem. In the past 15 years, scientists have learned that:

- A toxin of the bacteria *Escherichia coli* 0157:H7 can cause colon and urinary infections, especially in children. Outbreaks have been traced to contaminated meat and/or water.
- The bacterium *Listeria monocytogenes*, formerly known to cause animal disease and occasional infections in people working with animals or drinking raw milk, can survive in many foods to cause human illness, particularly in those with compromised immune systems.
- *Yersinia enterocolitica* bacteria in foods as diverse as chocolate milk, mussels, and tofu can cause the disease yersiniosis. Children are most at risk for contracting the illness. In pediatric cases, the disease symptoms mimic those of appendicitis. (1972, Japan; 1976, USA)

The pathogens described above have something in common—they can all grow at refrigerated temperatures—unlike most other foodborne bacteria, which merely survive at low temperatures.

In addition to the new pathogens, a dramatic increase in reports of foodborne illness has highlighted the importance of foodborne illness to public health. (See box on *Salmonella enteritidis*.) Finally, public concerns about food safety and nutrition that had steadily grown since the 1970's reached critical mass in the mid-1980's.

The controversy that has accompanied this heightened public concern about food safety has generated many positive results, among them an informal consensus among scientists, regulators, food industry associations, and consumer groups that one particular approach to food safety offers the most hope for resolving today's food safety concerns.

An ideal approach would apply to the whole food environment, from farm to table. The National Academy of Sciences, in its 1985 and 1987 reports on meat and poultry inspection, recommended just such an approach, endorsing the incorporation of the Hazard Analysis and Critical Control Point (HACCP) system at various points in the food production, processing, distribution, storage, and handling cycle.

HACCP is a preventive, "total systems" approach to food production. It is a process control system that recognizes the compounding effect that changes in the environment may cause. However, HACCP differs from other process control systems. It seeks to determine the major problems, assess their significance and the likelihood of their occurrence, in order to prevent them.

A HACCP system not only determines what could go wrong at different steps in a process; it also determines the critical control points in the process. These are the points at which a mistake would have the *most* negative effect on the safety of the final product. Thorough cooking is an obvious critical control point in almost all food-processing systems. However, depending on the product and the plant, there could be several others. Under a HACCP system, the food processor would monitor critical control points the most closely, in order to prevent safety problems in the finished product. The regulator would monitor the plant's effectiveness, including verification testing.

Some of the risks—such as undercooking and slow, uneven cooling—are well understood. Others are not. The National Advisory Committee on Microbiological Criteria for Foods is examining some of these issues for USDA and FDA.

Salmonella Enteritidis and the Environmental Approach

The egg. In recent years, many home cooks have become concerned about poached eggs, homemade mayonnaise, and other dishes using raw or lightly cooked eggs. Hospitals, nursing homes, and other institutions are using pasteurized eggs or heat processing in these recipes.

These home and institutional foodhandlers are protecting their families and their clients from possible illness caused by *Salmonella enteritidis*—SE for short—which could be present in some table eggs.

Until a few years ago, salmonella in eggs was not suspected, as no one knew that uncracked eggs could be a source of these bacteria. Over the last 10 years, the Centers for Disease Control observed a dramatic increase in human illness caused by SE. Epidemiologists—who might be described as public health detectives—were able to determine that people who became ill often lived in the Northeastern part of the country, and they had often eaten foods containing raw or lightly cooked eggs.

The chicken. Thoroughly cooking eggs is one effective way to prevent illness, but it doesn't attack the roots of the SE problem. In 1988, USDA's Animal and Plant Health Inspection Service (APHIS), working with other public health agencies, began researching to learn about those roots. APHIS was also concerned about solving the problem in a way that would encourage maximum cooperation from the poultry and egg industry, as well as educate consumers on the risks of mishandling eggs and foods containing eggs.

Studies have subsequently shown that certain invasive strains of SE may infect the internal organs of laying hens, passing the bacteria into the interior of eggs before they are laid. Testing under the voluntary National Poultry Improvement Plan uncovered SE in the internal organs of birds from 3 breeding flocks in 1990. These flocks have been restricted from interstate commerce.

In February 1990, USDA intensified its

For several years, FSIS officials have been encouraging the meat and poultry industry to use this risk-based, "total systems" approach to food production. The problem, however, has been that few understood what HACCP meant in practice.

In 1991, FSIS began holding workshops at which industry and government actually determine what HACCP is, in practice. They develop model HACCP plans for several products and processes, which will then be pilot-tested and evaluated. If successful, the plans will provide the meat and poultry industry with a better way to comply with inspection requirements and at the same time to ensure uniform, consistently safe and wholesome meat and poultry products. FSIS is also working with USDA's Extension Service on increasing Extension agent and public understanding of HACCP as it applies to all aspects of agriculture.

International interest in HACCP and other environmental approaches is growing, and that is where such approaches hold

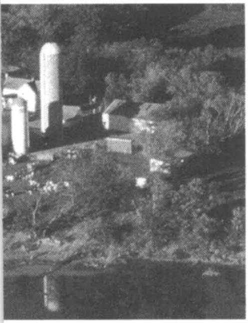
efforts against SE by forming the *Salmonella Enteritidis* task force. During its first year, the task force made significant progress. It reported that in response to reports of human SE outbreaks, testing for SE involved some 5 million chickens, 2 million of which were voluntarily destroyed. The task force identified only 12 table-egg laying flocks affected with the disease in 5 States: Maryland, Pennsylvania, Alabama, Indiana, and Delaware. Some 300 million table eggs from SE-positive farms were diverted away from the table-egg market to processing plants for pasteurization, a process that kills *Salmonella*.

John Mason, APHIS veterinarian and director of the Task Force, believes that only a limited number of egg-laying poultry flocks may be affected with the new invasive strains of SE. The hope is that by systematically locating those flocks and replacing them with birds free of SE, the incidence of the bacteria may be reduced and eventually eliminated.

In 1991, the task force began considering use of a more extensive environmental approach—the HACCP system. The task force believes use of the HACCP approach may be more effective in solving the SE problem sooner, because it would involve concerted efforts to reduce contamination at many different points in the food chain. SE-free feed, SE-free laying hens, good sanitation, biosecurity (a collection of good housekeeping measures designed to keep disease organisms from entering or spreading), careful refrigeration of table eggs, use of pasteurized eggs, and food-handling education programs could all help reduce SE contamination. The HACCP approach may also be fairer, the task force believes, because it does not place the burden of SE control only at the henhouse door—or the food handler's. "We've all got a stake in solving the problem," said Mason. "So we've all got to take on some of the responsibility."

— by Sharin Sachs, FSIS; and Margaret Webb, Public Affairs Specialist, Animal and Plant Health Inspection Service, USDA, Beltsville, MD perhaps the most hope of significantly reducing human suffering. The United States has one of the safest food supplies in the world, and HACCP will make it even safer.

Yet, around the world, millions of people die each year from foodborne illness, water contamination, and simple starvation. Sometimes these deaths are related to natural disasters, and the United Nations has in fact designated the 1990's as the Decade on Natural Disasters. Foodborne illness, like other environmental problems, is ultimately a global issue. In our concern for the consumers of the United States, let us remember our responsibility to the citizens of the world. ■



Part VI What You Can Do

Introduction by
James R. Moseley,
Assistant Secretary, Natural Resources and Environment

More than ever before, we need to work cooperatively to conserve the land, water, and air in a manner that will best sustain the Earth and all its people.

USDA, through its own and other Federal, State, and local organizations, works to enhance public environmental awareness and to encourage sound conservation practices. USDA provides a variety of publications on soil and water conservation techniques, a cadre of technical experts to assist landowners and communities in planning and implementing conservation practices, and an array of videotapes, slides, and field guides for schools and local organizations. Protecting our environment is a shared venture, and USDA needs your ideas, your interest, your time as a volunteer, and your participation at the local and national levels.

What can you do? If you are 16 or over, you can join USDA's Earth Team as a volunteer and actively encourage conservation practices by helping farmers and ranchers reduce erosion, conserve water, and enhance wildlife. If you are a concerned citizen and interested in supporting environmentally sound legislation and conservation programs, you can contact your local USDA office to become environmentally informed.

In a larger sense, an Earth Team has many members. Farmers, ranchers, and landowners—those most directly affected by environmental policies and programs—work in partnership with USDA Soil Conservation Service technical experts to develop and implement conservation plans for their land. Local citizens participate through local groups and conservation districts to conserve and protect water and air quality in their communities. Researchers develop new technologies to survey and conserve the Earth's natural resources. And USDA specialists work with other countries to encourage conservation practices that enhance land, water, and air quality and improve agricultural productivity around the world.

Get involved. Help promote the use of economically feasible and practical measures for conserving our land, water, and air and for promoting the productive vitality of our agriculture.

Sustainable Agriculture: Farmers Teaching Farmers

35

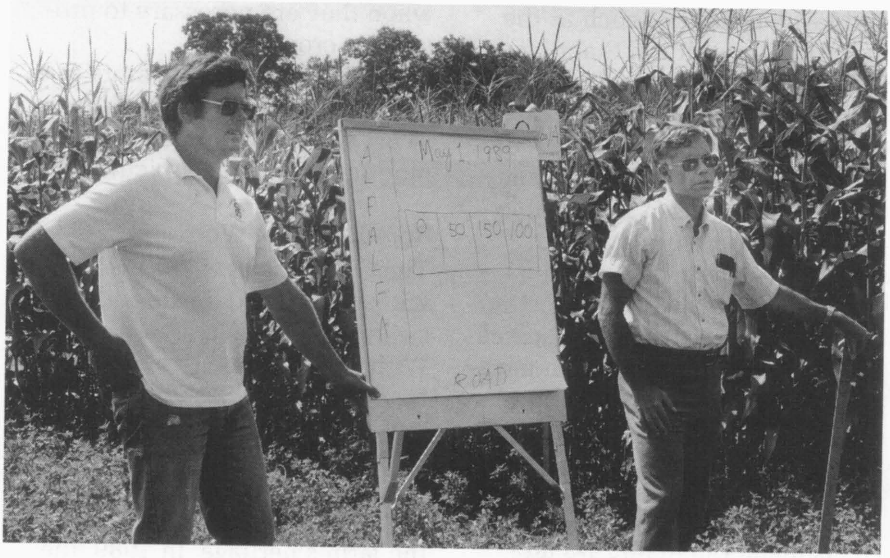
by Alyssa DeVito, Public Affairs Specialist, Soil Conservation Service, USDA, Storrs, CT

In an 18 1/2-hour workday that includes caring for a herd of 230 cattle and working in the corn fields, John "Jack" Collins also has time to be a teacher.

Collins, who owns and operates the Powder Hill Farm in Enfield, Connecticut, has become a teacher of sorts to farmers in the State. A leader in environmentally sound farming, Collins actively spreads the conservation word.

North-central Connecticut may not be the agricultural center of the country, but in regard to innovation, area farmers such as Collins are leading the way in sustainable agriculture.

Collins has significantly reduced the use of chemicals applied to his fields and is teaching other Connecticut dairy farmers how using fewer chemicals can work for them.



John "Jack" Collins (left), owner of Powder Hill Farm in Enfield, CT. Collins says, "the goal of the sustainable agriculture effort is to utilize fertilizers, chemicals, and manures efficiently, through the use of soil testing, innovative crop management techniques, and integrated pest management."
Philip Morneault/USDA 91BW0323.

"Some think that not using weedkiller is a little offbeat. But we're trying to protect ground water," says Collins. "We're responsible for not polluting it."

The Concern

Collins became concerned about water quality when ethylene dibromide, an insecticide, was discovered in the ground water supply of a neighboring town. He contacted the local Soil Conservation Service (SCS) field office.

"I figured, the quicker we were getting in on the act, the quicker we could find ways to reduce or eliminate the problem," said Collins.

In a cooperative effort to help farmers, several Federal, State, and local agencies—such as the SCS, the Agricultural Stabilization and Conservation Service (ASCS), and the University of Connecticut's Cooperative Extension Service (ES)—have worked together "to see that sustainable agriculture becomes standard practice," according to Collins.

Through nutrient management research done by the ES, researchers discovered that nitrogen fertilizer applied prior to planting is often inefficient. From this research the June nitrate test was developed to determine the need for application of nitrogen to corn silage when the plants are less than knee high.

Denise Conkling, Hartford County Soil and Water Conservation District manager, says, "Jack has so many conservation ideas, it's incredible. He's a progressive farmer. If there's a new idea, he'll try it. He's reduced the use of pesticides and herbicides while improving the crop yield. Then he said, 'I'm having success with this. I think I'll share it with other farmers.'

"Many farmers feel that the use of weedkillers and pesticides allows them to forget about the weeds." However, practices such as Collins' are not organic farming, which does not use any chemicals. Rather, sustainable agriculture is the practice of applying chemicals only at the point when they are necessary to protect the crop.

"I knew it would be more than a passing fancy," said Collins. "That's why I got involved in promoting sustainable agriculture."

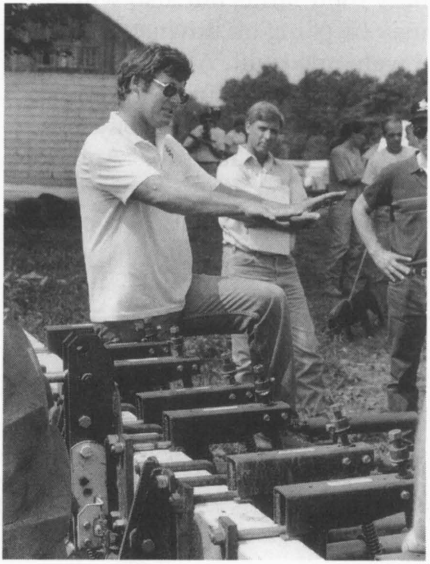
Spreading the Word

The Connecticut River Valley, with its rich and fertile soil, is seeing a decline in area farming. With developers eager to buy farmland, many farmers have sold out.

Collins, however, who went into partnership with his father in 1970, is dedicated to maintaining the farm's heritage. In 1989, the farm, which has been in his family for about 100 years, was chosen by the National Endowment for Soil and Water Conservation as one of the 10 best conservation farms in the United States.

Collins leads by example. Other farmers in the Connecticut River Valley are studying his techniques and practices and then trying them on their own land. He practices what he preaches. And he wants to talk about it—to anyone who will listen.

Collins, who is chairman of the Hartford County Soil and Water Conservation District, invites farmers and others from around the State who are interested in agriculture to "come and see what we're doing." He works with high school vocational agriculture students, 4-H clubs, and American Farm Bureau Federation programs to promote his farming methods. "We want to give young people an environment with a future," he explains.



John "Jack " Collins explains the use of a cultivator to farmers at a sustainable agriculture demonstration project in Connecticut.
Philip Morneault/USDA 91BW0322

The Practice

"The goal of the sustainable agriculture effort is to utilize fertilizers, chemicals, and manures efficiently through the use of soil testing, innovative crop management techniques, and integrated pest management," said Collins.

According to Collins, crop yields have not been affected by his reduction in chemical usage. He has, however, reduced production costs. By experimenting with various conservation techniques, Collins has successfully turned his operation into a more efficient and more environmentally sound enterprise.

In an effort to keep soil loss to a minimum, Collins practices conservation tillage, including no-till on corn silage and forage crops. He also uses crop rotations of cover and green manure crops, contour farming, and proper animal waste application. Many of these measures are used in combination, depending on both time and need. In June, Collins tests for nitrates in the soil on all his corn fields to determine whether any additional fertilizer is needed.

Because an aquifer lies beneath Powder Hill Farm and because of the well-drained nature of the area's soils, Collins does his best to make sure that his sustainable agriculture practices are successful. Water quality is at stake not only for his own farm and family but also for people downstream whose wells draw water from the aquifer and who may be affected by agricultural runoff. Collins, who is also coordinator of the Connecticut Association of Soil and Water Conservation Districts (CACD) sustainable agriculture demonstration program, has been successful at reducing the risk of ground water contamination on his own farm and at showing others how to do the same.

Sustainable agriculture is a way of managing the farm so that it is both environmentally sound and economically viable. Economically, sustainable agriculture makes sense, because conventional amounts of chemicals may be unnecessary. In reducing the amount of chemicals applied to the land, farmers lower operating costs and protect the ground water. Ecologically, sustainable agriculture also makes sense because adverse effects on the environment are reduced or avoided. It also minimizes the risk of chemicals entering the food chain.

Regarding the use of herbicides, insecticides, pesticides, and fertilizers, Collins simply says, "If you don't need it, don't use it. Applying pesticides when they aren't needed is like giving a child antibiotics when he isn't sick." Not only does sustainable agriculture protect our Nation's resources, but it is also extremely cost-effective, which helps ensure the viability and sustainability of the farm.

Since water quality is such a concern today, farmers who take it upon themselves to improve not only their farms but also what may be going on downstream are a welcome sight. Although farming serves as Collins' livelihood, it's also his way of life. Says Collins, "It's what I do." And he's protecting the future of his environment, his farm, and his community for generations to come. ■

Natural Filtration for Aquaculture

36

by Art Greenberg, South Regional Information Officer, South National Technical Center, SCS, USDA, Fort Worth, TX; and George O. Stapleton, Deputy Director, Public Information Division, SCS, USDA, Washington, DC

Catfish production, clean water, and conservation farming go hand-in-hand in Mississippi agriculture. Not only are they compatible, but they are also profitable and make a positive contribution to a quality environment.

Credit goes to National Aeronautics and Space Administration (NASA) research on wastewater treatment for long-term space travel using plant roots as a filter. Now, several towns in Mississippi and catfish farmer Truman Roberts have adapted this research to meet their needs.

To replace its sewage plant, the town of Collins, MS, constructed a relatively inexpensive wetland of living plants that filters the effluent. The filtered water, without added chemicals, safely discharges into a river that is used for canoeing.

Roberts, the Forrest County Soil and Water Conservation District commissioner, wondered why nutrients and waste from his

Several catfish farmers and towns in Mississippi are using plant roots as a filter for waste water treatment.
Art Greenberg/USDA 91BW0785

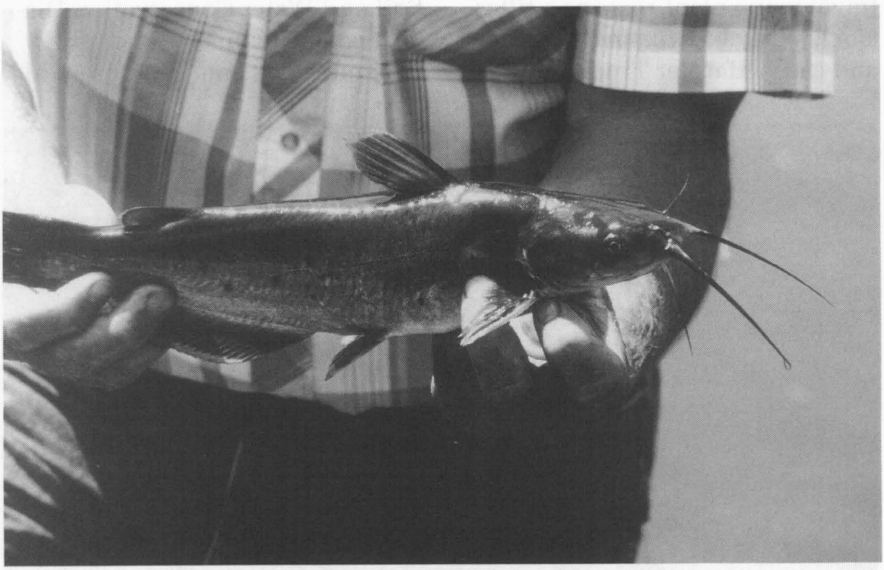
catfish ponds couldn't be similarly filtered. So he discussed pond filtering with NASA's Bill Wolverton and Ken Blan, the Soil Conservation Service's (SCS) liaison to the Gulf of Mexico Program, a multiagency effort to improve the quality of Gulf water.

"The growing number of catfish ponds in Mississippi and the excessive nutrient enrichment in Gulf waters are related," says Blan. "Recirculating catfish pond water through a constructed wetland can reduce nutrient and organic discharges into streams and, ultimately, the Gulf."

Ronnie Thomas, SCS wildlife biologist in Hattiesburg, says, "As far as I know, Roberts has the first constructed wetland in the United States that filters a catfish pond. This could revolutionize the catfish industry in Mississippi."

Conventional catfish pond outlets have long delivered nutrient-rich water to streams, bayous, and the Gulf of Mexico. Because there are nearly 100,000 acres of catfish ponds in the State—most of them in the Mississippi Delta—the potential to reduce wastewater discharge from catfish ponds is enormous.

Behind the dam of a 4-acre catfish pond, Roberts constructed a 1-acre wetland site. He split the acre and installed two complete filter systems. Gravity-fed inlet risers are at both ends; two



The growing number of catfish ponds in Mississippi and the excessive nutrient enrichment in Gulf waters are related. The catfish industry in the United States could be revolutionized by using constructed wetlands to filter nutrients and organic discharges.
Art Greenberg/USDA 91BW0787

pumps, which spray filtered water back into the pond, meet in the middle.

In his wetland, Roberts planted torpedograss, maidencane, giant smartweed, and waterhyacinth. They remove ammonia and phosphorus from the water.

All catfish ponds need a freshwater flow to prevent ammonia toxicity. Ideally, water takes 36 hours to flow through the systems, and the water in the pond is completely "turned over" each month. Flow is varied depending on total ammonia in the water at the inlet versus the sprayer. Plants filter and take up nutrients, grow larger, and, in turn, use more nutrients.

Bottom water from the pond enters wetland filter through a gravity-fed inlet riser.
Art Greenberg/USDA 91BW0823

After the "closed" filtering system was operating for just a few months, local people in Hattiesburg said it was easy to smell the difference. Water entering the filter from the bottom of the pond lacked that odor that makes you wrinkle up your nose.

Wetland plants constantly purify the pond water as they filter it. This improves water quality and has allowed Roberts to stock his pond with 10,000 fingerlings per surface acre, versus the conventional 7,000 rate.

Constructing a wetland filter and recycling the water cost Roberts $15,000 (including $9,000 for gravel, which was optional). Without the recycling project, Roberts would have needed a 1,000-foot-deep well costing more than $20,000.

Well water would be high in sulfur and would cost more than twice as much to pump, compared with recirculating water in the filter system. As water sprays back into the pond, it picks up oxygen, eliminating the need for aerators—something catfish farmers who pump ground water have to install and run.

"I'm doing it all in one motion," says Roberts, who has 60 acres of catfish water and plans to build four more wetland filters.

As Roberts lowered his water costs and kept ammonia levels low, other benefits became evident. The wetland filter:

- Improves water quality through improved water clarity and oxygenation,
- Increases fish production and improves fish flavor,
- Reduces disease and algae bloom,
- Increases wildlife habitat, and
- Saves ground water, money, and energy.

Although Roberts' plant-filter system is working quite well, more hard data are needed. The Environmental Protection Agency, through the nonpoint source provision of the Clean Water Act, has

Constructed Wetland in Maine

Soil Conservation Service (SCS) programs at the local level focus on technical assistance and information about water quality in such areas as sediment, nutrients, animal waste, pesticides, and salts that arise from agricultural operations. In Maine, a constructed wetland is helping to improve water quality.

"With the use of constructed wetlands," said Charles R. Terrell, national water quality specialist with SCS in Washington, DC, "many pollutants can be controlled to improve water quality on and near farms and ranches." According to Terrell and Robert J. Wengrzynek, SCS biologist in Orono, ME, the agency has developed a water quality treatment system in the State that uses a constructed wetland in combination with other conservation practices to improve the quality of agriculture-related waters. The system incorporates the pollutant removal features and other benefits of wetlands to improve water quality.

The newly developed water quality treatment system is composed of a series of conservation practices, namely a (1) sediment collection basin, (2) grass filter, (3) constructed wetland, (4) pond, and (5) wet meadow.

"Water from agricultural fields," said Terrell and Wengrzynek, "enters the treatment system, where the sediment basin removes coarse sediment particles and the grass filter removes fine sediment. The constructed wetland and pond act on pollutants to change them to less harmful components. The wet meadow is a final 'polishing filter.'"

The constructed wetland and pond are stocked with minnows and clams to create, along with the other components, a living filter. Minnows may be harvested commercially, and other limited uses are permitted, such as using the water for fire protection. Also, wildlife benefit from the constructed wetland and pond by obtaining food and shelter from the site.

According to Wengrzynek, first-year results of these water quality systems in Maine show that during storms, over 90 percent of available phosphorus and suspended solids were removed by these constructed wetland systems. Water flowing from cultivated potato fields through the treatment system has an improved quality when it exits the system into a receiving stream or other body of water.

Terrell reports that preliminary data confirm literature reports and expected results for these types of systems. "Successful implementation in the cold climate of northern Maine," said Terrell, "demonstrates that these constructed wetland treatment systems can provide low-cost, effective nonpoint source pollution control in many agricultural areas of the United States."

funded a project to monitor and analyze this system.

The University of Southern Mississippi is monitoring and analyzing these catfish pond wetland filters as one solution to improving the quality of water entering the Gulf of Mexico.

L.P. "Pete" Heard, SCS State conservationist for Mississippi, says, "Water quality and quantity have become a significant concern to the people of Mississippi and to a large segment of the American people. Solutions to specific problems will take commitment and innovative approaches by agriculture. With that commitment, new methodologies will emerge, such as the use of wetlands, both constructed and natural, that will significantly improve aquatic systems." ■

Pond water filters slowly through a constructed wetland on Truman Roberts' catfish farm near Hattiesburg, MS. The plants remove ammonia and other nutrients from the water.
Art Greenberg/USDA 91BW0822

Recycling Wastewater In Florida

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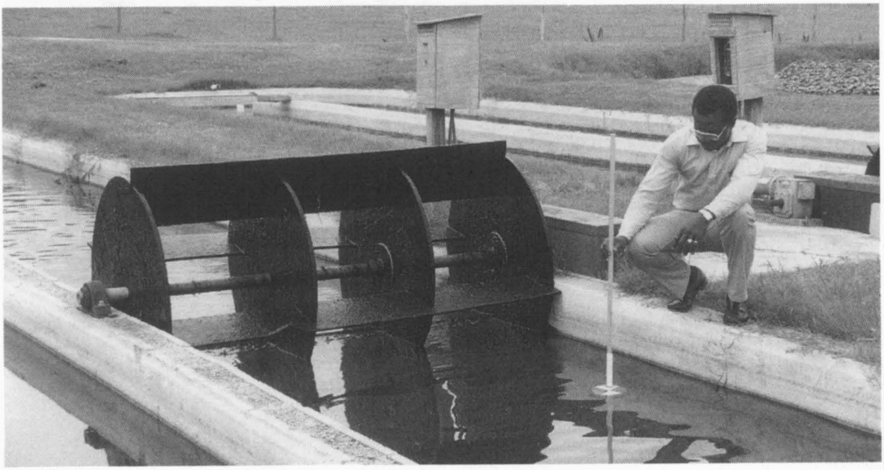
by Charles T. Woods, Associate Extension Editor, Institute of Food and Agricultural Sciences, University of Florida, Gainesville

Although the thought of free water sounds like a dream to most farmers, it has become a reality for central Florida citrus growers participating in one of the Nation's largest water re-use projects—and the first in Florida to irrigate crops for human consumption with treated wastewater.

Officially known as the Water Conserv II/Southwest Orange County Water Reclamation Project, it pipes millions of gallons of treated wastewater from the booming Orlando area to irrigate central Florida citrus crops and to protect trees from frost damage. The project will eventually distribute up to 50 million gallons per day—with peaks to 75 million gallons—of nutrient-rich wastewater to 15,000 acres of citrus.

Rapid urban growth in the Orlando area over the past two decades has placed an enormous burden on wastewater treatment facilities. In 1979 the U.S. Envi-



Jonathan Earle, an agricultural engineer in the Swine Research Unit at the University of Florida's Institute of Food and Agricultural Sciences, investigates the feasibility of recycling swine waste into high-protein animal feed. Earle is involved also in a project aimed at producing high-protein algae and photosynthetic bacteria from swine waste.
Bunny Ingles Stafford, University of Florida/USDA 91BW0782

ronmental Protection Agency ordered the city of Orlando and Orange County to stop discharging effluent into Shingle Creek by 1988 to protect fish and wildlife in the area and to improve water quality in connecting lakes. As a result, the city and county established a combination citrus irrigation and rapid infiltration basin system that began operating in December 1986. This new system piped reclaimed water from two of the city's wastewater treatment plants nearly 21 miles to the new Conserv II distribution center. From this location, the water is delivered to participating citrus groves under a pressure of 40 pounds per square inch, eliminating the growers' need for pumping equipment and reducing energy costs.

Extension Involvement

Extension agents with the University of Florida's Institute of Food and Agricultural Sciences (IFAS) worked with city and county officials and area citrus growers to help launch this huge water re-use program.

John L. Jackson, multicounty Extension agent based in nearby Lake County, has been involved in this water reclamation project, from its inception through the final stages of persuading skeptical citrus growers to begin using the treated wastewater. Jackson worked with officials to plan and design the project, and is credited with recruiting at least 24 of the growers who now participate in the program.

Participants sign a 20-year agreement to take from 26 to 52 acre-inches of water per year, which equates to 1/2 inch to 1 inch per week. The system now handles about 27 million gallons of water daily, with 20 million going to citrus groves and 7 million into rapid infiltration basins that allow the water to percolate through the sandy soil into the Florida aquifer.

Research Opportunities

Jackson also arranged for 60 acres of citrus groves next to the Conserv II distribution center to be set aside for research purposes. At this site, scientists from the IFAS Citrus Research and Education Center, in Lake Alfred, are measuring the effects of reclaimed water on citrus trees. Tests on 20 acres of newly planted trees will allow scientists to measure the effects of different application rates of reclaimed water on tree growth. The remaining acreage will be used for experiments on irrigation scheduling, "fertigation" (the application of liquid fertilizer through the irrigation system), cold protection, tree spacing, and pesticide use.

Additional research to examine the effects of reclaimed water on older citrus trees is also being conducted in groves where this water is used.

"Extension at Its Best"

Orlando citrus grower Jerry Chicone, who has more than 500 acres under Conserv II irrigation, says the wastewater irrigation program is "Extension at its best."

"Extension has played a crucial role in making this project a success," Chicone says. "It's a project where everyone wins—the urban areas get rid of treated wastewater, the growers get an almost unlimited supply of free water, and the environment is protected." ■

Creative Young Minds Grow in the Outdoors

38

by Katherine C. Gugulis, Chief, Media and Educational Services, Soil Conservation Service, USDA, Washington, DC

When the Iron Curtain came crashing down last year, Americans got a shocking glimpse of a ravaged landscape, mud-clogged rivers, and fouled air. That glimpse gave many Americans their first real picture of what could happen here if we don't step up efforts now to safeguard our own environment. Along with the pollution, they saw long lines of people waiting to enter grocery stores with empty shelves . . . people waiting in line for hours for a loaf of bread, a turnip, a few potatoes.

Contrast that with a stop at any American grocery store where food of every kind, color, and variety fills rows of shelves; where you can get strawberries and oranges and apples in the dead of winter; where beef, pork, poultry come in all cuts and sizes; where even bread comes in a mind-boggling array of types and flavors.

While the abundance at America's grocery stores results directly from our economic and political system, it is just as much related to the wealth and variety of our natural resources. Caring for those resources is a high priority for those who own and manage three-quarters of America's land—our farmers, ranchers, and forest owners. Unfortunately, not everyone who makes decisions about the use of natural resources has a stewardship ethic. And the number of those who do is likely to become even smaller, simply because the number of people who have grown up on farms becomes smaller each year as the population grows and the number of farms shrinks. The majority of future voters, legislators, commu-

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Outdoor Classrooms Open onto the World

Fortunately, thousands of youngsters are acquiring a conservation ethic through direct contact with nature. Their teachers and school administrators are opening the world to them simply by opening the classroom doors.

Things students would have learned about only through books and classroom modules suddenly come alive to them. They see, touch, smell, taste, and hear the outside world, and they begin to know why it is important. Conservation education focuses on real-world, future-oriented issues and activities that are relevant to students and their communities.

Boy Scouts touring the SCS Conservation Trail at Camp A.P. Hill, VA, received advice ranging from gardening to soil science. Wayne Bogovich, SCS agricultural engineer, describes soil profiles taken from the area.
Tim McCabe/USDA 91BW0831

In towns and cities throughout America, USDA's Soil Conservation Service, Extension Service, and Forest Service work with local soil and water conservation districts to promote and establish outdoor classrooms. Youngsters of all ages, backgrounds, and talents are learning to appreciate and protect their environment with the help of resource professionals, their teachers, and other people in their communities.

William Richards—a farmer, visiting college professor, and currently the chief of USDA's Soil Conservation Service—believes conservation education is critical if America is going to maintain a leadership role in the world agricultural market.

"We have to give young people an opportunity to learn about our natural resources and the importance of those resources to their lives if we really want to leave them a legacy that is worthwhile," Richards says. "Outdoor classrooms are one way we can do that; it's as simple as walking outside and looking at the natural systems around you."

Richards, whose father was a farm equipment dealer, bought a rundown 160-acre farm in Ohio when he and his wife were first married. Together, they restored the land through good conservation practices, including conservation tillage, and expanded it to a 2,000-acre-plus farm operation that their three sons now manage.

"I didn't know anything about farming when I started. I read and got as much advice from the Soil Conservation Service and Extension Service as I could. I believe farmers today have an obligation to learn as much as they can about current technology and apply good conservation management to their farms. , I believe it's critical for us in agriculture to help instill a conservation ethic into those young people who will one day become our community leaders and decisionmakers. We need them as much as they need us."

Outdoor Classrooms Go Everywhere

Outdoor classrooms are more a matter of mind than of circumstance. They can be established virtually anywhere and under any condition, as long as there is a creative and dedicated sponsor.

In south-central Florida a few years ago, a third grade class of gifted students at Zion Lutheran School in Deerfield Beach realized during their study of threatened and endangered animals that there were few natural areas remaining in South Florida to provide habitat for endangered animals. As a result of their study and with the help of their teachers and community, they brought a little bit of native Florida back to their school by turning a grassed courtyard into a virtual paradise with over 40 specimens of native plants.

They've installed a big wooden deck, a post and rope fence, and a beautiful cypress sign to welcome everyone to their habitat. They've established a nature trail complete with guide book. Visitors can listen to all the birds, watch the butterflies, and marvel at the small mammals and reptiles that come to eat or hide. Fruits and flowers are everywhere.

The students obtained help from a wide range of community agencies and organizations including the Broward County Soil and Water Conservation District. Thaddeus Hamilton, the District's naturalist, told them how to rebuild the sandy soil with mulch and compost. The city forester approved a permit for removing two non-native trees. Parents, students, teachers, administrators, and other volunteers helped remove the trees and ready the site for planting.

Pamela Farmer, the teacher and coordinator of the school's gifted program, says, "There is something I can do as an educator—instill an understanding and appreciation of our fragile ecosystems in the children. When our young people are made aware, they become concerned and want to help. Hopefully, they will later become responsible, caring, and informed adults who will take better care of their world than we have."

At the North Pole Middle School in Alaska, students have categorized 160 trees in the Northern Boreal Forest where the school is located, determining the age of the trees and noting their growth patterns. They have studied aquatic life in the stream that runs across the schoolground; and they have studied beavers and their work, including the effect of a newly created dam on the insect population. This year, Teacher Gerry Young and her students are planning to reestablish salmon that used to hatch in the stream "back when the pioneers came."

Young has been teaching for 25 years and has been at the North Pole Middle School for the last 5. "Wherever I have taught, I've always taught conservation," said Young, who won first place in the 1989 Conservation Education Awards Program of the National Association of Conservation Districts. "I think, with a species disappearing daily, we need to learn all we can now."

Denise Parsick, at the time a sixth grade teacher at the Broad River Elementary School in Beaufort, SC, enlisted the help of her students, fellow teachers, and members of the community in reclaiming a long-neglected nature trail on the 25-acre schoolground. To raise money for materials, such as railroad ties for controlling erosion along the trail and wood for building birdhouses, Parsick wrote grant proposals and headed up a recycling center for newspaper and aluminum cans at the school.

"My philosophy of teaching science is that nothing beats experiencing it," said Parsick. "You can memorize a lot from books and classroom discussion, but when you go to an outdoor classroom and touch, see, hear, and analyze, it makes a big difference."

"For example, when we are studying decomposition, my students and I can go to the woods and find a rotting log," Parsick said. "Then I show them that not only does the log have its own built-in community, but that it is also part of a much larger community that involves generating oxygen, making soil, growing new trees—the entire cycle. They watch. They record. They analyze. They gain a respect not only for nature, but also for each other."

On the day after a 4-inch rain, at Cashion Elementary School in Cashion, OK, 25 students slipped plastic bags over their shoes and sloshed to their 10 a.m. class in their school's outdoor classroom. "It's a little muddy, but that's no reason not to go outdoors," said Pam Deering, special education teacher at the small, rural school.

"In fact, the students found some interesting things like mushrooms, mold, and insects that hadn't been there in dry weather."

The triangular-shaped outdoor classroom is located in a corner of the schoolground and is slightly over an acre in size. It is enclosed by a chain link fence and has a small pond, trails made of landscaping timbers and wood chips, and a variety of trees and grasses. Soil removed when digging the pond was used to build up the landscape along the south side of the area to add diversity to the flat schoolground.

"Developing the outdoor classroom has really been a cooperative effort among the school, State and Federal agencies, businesses, and individuals," said Jim Stover, Kingfisher County Soil and Water Conservation District manager. Stover helped the school get the project started by helping to develop a plan for the area. Jack Miller, a Soil Conservation Service soil conservationist in the county, made recommendations on the pond, trees, and grass cover, and provided soils information. Parents helped to install fencing and plant some of the larger trees.

Rural Areas Need Outdoor Classrooms, Too

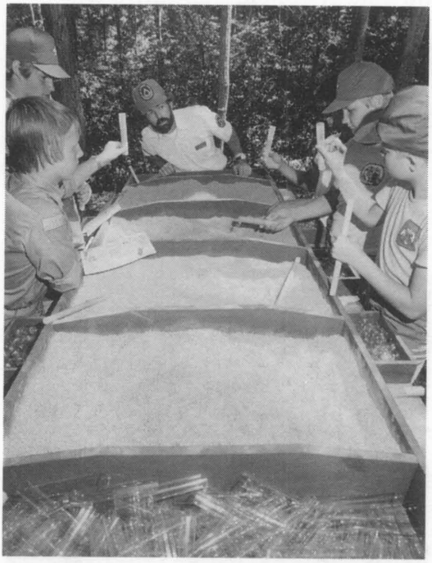
Rural communities aren't content to let their young people learn environmental values simply by osmosis. Many realize they have a special obligation to instill conservation values into the young people who will one day manage their farms, forests, and ranches.

Western Kentucky University made available a 20-acre wooded site for an outdoor classroom and the entire community turned out to help. University volunteers identified and marked more than 30 species of trees and shrubs; a local contractor donated time and equipment to install a pond; and the garden club provided and installed bird nesting boxes along the ½-mile hiking trail.

"We realized we were living in one of the best agricultural areas of the State and our young people were learning very little about it or about natural resource conservation," said Pete Dotson, an assistant professor of agriculture at Western Kentucky University and a district board member of the Warren County Soil and Water Conservation District. "Students weren't learning enough about protecting our soil and water and the wise use of our forests."

The idea for an outdoor classroom came when a local committee was formed of representatives from such groups as the Warren County Board of Education, FFA, the Bowling Green Women's Club, the Kentucky Division of Forestry, and the Soil Conservation Service to address these conservation education needs. The Tennessee Valley Authority contributed $17,000 through a 3-year grant, which is being used in part to purchase bleachers and a podium for a group instruction area, improve hiking trails, and construct a bridge over the pond. A 4-acre conservation tillage plot was established adjacent to the outdoor classroom to show students erosion control methods for croplands.

The site is maintained through a scholarship provided by the Warren County Conservation District to all university students studying environmental or conservation issues. The classroom is presently being used by local elementary and high schools and by university students for aquatic studies, soil classification, soil testing, and other environmental and agricultural studies.



The soil profile building area is a popular stop along the SCS Conservation Trail at Camp A.P. Hill, VA. Under the guidance of SCS Conservation Technician Burleigh Kay, scouts built soil profiles and learned how to control soil erosion around their homes.
Tim McCabe/USDA 91BW0832

The agriculture and biology departments at Montevideo Senior High School in southwestern Minnesota are the primary users of an 80-acre outdoor classroom at their school. But, the teachers in those departments also provide teaching assistance to students and teachers of other K-12 classes from throughout Chippewa County.

Kevin Hansen, an agriculture teacher at Montevideo, credits the local conservation district and Joe Keller, an SCS technician, for being instrumental in developing the design and management of the 80-acre site in the early 1970's. Conservation education activities are being expanded in that school district. Last spring, the school district worked with the local SCS, the soil conservation district and the Sugarbeet Growers Association to secure 1,000 trees to plant on 3 acres near an elementary school in Montevideo.

Nearly 400 students, ranging from kindergartners to sixth graders, were involved in planting the bare-root trees in holes dug by the school's maintenance department using a tractor and power-driven auger. As the trees need to be thinned, the students and teachers will plant them either on school-owned land or on community-owned easements or other community owned or managed property. The 3-acre site will also be used by high school biology and agriculture classes.

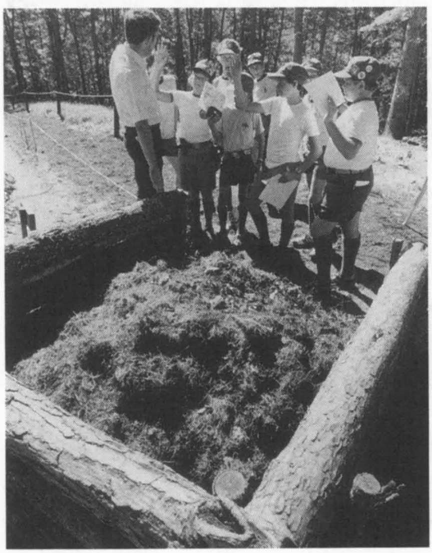
Concrete Doesn't Deter City Kids

While open space is limited in most big cities, kids can look beyond the concrete to learn about nature. In Washington, DC, teachers, administrators, and kids are being helped to do just that through the District of Columbia Soil and Water Conservation District (SWCD) and the Thomas L. Ayers outdoor classroom program. Through the Ayers program, sponsored by the SWCD and the local chapter of the Soil and Water Conservation Society, schools can receive technical assistance and funding for supplies and plant materials. Volunteers from the city's Cooperative Extension Service and Recreation Department, the U.S. Department of the Interior's Geological Survey and National Park Service, USDA's Soil Conservation Service, and other Federal and city conservation agencies also help with outdoor learning projects and activities.

The Francis Scott Key Elementary School, one of over 50 schools to participate in the Ayers program, assisted by SCS through the SWCD, involved students in building terraces and planting ground cover to control soil erosion. James V. O'Connor, a geologist at the University of the District of Columbia, helped students develop a topographical map of the school site.

At Green Elementary School, runoff from a steep hill had for years deposited silt and sand on the schoolyard and flooded the basement. SCS technicians planned the installation of drainage tile to carry away excess water, and students planted a thick cover of grass to reduce the rate of runoff.

Woodson Senior High School students joined the effort to help restore the Chesapeake Bay by repairing damaged streambanks along Watts Branch to reduce the amount of sediment and other pollutants discharged into the



SCS District Conservationist Richard Shockey explains the uses and benefits of a homemade compost pile to Boy Scouts touring the conservation area at Camp A.P. Hill, VA. SCS provides onsite demonstrations and conservation education. *Tim McCabe/USDA 91BW0830* stream system and eventually the Bay. Woodson lies along Watts Branch, the largest tributary of the Anacostia River to enter the Potomac River and flow into the Chesapeake Bay.

Interdisciplinary Approach to Outdoor Learning

Outdoor classrooms teach more than conservation education. They provide opportunities to participate in interdisciplinary approaches to solving problems and making decisions. Not only do students learn math by measuring and calculating, and science by observing natural phenomena, but they also learn important lessons in the social sciences, languages, arts, and esthetics.

As part of a bilingual conservation education project of Brooklyn School District No. 32, students are learning to speak English at the same time they are learning gardening. The students turned a vacant lot that was used as a dump site for building debris into a vegetable and flower garden, a sitting area for adults, and a play area for children. A mural depicting themes chosen by the youngsters decorates a wall facing the garden.

The group began the project with $480,000 in bilingual education aid from the U.S. Department of Education. Harvey Mack, district conservationist for USDA's Soil Conservation Service in New York City, held hands-on teacher workshops to show the instructors how to teach gardening and provided technical assistance at the gardening sessions from time to time.

Bilingual science teacher Bianca Tirrito, who regularly helps out with the gardening sessions, sums up the project's importance this way: "The students will improve their neighborhood. They will learn as they do these activities. Not only will they speak the words, but they will see what they represent."

Tirrito said the project will also encourage many students to love the land. "Many come from countries with strong agricultural bases," she added," but respect for the land can quickly disappear within Brooklyn's concrete environment."

How To Start an Outdoor Classroom

If there is one thing to remember when starting an outdoor classroom, it is that there is no one right way to go about it. Every outdoor classroom is different. While some schools have the advantage of being able to devote several acres of school property to it, an outdoor classroom can just as easily be a playground, a courtyard, a woods, a window ledge, a grassy slope, a patch of sky, or a concrete sidewalk. What it really takes to be successful is creativity, determination, cooperation, and commitment by teachers, students, administrators, parents, and the community. Like anything else in life, outdoor classrooms are what you make of them. But there are some guidelines that will help ensure success when planning an outdoor classroom.

- Develop a well-thought-out presentation and strategy to obtain the support of the school board and administrators. You'll need their backing for making changes to the school property and, in some cases, even for taking children outside.
- Clearly define your educational objectives. That will make it easier to secure support.
- Not all outdoor classrooms have a cost associated with them. But if yours does, prepare a preliminary budget estimate. If school funds are not available, include some suggestions for raising the necessary funds through donations, bake sales, car washes, or other ways.
- Ask your principal or other administrator to name a small committee to take leadership in developing the outdoor classroom. You'll want like-minded teachers as well as resource specialists, students, parents, and, in some cases, representatives from community groups, businesses, and professional organizations. Be sure to include the maintenance staff—many a new planting has been mowed down by an unknowing groundskeeper!
- Enlist the help of a professional to survey the area's natural features and resource areas, identify conservation problem areas, and develop plans for improving those areas through student projects. Sources of such help include your local conservation district and local offices of the USDA's Soil Conservation Service, Extension Service, and Forest Service.
- Perhaps most importantly, involve your students in the planning. Remember, people support what they help create. Give your students the opportunity to learn important lifelong lessons about assuming responsibility for their environment by giving them the opportunity to help make and carry out their own decisions.

An outdoor classroom is a natural for supplementing a school's environmental education program. As a place for creative learning experiences, it gives depth, meaning, and new dimension to the words that are used to describe the relation between humans and the environment.

Today, school programs often provide the only opportunity for many young people to learn how they depend on natural resources and how our use and care of soil, water, and air affect our environment. Much can be learned from textbooks, lectures, and discussion. But outdoor classrooms add another dimension to learning. A sign at an outdoor classroom in Cuthlamet, WA, says it aptly:

May there grow here
The rack of the buck
The reach of the pine
The mind of a child
The heart of a man
And the spirit of our
community. ■

Extension and Private Sector Work Together on Youth Programs

39

by Greg Crosby, National Program Leader, 4-H and Youth Development, Extension Service, USDA, Washington, DC

The Cooperative Extension System (CES) in the 1990's is using public-private partnerships to help expand its capacity to offer youth programming in environmental education and other areas.

Linda Jordan (center), a teacher at the Dale City Discovery Preschool in Dale City, VA, explains how plants grow to P. J. Hammond (left) and Michael Lyons (right) while on a field trip to the Belvedere Plantation in Fredericksburg, VA.
Ken Hammond/USDA 91BW0739-23

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Ken Hammond/USDA 91BW0739-23

These partnerships are a strategy to harness the resources and expertise of many stakeholders in confronting complex problems. The future quality of our environment, for example, may well depend on how well we do today in imparting values of stewardship, general science knowledge, and social skills to the general public and our youth.

Partnerships Create Synergy

The CES has a long tradition of national, State, and local government partnerships. As Extension increases its cooperation with the private sector, each partner, including CES, can coordinate and reallocate existing resources, to reach more clientele than they could if any one partner did it alone. Corporations become full participants in the development process by providing human and material resources, including leadership, subject matter expertise, and financial support.

The following are examples of public-private partnerships:

- **Environmental Stewardship through Partnerships.** 4-H is expanding and modifying its traditional nonformal natural resource education for youth. Through a novel public-private partnership, the National 4-H Council and the USDA Extension Service have recruited five environmentally concerned corporations to provide leadership and resource support in creating and promoting a new environmental curriculum for

Katherine Marple shows a marigold display to a group of students from Dale City Recreation Center Preschool at the Belvedere Plantation, Fredericksburg, VA.
Ken Hammond/USDA 91BW0739-6

youth. Joint chairs include executives from Monsanto Company, the Extension Service, and the Cooperative Extension System.

Five committees—chaired by private sector representatives from Amoco Corporation, Deere & Company, Waste Management, Inc., Monsanto Company, and International Paper Company—focus on energy conservation; forestry, rangeland, and wildlife; waste management; clear water and air; and conservation of natural resources. Members of the full committee include county agents, State specialists, Federal program leaders, and other interested organizations. The private partners are investing resources in developing and producing new education products. For further information, contact National Program

Katherine Marple (left) and Cindy Allen with the puppet "Miss Marigold" explain plants we eat to a visiting group of preschool children on the Belvedere Plantation, Fredericksburg, VA.
Ken Hammond/USDA 91BW0738-33

Leader, Extension Service, 4-H and Youth Development, Room 3860 South Building, USDA, Washington, DC 20250-0900.

- **America the Beautiful—Acre by Acre** is a tree planting program for youth. Through a public-private partnership between International Paper Company (IP) and Extension's Southern Region, foresters in 1991 are helping 4-H'ers in 8 Southern States to plant 5 million tree seedlings supplied by IP. CES and IP are planning to create a national program in the coming years. For further information, contact Southern Region Extension Forester, Cooperative Extension Service, Hoke Smith Building, University of Georgia, Athens, GA 30602.
- **Water Riches** is a 4-H water quality curriculum for youngsters 8-10 years of age in Nebraska, through a partnership with the Nebraska WellDrillers Association and the State's Natural Resource Districts. The video and print materials are formatted like a network news program around five critical water issues: how we use it, where it comes from, above and below the ground, groundwater pollution, and keeping it safe. **Water Riches** involved 8,500 youth in Nebraska last year, and 5 States have adopted it. For further information, contact Extension Specialist, 4-H Youth Development, 114 Agricultural Hall, University of Nebraska, Lincoln, NE 68583-0700.
- **National Drinking Water Week**, the first week in May, is supported by CES. It is a collaborative effort of public and private organizations to help people increase their understanding of drinking water as a valuable resource.

The ES Water Initiative Team sends packets of information with news releases, factsheets, tips, clip art, and a proclamation to every county Extension office nationwide. Counties use hundreds of newspaper articles, radio programs, and television broadcasts. Water quality information is also incorporated into agriculture, home economics, and youth newsletters.

Katherine Marple explains to a preschooler the root system on a plant in the greenhouse of the Belvedere Plantation, Fredericksburg, VA.
Ken Hammond/USDA 91BW0739-26

In many counties, agents plan activities with schools and other youth groups, such as classroom presentations, day-long student programs, science project mentoring, field trips, poster contests, and essay contests. Agents also plan seminars, workshops, tours, exhibits, and other educational activities for the public, including water testing by rural homeowners, which is encouraged by exhibits staffed in malls and banks. For further information, contact Extension Service, Room 3328 South Building, USDA, Washington, DC 20250-0900.

- **Youth at Risk**, a CES national initiative, has seven centers for action funded by the Kellogg Foundation to provide technical assistance to 69 federally funded pilot sites selected in 1991 alone. Two of these centers for action, at the University of California and Michigan State University, will focus on providing science, reading, and technology literacy. The California **Science Experiences and Resources for Informal Educational Settings (SERIES)** curriculum contains environmentally oriented modules on recycling, waste management, and agriculture.

  The Michigan State curriculum, **SPACES**, a comprehensive three-part experience, aims at helping young people develop technical skills and concern for our planet, as well as for themselves. It includes a segment called **Our Common Earth**, which offers experiential activities for children to explore global environmental issues and begin to solve real-life, local environmental problems. **Adventure in Science (AIS)** is an all-volunteer program aimed at stimulating pre-high-school students to be excited about and pursue math and science. Under this program, scientists and engineers are volunteers in out-of-school programming. For further information on the centers for action, contact Community Cares Project Director, National 4-H Council, 7100 Connecticut Ave., Chevy Chase, MD 20815.

When Partnerships Work Best

Partnerships work best when each organization evaluates its strengths and weaknesses. Each group needs flexibility and patience to understand and respect the goals of the others. Extension has a vast infrastructure, a variety of educational delivery systems, and a wide array of staffing patterns and training expertise to share with potential partners who lack ready access to such an educational network.

The formation of broad-based alliances or coalitions may be most beneficial when a community or State wants to focus many resources on a complex problem. Coalitions can include a large number of partners who have similar goals, but who may be competing for similar clientele. Since members of the coalition may disagree on the approach or message to be communicated, the coalitions are most useful in cases where a balanced view of a given issue will provide effective results—for example, in the case of water contamination or youth at risk. ■

Taking a Fresh Look at Waste Reduction

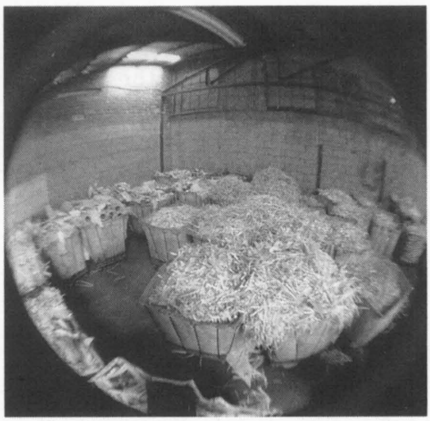
40

by Jim Wolfe, Communication, Information, and Technology Staff, Extension Service, USDA, Washington, DC

Americans generate about 160 million tons of municipal solid waste annually—which equals about 1,300 pounds of waste per year for each of us, or about 25 pounds per person per week. According to the Environmental Protection Agency (EPA), every year Americans throw away 60 billion cans, 28 billion bottles, 4 million tons of plastic, 40 million tons of paper, 100 million tires, and 3 million cars.

Community landfills are closing faster than replacement facilities are opening. According to EPA, 45 percent of all landfills will be closed by 1991, leaving 3,300 sanitary landfills in operation. In some areas of the United States, the fees for dumping waste have increased to over $160 per ton of waste.

Across the Nation, a revolution is under way in waste management. This revolution is accompanied by a hue and cry over laws



Newspapers made up about 14.4 percent of the landfills studied in the "Garbage Project" by the University of Arizona. Newsprint represented the largest single item in landfills by both weight and volume.
Bunny Ingles Stafford, University of Florida/ USDA 91BW0780

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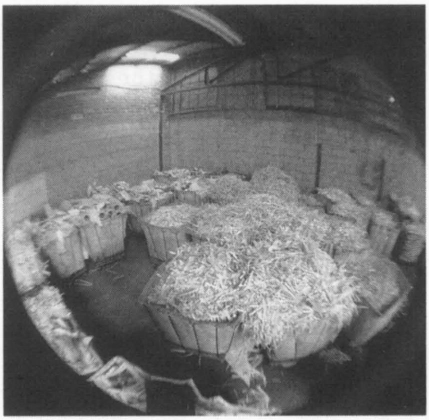

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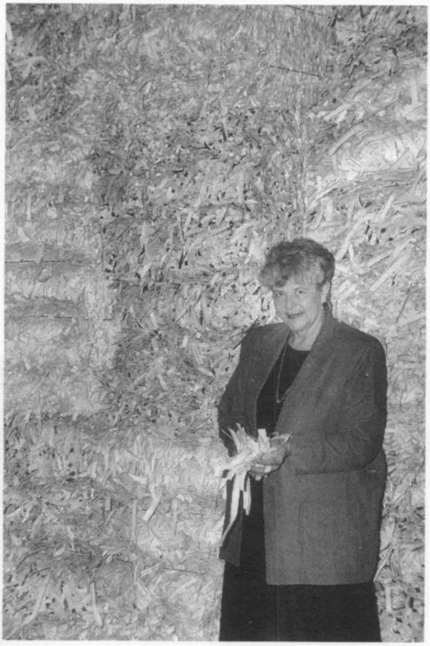
and upcoming changes in minimum standards for solid waste landfills.

Communities Need Answers

Ten States have already adopted mandatory recycling laws. Communities everywhere are reexamining local waste management practices. Changes in minimum standards significantly increase the cost of upgrading existing sites as well as the costs of waste collection, transport, handling, and disposal.

Communities know they must find cheaper solid waste disposal methods. First, some critical questions need answering: How can they afford state-of-the-art, well-engineered landfills? Is it possible to develop cost-effective waste management systems to take advantage of maximum waste reduction, recycling, and processing methods?

Nationwide, Cooperative Extension educational programs are helping communities, public officials, and citizens examine these issues and make the best decisions for their localities.



Dwarfed by towers of recycled newspaper, Marie Hammer, associate professor and home environmental specialist at the University of Florida's Institute of Food and Agricultural Sciences, promotes opportunities for recycling throughout Florida. "Waste, after all, is in the eye of the beholder," says Hammer. "If we really look at things we are throwing away, we can learn to see them as raw materials that can be reused to solve everyday problems."
Bunny Ingles Stafford, University of Florida/ USDA 91BW0781

The Garbage Project

One solution is waste source reduction—create less trash. But what should be reduced? To find out how to accomplish this, researcher William Rathje of the University of Arizona developed the "Garbage Project," starting in the late 1970's, to analyze the contents of 9,000 pounds of municipal solid waste taken from landfills in Arizona, Illinois, and California.

Rathje's findings indicate that less than 1 percent by weight and volume of each landfill was composed of fast-food packaging. He also found that plastics accounted for only 12 to 18 percent of the volume of landfills—not the 30 to 70 percent assumed by the public.

Newspapers made up about 14.4 percent by volume of the landfills studied, representing the largest single item in landfills by both weight and volume. Biodegradation of paper is surprisingly slow. In the last 10 years, there has been no major reduction in the percentage of paper found in landfills. Since 1989, Extension education programs in Arizona have helped make newsprint the most commonly collected recyclable material. Extension specialists believe such programs may ultimately reduce by 10-16 percent the newspaper volume found in landfills.

Jo Townsend, Orange County Extension energy agent, teaches hotels how to overcome space limitations by designing systems for recycling in central Florida's 80,000-room hotel and resort industry.
Bunny Ingles Stafford, University of Florida/ USDA 91BW0779

Reduce, Reuse, and Recycle

In the summer of 1988, Florida passed one of the most comprehensive solid waste laws in the Nation. The Solid Waste Management Act requires every Florida county to reduce its solid waste 30 percent by 1994.

To meet the challenges of solid waste, Florida Extension programs in the State's counties are forming new partnerships: Extension specialists are tapping the knowledge of disciplines in natural resource areas, and they are building extensive contacts with leaders in business, industry, and other government agencies to support this mandated source reduction and to encourage recycling.

Extension specialists in counties are conducting educational seminars and public forums to educate citizens. They train volunteers and youth from various groups to hold waste management activities at schools and special events. Consumer education programs promote source reduction, recycling, and proper management of household hazardous waste.

In another program, Extension energy agents with the University of Florida's Institute of Food and Agricultural Science (IFAS) in Orange County are working with business, industry, and academic teams to design systems for recycling in central Florida's 80,000-room hotel and resort industry.

They are promoting a pilot program with six large Orlando hotels to test the most efficient methods of recycling waste. Innkeepers in Orlando, the Nation's top tourist destination, are learning how to improve the environment while cutting their cleanup costs. Hotel employees now recycle newspapers, glass bottles, aluminum cans, cardboard, and plastic in recycling bins placed on each floor. Each hotel is encouraged to devise its own system of recycling by using balers and crushers as well as bins.

Wood Resource Recovery, Inc., in Gainesville, FL, is a composting demonstration project by IFAS researchers that shows the feasibility of composting yard trash from a typical municipal solid waste stream. To develop the market for composts, IFAS researchers are studying which types are best for vegetables, containerized plants, and landscapes.

Minnesota's Innovative Approaches

In Wabasha County, MN, Extension has an innovative education program under way that uses recycling stickers on grocery store shelves. The small stickers are placed on the shelves so consum-

Mountains of yard trash are converted into compost, mulch, fuel wood, and landscape chips at Wood Resource Recovery, Inc., in Gainesville, FL. The composting demonstration project shows the feasibility of composting yard trash from a typical municipal solid waste stream.
Bunny Ingles Stafford, University of Florida/USDA 91BW0783

ers can identify products that are packaged in materials that are currently recyclable in that area.

Since 1990, Minnesota has prohibited disposing of yard wastes in landfills or incinerators in the Minneapolis-St. Paul metropolitan area. In 1992, this prohibition will encompass the entire State. Minnesota Extension is educating homeowners in how to deal with this law through a special "Don't Bag It!" lawn care program and various publications. The program uses Master Gardener volunteers to teach these yard waste management practices.

Minnesota 4-H youth programs also emphasize environmental concerns through summer youth activities. Workshops on "Pollution Solution . . . Kids for Saving the Earth" involve 50 young people, ages 12 to 18, with funding from both Minnesota Extension and four counties.

Reducing Hazards in Missouri

Extension staff at the University of Missouri worked with two hazardous waste committees in Howell County responding to citizen concerns about contaminated drinking water and toxic chemicals poured into landfills. After learning about these problems, residents from the town of West Plains and 14 surrounding counties were asked to collect contaminants. They brought used motor oil, dead batteries, old paint, varnish, gasoline, and weed killer to a hazardous waste collection site at the fairgrounds.

In a followup resident survey, 98 percent of the citizens responding said they would purchase less hazardous waste. Eighty-one percent said they would be willing to pay for future hazardous waste collections. Ninety percent stated that after learning of the environmental threats counties face, they would change the way they disposed of hazardous waste.

What Next?

These accomplishments are just a sampling of Extension's national initiative in waste management. To get involved in your community, contact your local county Extension office.■

Disposal of Municipal Wood-Based Materials

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by Howard N. Rosen, Research General Engineer, Forest Service, USDA, Washington, DC

Few issues make Americans more anxious than how to dispose of waste materials. Since Earth Day 1970, the desire to clean up America has been growing. Encouraged by support from the general public as well as many commercial interests, most environmental organizations have demanded a cleaner America and less wasteful use of its resources. In this climate of concern, lawmakers at the Federal, State, and local levels have proposed more than 3,000 pieces of legislation on recycling waste.

Each Year—160 Million Tons of Waste

What are we to do with the 160 million tons of municipal solid waste that we generate each year? Municipal solid waste—that is, postconsumer solid waste generated at residences, commercial establishments, and institutions—is something we all had a stake in producing.

The United States is running out of acceptable sites for landfills for municipal solid waste. Our Nation, which once had 18,000 landfills, now has only 6,000; in the year 2000, we anticipate a shortage of space for 54 million tons of waste products per year. There is an additional downward spin to this news: The data, and the problems they suggest, do not include industrial waste, waste from construction sites, or sludge from wastewater.

Forest Product Waste: What Happens to It?

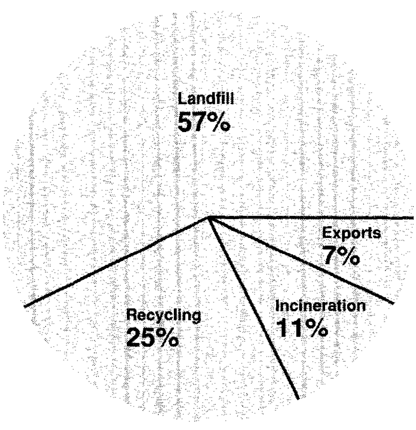
Disposal of the 84 million tons of paper and wood products annually consumed in the United States occurs in many ways. Of this, 58 million tons, mostly paper, goes to landfills—where it represents the largest component of municipal trash. Methods to reduce the amount of municipal forest product waste would have a good potential to reduce landfill space needed to dispose of trash.

Landfill. About 57 percent of all paper and wood products consumed in the United States is disposed of in landfills near cities. The waste is layered with a series of compact layers of dirt over a large area and left to decompose. That decomposition can be surprisingly slow. Studies of landfills have shown, for instance, that paper products are still readable after 20 years in a landfill.

Recycling. Another 25 percent of used paper and wood products is recycled. The material is collected, separated, stored, broken down chemically to fiber, and reprocessed to make new paper products. Recycled paper is usually a mixture of recycled and virgin fiber whose composition depends on the required properties of the final product. A wide variety of fiber products, from photocopier paper to boxboard, are made from recycled fiber.

Incineration. Eleven percent of paper and wood product wastes are burned. This burning converts wood to carbon dioxide and water with minimal residual ash and generates energy.

Figure 1. Disposal of forest product waste, 1988 (percent)



Export. The remaining 7 percent of our paper and wood waste is exported to other countries. The United States is the world's largest exporter of waste paper, with over half going to the industrialized countries of the Far East such as Taiwan, Korea, and Japan.

The Best "Use" of Waste Products

A look at this breakdown of how we dispose of our wood fiber wastes leads us to the next question: What's the best "use" of waste products? Even asking the question about the disposal of wastes in this way rests on a new way of thinking about waste materials. Now, it is assumed that a waste "product" has utility.

Saving space and reducing contamination of our natural resources are very important goals. If there is an economic incentive to reuse wood-fiber waste products, recycling will increase and less material will be sent to landfills. Another important side benefit is that there will be less landfill waste to contaminate the water systems.

Conservation. If recycling were to increase, demand for timber would decrease substantially, and our timberlands could be conserved for other uses. Each year, discarded paper and wood products equal 86 million cords of pulpwood, or the annual harvest from almost 3 million acres of southern pine plantations.

Economic Return. Recycling and exporting waste material for reuse returns economic benefits to the provider of the waste material as well as to the manufacturer of the product made from the waste material.

How Can Research Contribute?

For researchers, two important areas of research focus are (1) recycling for better use of waste products and (2) more rapid decomposition of waste products in an environmentally sensitive way.

Recycling. Two great challenges facing the U.S. forest products industry are to find environmentally benign, low-cost recycling methods and to increase the number of products that can be made from waste-wood fiber. In a major commitment, the U.S. pulp and paper industry, through the American Paper Institute, has announced its goal of increasing recovery (recycled and exported waste paper) from 31 percent in 1988 to 40 percent in 1995. Research will help but available technology and recovery systems are not likely to achieve higher recovery rates. New methods will be needed to expand the recovery of waste paper beyond the 1995 goal of 40 percent.

Bob Kelley, physical science technician at USDA's Forest Products Laboratory in Madison, WI, takes samples of laser- and photo-copy waste paper from bales of mixed office waste. The samples are used in recycling research aimed at de-inking difficult-to-recycle waste papers.
USDA 91BW0828

Technology is needed for recycling paper and wood wastes into high-value products if recycling is to be economical on a widespread basis. Current recycling technology fills narrow product niches, such as tissue papers and toweling, and serves limited geographic areas. In order to develop the technology essential for expanding recycling possibilities, new research is needed in three areas—separation, cleaning, and alternative processes and products.

Separation. Research is needed on separating paper and wood waste from the municipal waste stream. This research will develop new mechanical sorting methods to reclaim paper and wood wastes, such as packaging materials and disposable diapers, from other urban garbage at incinerators and landfill sites.

Cleaning. Research is needed on cleaning separated paper and wood wastes. Current knowledge and technology limit the large-scale use of most paper waste to the production of relatively low-valued or colored paper products. New cleaning methods are needed to produce whiter, brighter pulps suitable for manufacturing a wide variety of high-valued paper products. Advances in this area would include:

- Development of new methods for cleaning fiber—removing inks, dyes, and other contaminants from waste paper—to make recycled pulps competitive with virgin market pulps.
- Development of pulp-bleaching technologies that are environmentally safe and appropriate for recycled fibers and urban environments.

Alternative Products and Processes. Research is needed to develop alternative products—such as structural products for furniture and housing components—that are capable of using paper and wood waste and the processes and facilities to produce them.

- Development of new products and processes to combine recycled wood fibers with other recycled materials such as plastics, glass, and metals, for example, to produce molded automobile parts from recycled wood fiber and plastic.
- Development of new forming and drying processes to use waste fiber in structural products and panels.
- Determination of methods to recondition used wooden pallets and to use pallets for fuel and fiber.
- Measurement of changes in fundamental structure and chemistry from recycling processes to improve the performance of recycled products.
- Development of new bonding concepts for wood fiber products so that these products will retain their strength when they are wet.

- Development of methods to convert organic wastes from recycling mills into fertilizer, energy, and other useful qproducts.

Decomposition. Fortunately, wood-fiber waste materials decompose or degrade with time. Our need at the time of disposal, however, is to speed up this process. The rate of decomposition depends on landfill or water conditions such as temper- ature, moisture, oxygen level, and acidity. In theory, wood fiber waste should eventually decompose, but as the studies referred to earlier report, decomposition in landfills is not as quick as first thought.

Some of our successes in making wood last longer now add to the difficulties of speeding up that process at the end of its product life. Chemicals are sometimes added to wood-based materials so that the wood can remain in the ground or be exposed to the weather without degradation. For instance, wooden posts are often treated with pentachlorophenol to reduce the degradation of wood in the ground. The treated wood poses a problem for us: How do we now make this wood degradable?

Enhancing Decomposition Rates

Redesigning Landfills. Researchers suggest that the decomposition rate of organic material can be enhanced by carefully changing the design of landfills. These landfill designs may incorporate such methods as the collection and recycling of leachate (water and dissolved chemicals) back into the landfill and the use of above-ground containment mounds and chemical and bacterial inoculation of landfills.

Biodegradation. One recent development has been the use of fungi to degrade wood fiber materials as well as to change hazardous organic chemicals into benign products. Fungi that degrade lignin, the binding material in wood, have been successfully used to degrade pentachlorophenol in soil contaminated with a commercial wood preservative product.

Research is needed to identify factors necessary to control the growth of lignin-degrading fungi to allow for optimum growth in landfill conditions. Further work is needed to understand the biochemistry of the fungal degradation and to identify those fungal strains that are most effective in degrading wood fibers in landfills. ■

Planting Trees Around Your Home and in Your Community

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by Robert D. Mangold, Forestation and Tree Improvement Officer, Forest Service, USDA, Washington, DC

Trees have long provided us with a host of practical and aesthetic benefits. They supply the raw materials for the buildings we live in, the furniture we sit on, and the paper for books, magazines, newspapers, bags, and boxes. Trees are also used in shelterbelts to protect crops, to preserve energy, and to reduce soil erosion, among numerous other uses.

Aside from these more practical considerations, trees have provided urban dwellers and people living in towns and the countryside with a source of inspiration and beauty. The brilliant colors of autumn foliage lift our spirits, and the peace and tranquility of trees enrich our lives. Trees make our homes beautiful, keep them cool in summer, and protect them from winter winds. In addition, trees help to absorb the excess carbon dioxide and other byproducts that our modern civilization puts into the atmosphere and thus may help mitigate the potential harmful effects of global warming. Indeed, the world would be a desolate place without these very big plants!

As a tree planter for over 15 years, I am amazed at how fast trees grow and modify the landscapes they occupy. It is a great feeling to see a grassy field or meadow grow into a forest. This experience, of watching little seedlings grow into fine flourishing trees, is available to everyone. President George Bush has made tree planting a national issue, and many groups are getting involved. Chapter 11 on America the Beautiful explains the President's tree planting program.

You can share in this wonderful process by planting trees around your home and in your community. Planting a tree is hard work but well worth the effort. However, trees, like all living organisms, have particular requirements for survival and growth. To make your efforts worthwhile in the long run, you need to consider some of the following questions when planting your tree or trees.

Selecting a Site

It may take only a short time to plant a tree, but remember, you and the tree will have to live with its location for a long time. Make sure you will like having a tree in the chosen spot, and make sure that the tree will like it too. Once they are established, trees cannot be moved around like sofas! Pay careful consideration to the following questions:

- Where will the tree be planted? Is the site wet, cold, dry, or sunny? Is the soil good, clayey, sandy, or rocky? These kinds of factors help determine the ecological characteristics of the site and thus the kind of tree that will prosper there.
- Is there enough room for the tree to grow to maturity? If the tree is an evergreen, will it provide too much shade in the winter or crowd out sun-loving shrubs? Where are the utility wires, sidewalks, and underground pipes? Planting a tree under wires or over sewer pipes is an exercise in futility, for you may have to prune it heavily or even cut it down when it grows larger.
- Where can the tree be planted to provide the most energy savings? Trees can be located around your home to provide shade in the summer and protection from the winter winds. Deciduous trees, which loose their leaves in the fall, can be planted to provide shade in the summer, yet allow sun to reach the house in the winter. Conifers (that, is evergreens) supply protection all year long. If placed properly, trees can make a significant reduction in the amount of energy used to heat and cool your house.

Selecting the Species

Although site requirements help determine which species would do well, more than one species will often fit a particular situation. Here you can have some fun! Pay attention to these questions:

- What tree species survive the local climate? Different species of trees are ecologically adapted to specific climates, and trees planted in the wrong climate zone can be killed or seriously damaged by the extremes of winter or summer weather. Refer to tree hardiness maps that delineate the geographic extent to which a species can be planted. Whenever possible, plant trees that are native to your local area.
- What tree species are reasonably resistant to the damaging effects of insects, diseases, and air pollution?
- What species will fit the chosen space when trees are mature? Branching pattern and overall size of the tree make certain species better suited for particular sites. For example, low-growing ornamental trees can fit under high wires or close to a house; trees that grow in tall columns can screen unsightly views. Large trees need to be planted far enough from a

house so that broken branches will not fall onto the house or your car.

- Do you want fall color or flowers? Maples, oaks, and sweetgums are known for their fall colors. Yellow-poplars, paulownias, horse chestnuts, rain trees, and magnolias are examples of large trees that have interesting flowers; the ornamental cherries, pears, and crabapples are small trees renowned for their beautiful flowers. Consider, though, how much mess you are willing to rake up to compensate for the flowers!

Selecting Your Tree

After you have determined which species will be best suited to your location, you must select the individual tree. Although trees are generally hardy plants, selecting healthy, vigorous planting stock is important to ensure success. Use reliable nurseries and take the time to inspect potential purchases carefully. Ask yourself the following questions:

- Does the foliage (or winter buds) look disease-free and insect-free? Do the leaves have a healthy color?
- Does the tree have a healthy root system? If possible, look at the roots and see if you can detect numerous white growing tips. Is the root system large enough to support the stem?

Remember to buy stock early in the growing season. The best stock is usually sold first. In colder climates, buying early may also help ensure that trees will be planted when they are more dormant. Planting actively growing trees (those that have begun to leaf out) is more risky than planting dormant trees (which have tightly closed, vegetative buds).

Look skeptically at large plants grown in small containers. Some plants will become rootbound if they are grown in containers that are too small. You can determine if a plant is rootbound by carefully extracting the plant from the container and noting if the roots have spiraled around the bottom of the container. These plants will not do well upon outplanting. If you happen to buy a rootbound plant, you should carefully prune off some of the encircling roots with a sharp knife.

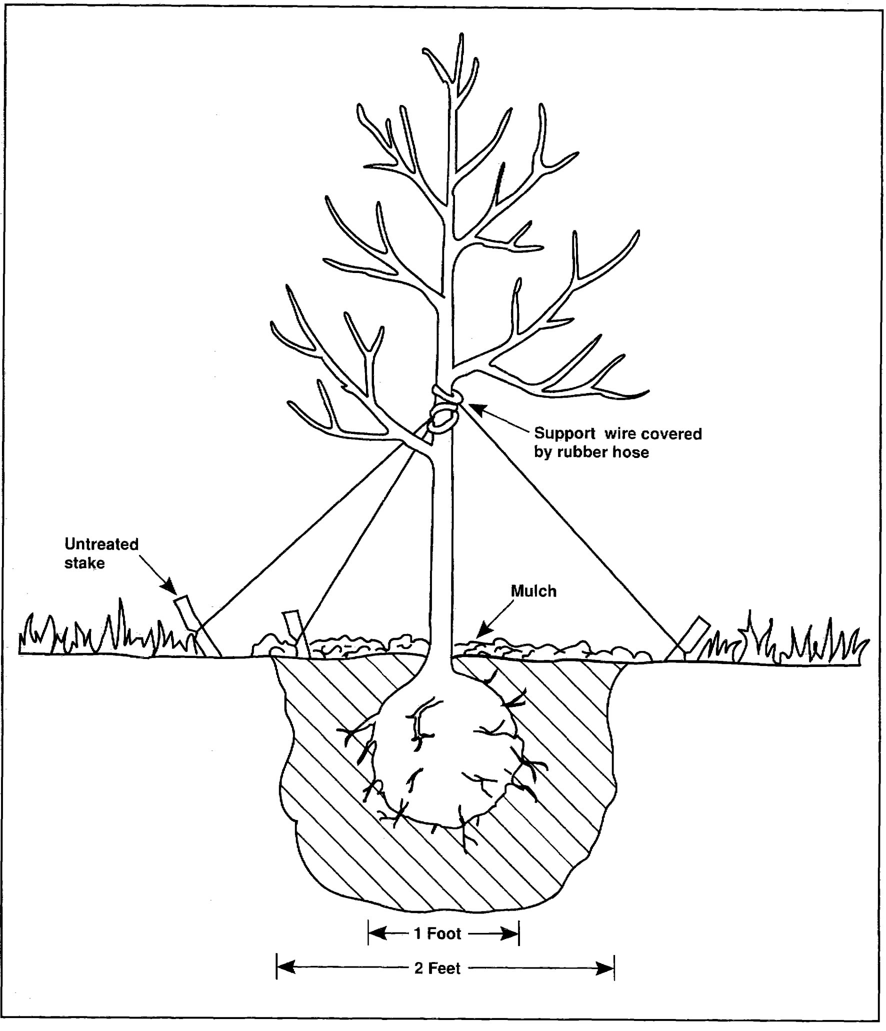
Have a frank discussion with the nursery personnel regarding the details of specific care needed for the tree you select. Most of these people are highly trained and can provide a storehouse of knowledge about trees.

Planting Your Tree

Now let's get down to the hands-on part of planting your tree. First, you must dig the hole. Trees planted in areas with loose, uncompacted soils can be successfully planted in a hole dug twice as wide and about one and a half times as deep as the root ball of the tree (fig. 1). Soils become compacted by construction machinery or heavy foot traffic. Recall the old adage "It's better to plant a $25 tree in a $50 hole, than a $50 tree in a $25 hole."

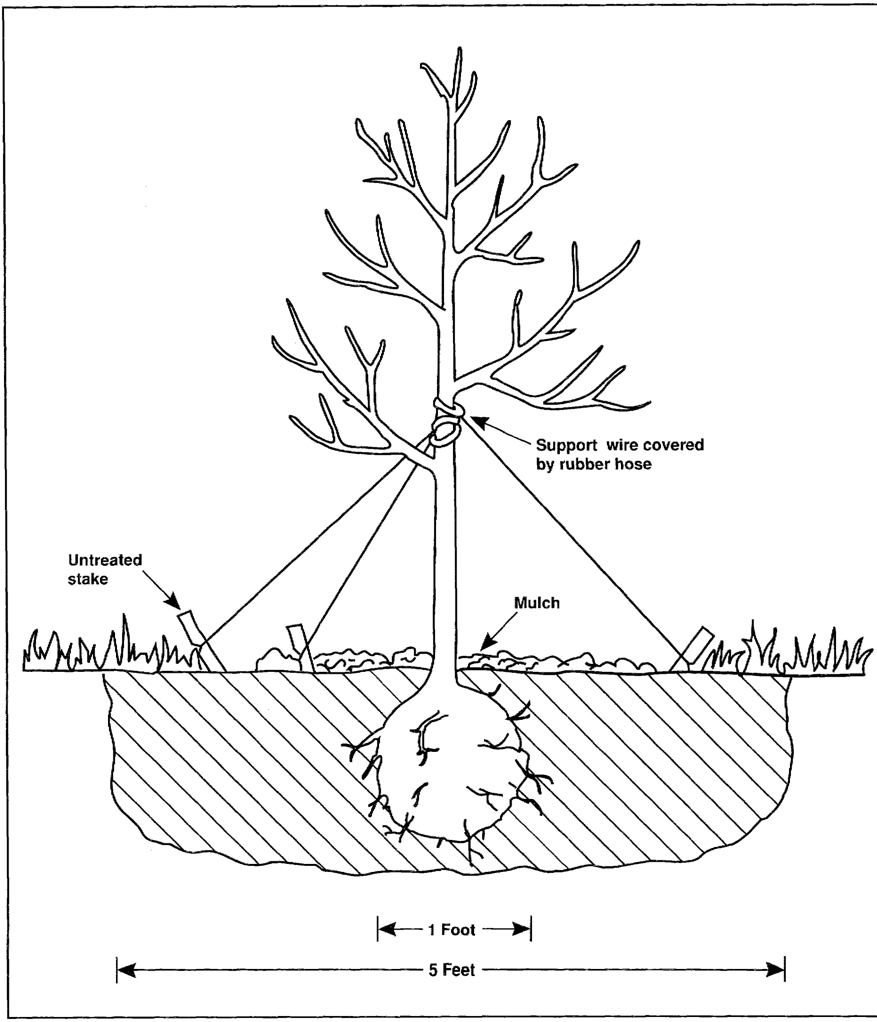
If the site you have selected is located in an area where the soil is heavily compacted, such as a planting site within a city sidewalk or where a lot of foot traffic occurs, consider using this relatively new technique, recom-

Figure 1. Technique for areas that have no soil compaction



mended by the American Forestry Association, for preparing the planting hole: Instead of digging the planting hole twice as wide as the root ball, dig up an area five times as wide as the root ball to a depth of about 12 inches (fig. 2). You may need to dig the hole a bit deeper in the center where the tree will be, if the root ball is greater than 12 inches in size, but not one and a half times as deep as for noncompacted soils.

Figure 2. Technique for areas with extensive soil compaction



This novel system of planting is based upon independent research and years of work with urban trees by the association. Roots penetrate through loose soil continually in search of new nutrients and water. Often, a tree planted in a tight pit (our first method) dug into heavily compacted soils cannot extend its roots beyond the root ball cavity. This new method is more time-consuming but the effort results in better survival and subsequent growth of planted trees.

After you have dug out the root ball cavity, follow these final steps for planting your tree:

- With a sharp knife, cut off any excessively long roots that extend beyond the main part of the root ball. Also trim off any excess branches that are diseased or damaged. Remove **all** burlap from the root ball and, if possible, gently loosen the root ball while leaving it intact.
- Break the dug-up soil into a fine loose planting medium and loosen up any large soil clods in the base of the hole.
- Plant the tree at the proper depth inside the center of the hole. When planted at the correct depth, the top of the soil should line up with a point on the stem of the tree where a color line is visible. This line is the "ground line" from the time spent in the nursery. If the tree is a bareroot tree (that is, its roots are fully or partially exposed to the air), drape the roots STRAIGHT down into the hole.
- Fill the soil back into the hole, while holding the tree upright and in place. Firmly pack the soil as you fill in the hole. Try to get all the air pockets removed when you do this, but don't compact the soil too much in the process.
- Stake the tree with guy lines if the tree is too tall to stand firmly on its own. This should be done using three supports, similar to the legs of a camera tripod.
- Give the tree ample water and cover the area with a water-saving mulch (such as bark or wood chips). The mulch will prevent excessive water evaporating from the soil.

Taking Care of Your Newly Planted Tree

Planting a tree is just the beginning. All too often people plant a tree and walk away from it. Depending on how harsh the environmental conditions are, trees will need a fair amount of care. Remember to remove support wires after the tree is well established and can stand on its own, usually about 2 years after planting. Guy lines left too long on a young tree can strangle it as it grows.

Be sure to follow up tree planting with these activities:

- Water amply on an as-needed

basis. Watch for drying out of the soil or wilting foliage, which will indicate that the tree needs water. To prevent the spread of water-borne diseases, it is best to water in the early morning or early evening. Watering at these times will give the water droplets ample time to dry on the leaf surface, which will impede the spread of any disease. Avoid watering in the heat of the day, especially if you are watering a short tree in which the foliage is receiving water. Sunlight can burn leaf surfaces because water droplets act as magnifying glasses on the leaf surfaces.

- Keep the ground area under the tree canopy (the "drip line") free of vegetation, especially if the tree is small. Grass and other plants can rob the tree of needed soil moisture.
- Fertilize if needed, but get some advice first. It's easy to harm a tree with an overdose of fertilizer, especially in the early years of a tree's life.
- Look the tree over carefully for diseases and insects. Get help from experts if you notice anything suspicious in terms of damaging agents on the tree.

Where To Get Help

Now that your tree is in the ground (green side up!), here are a few ideas on where to get help. There is usually an ample supply of experts in the field available for free or for hire to help you. You can call the following for advice:

- The State forester's office (every State has one)
- The county Extension Service
- The local USDA Soil Conservation Service, district conservationist's office
- Organizations such as American Forestry Association, American Forestry Council, and the National Arbor Day Foundation

Services for a fee are available from consulting foresters, arborists, and some landscape nurseries.

Trees Can Be Special

The planting of a tree can be used to commemorate many of the stages of our lives—birth, graduation, marriage, anniversary, and other important events—or to memorialize our loved ones who have died. Indeed, planting trees, for whatever reason, has much to offer modern society, and to share in the joy of planting and culturing of trees in one's own backyard or neighborhood is a special experience. Plant a tree—then sit back and watch it grow for a long, long time. ■

Wildlife: Entertainers and Pest-Controllers for Farm and Garden

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by Henry M. Cathey, Director, U.S. National Arboretum, Agricultural Research Service, USDA, Washington, DC

In the past, wildlife was thought of as the enemy of gardening and agriculture. Everyone has stories of destruction and ruin of valued plants and crops. These concerns no longer have to be reasons why wildlife cannot be welcomed back into our living space. A new garden style, first designed by Oehme and van Sweden, landscape architects of Washington, DC, was created on the grounds of the U.S. National Arboretum, Washington, DC, as the **New American Garden Style.** The design, the plants, the preparation of the site, the maintenance schedule, and the year-round display all work together to reclaim any disturbed site and restore it as a habitat where wildlife and humans can coexist.

Concept

Agricultural research made great strides in the 1970's and 1980's in reducing the uses of agricultural chemicals that often left residues in our water, soil, and air. Society has required in most urban areas that pets be leashed or contained in fenced areas. Federal and State agencies have protected more and more wet, marsh, forested, prairie, and mountain areas from development; even in areas selected to be developed, developers now must preserve undisturbed vegetation as a part of their site plan prior to receiving permission to begin construction. All of these actions, and others, have set the stage for the revival of wildlife in our living spaces.

Wildlife Habitat

Plants that provide food—seeds, fruits, nuts, and roots—are the most important elements in attracting wildlife to your garden. Assess your garden and surrounding areas to identify the habitat elements that exist to support wildlife. To improve habitats for wildlife, incorporate these ideas into your design:

Food. The ideal garden supplies to the wildlife as much food as possible from its own vegetation. Every species of wildlife has food preferences to meet its year-round needs. Trees, shrubs, perennials, annuals, grasses, and aquatics (which produce acorns, nuts, berries, buds, catkins, roots, bulbs, fruit, nectar, and seed) should be included. Favored plants include woody plants such as sweetgum, crabapples, blueberry, sumacs, bayberry, hollies, dogwoods, viburnums, and cotoneaster. Favored plants for butterflies and hummingbirds include butterfly weed, cardinal flower, zinnia, marigolds, purple coneflower, lantana, and garden phlox.

To maintain the presence of songbirds year round, it may be necessary to supplement the natural food sources in winter with sunflower seeds, niger seed, preso millet, cracked corn, suet, and raisins. In summer, a nectar solution should be available for hummingbirds.

Water. Wildlife requires water for drinking and bathing. Since wildlife comes in all different sizes and behavioral patterns, water should be supplied in birdbaths, small pools, recirculating waterfalls, shallow dishes, or from a dripping hose. The birdbath should be elevated to protect the birds from cats and other predators. A small pool also provides cover and a reproductive area for fish, frogs, insects, and reptiles. Be sure to replace the water frequently on hot summer days and to remove ice and refill the basin with water daily during the winter.

Cover. Masses of trees, shrubs, and ground covers of different sizes offer effective protection year round. Songbirds and other animals thus can choose the appropriate cover that they need for feeding, hiding, courting, and nesting activities. Dense shrubs, hollow logs, rock piles, brush piles, stone walls, evergreens, tall grasses, and water provide cover for the wildlife. Mammals, amphibians, reptiles, and a great variety of other animals find homes in the structures.

Raising Young. Wildlife will not persist in your garden unless young can be raised safely. Evergreens and deciduous trees and shrubs provide birdnesting areas. Nest boxes of special design (special books are available) attract bluebirds, chickadees, wrens, and purple martins. Rabbits, mice, shrews, snakes, and salamanders lay their eggs or raise their young under plants or in the rock, log, or mulch piles. Aquatic animals use the ponds for depositing their eggs. Butterflies deposit their eggs within the vegetation. The life cycle depends on the kinds of plants available. The vegetation should be allowed to remain year round to carry the eggs over into the next year.

Garden Design and Installation

Regardless of the size of garden that you plan to create, use these basic principles in the design and installation to attract wildlife within your living area:

Site. Drainage and amount of shade will determine what you can create. It is imperative that you provide a drainage field to prevent uncontrolled drainage water from spilling over into the surrounding areas. At the U.S. National Arboretum, we install catch basins, various kinds of drains, and berms to manage the water. Our aim is to contain and conserve all water in the ground to sustain growth.

Movement. All-weather walks, ramps, and patios that are accessible to handicapped people should be installed throughout the natural garden. A thin layer of mulch is never the answer. It moves, floats, and decomposes too rapidly to make the area a pleasing and safe site for movement. Plastic or metal edging strips (bottomed with packed gravel and fine dust and covered with paving stones or bricks) are easy to install. They do settle, change, and move out of position as the garden matures. They can, however, be removed and replaced to the desired settings. It is strongly recommended that you install a few broad walks and plant the entire area. Plan for an area of lawn only where you need room for play.

Media. You will need to build up a mantle of organic matter over the entire surface of your designed area. Remove unsightly native trees and shrubs to increase the light available in your garden and to reduce water-guzzling roots. Dig down to 16 inches to open up the soil. Test your native soil at your State agricultural experiment station (SAES) for its acid level and nutrient potential. Based on SAES recommendations, add at least 4 inches of composted sewage sludge or well-decomposed leaves on top of the ground.

At the Arboretum, for every 1,000 square feet of space, we use 80 pounds each of agricultural limestone-dolomite (calcium/magnesium carbonate) and land plaster (calcium sulfate). Reduce the lime to 10 pounds per 1,000 square feet of space but use the full amount of calcium sulfate if you plan to grow acid-requiring plants.

Incorporate the organic matter and calcium compounds into the entire dug area. Keep the area moist, but not wet, as you are preparing the site. Never walk on the area once the soil is prepared. These techniques will ensure maximum uptake of water from rain, drip, or sprinklers.

Planting. A slow-decomposing mulch of 3 inches is applied to the entire area to discourage weeds from emerging, to conserve moisture, and to insulate the roots from rapid moisture and temperature changes. All plants are placed on the prepared ground and are planted directly into the soil/calcium/organic matter mixture. Use several plants in natural groupings, mixing height, bark, leaves (color, size, form, and seasonal change), flowers, and fruit for all-season displays. Do not plant any types of plants that require frequent pruning, applications of pesticides, staking, or removing of dying flowers. Select types that can grow for many years with an attractive natural form.

Maintenance. When all of the previous steps have been performed properly, and your natural garden becomes established, little weekly care will be required. You should plan to sweep the walks, remove debris and limbs, add food to the feeders, and replace water.

As growth starts each spring, selectively cut back most perennials and grasses to the ground. You should leave those stalks bearing egg masses alone to ensure another generation. Trees and shrubs should be left as natural as possible to provide the dense cover that most songbirds require.

All debris and clippings should be chipped and composted to return the nutrients and organic matter to the soil. A compost pile

The Friendship Garden at the U.S. National Arboretum, Washington, D.C. The garden is designed to illustrate the new American garden ethic—gardens and landscapes planned to thrive with minimal maintenance. H. Mark Cathey, director of the National Arboretum, says, "emphasis in the garden is on perennials, grasses, evergreen ground covers, and small shrubs and trees." This new garden shows how a beautiful landscape can be created that has interest and color all year round without the need for continual maintenance. The concept calls for gardens filled with plants that do not need watering, fertilizing, pruning, or spraying for insects.
John Kucharski/USDA 91BW0687-9

can be easily hidden in your garden. Add the wet garbage from your kitchen to the clippings from the garden in your compost pile. Add any type of manures and fertilizers to the compost pile to accelerate breakdown. Apply this element-rich compost to your garden on a semi-annual cycle of March and November. Try to maintain the garden with a low but adequate nutrition level.

Protection. Some fruiting plants such as strawberries, peaches, and apples must be given physical protection when their fruit ripens. The only sure protection of valued plants is to use nonbiodegradable netting to cover the entire plant. It is applied as the fruit forms and removed immediately after harvest. The growth of the covered plants is not affected. Repellants for all sorts of pests are also available, but as most persist only for a limited time, new plant growth is not protected, and rains may wash the active ingredients away. Read the label for best use. Fencing with electrified lines is the only effective control system for deer.

Bonuses. Your natural garden is still not complete. You need to plant spring-flowering bulbs to brighten your garden before the perennials and grasses begin to grow. Narcissus, tulips, muscari, crocus, iris, and many other small bulbs will thrive for years with little care. Also, add color spots of annuals in large containers for seasonal changes. Select red tubular flowers such as cardinal-flower, scarlet penstemon, scarlet salvia, bee balm, scarlet petunia, and coral bells to attract the ruby-throated hummingbird.

Wildflowers. The final touch to your natural garden is to overseed the entire area with native wildflowers. The seed packet will suggest which species will be most successful in your site. Plant and enjoy the abundance of wildlife, the diversity of species, the year-round entertainment and display, and a garden that will help sustain and stabilize our environment. ■

The Earth Needs You—Join Our Team

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by Carolyn A. Miller, State Volunteer Coordinator; Jeffrey G. Anliker, Deputy State Conservationist; and Judith K. Johnson, State Conservationist, Soil Conservation Service, USDA, Storrs, CT

Imagine how you would feel if you knew you were doing your part to help take care of the Earth. Now, imagine how you would feel if you could do something to create a healthier environment for you and for future generations.

These emotions are not just dreams—they are a reality for more than 12,000 people nationwide. They are the people who, when combined together, form the USDA Soil Conservation Service (SCS) Earth Team. They are a group of concerned men and women who volunteer to help SCS provide leadership in the wise use of our Nation's soil, water, and related resources.

The Earth Team Program began in 1982 as a provision of the 1981 Farm Bill. The program serves two purposes: It helps both SCS and the local soil and water con-

SCS Earth Team volunteer George E. Lechlider (right) explains the stages of corn growth to Melissa Howell (center) and Jeffery Brown (left) during a recent farm trip in rural Maryland.
Tim McCabe/USDA 90BW1619-36

servation districts practice more conservation on the land, and it helps keep down Federal costs.

What Can Earth Team Volunteers Do?

Earth Team volunteers help SCS employees with conservation work—such as helping farmers, ranchers, and other landowners reduce wind and water erosion, conserve water, enhance wildlife habitat, reduce upstream flooding, and keep streams clear. They achieve this by doing everything from surveying and planting to typing and filing.

An Earth Team volunteer can assist SCS personnel with information and education programs by going to schools and explaining the importance of conservation. The volunteers may help teachers plan outdoor classrooms where students can learn about natural resources. This is especially helpful to inner-city schools where children might not otherwise have the opportunity to learn firsthand about the environment (see Chapter 38).

Essentially, Earth Team volunteers can do any job that paid employees do—the only requirement is that they be at least 16 years old. Here are some of the jobs volunteers do:

- Assist with a wetland inventory
- Prepare displays and exhibits
- Write press releases, newsletters, and publications
- Teach environmental education
- Enter computer data
- Manage audiovisual productions
- Assist with computer programming
- Maintain files
- Provide clerical assistance
- Assist with volunteer coordination
- Assist with information and education programs
- Conduct surveys

What Are the Benefits for Earth Team Volunteers?

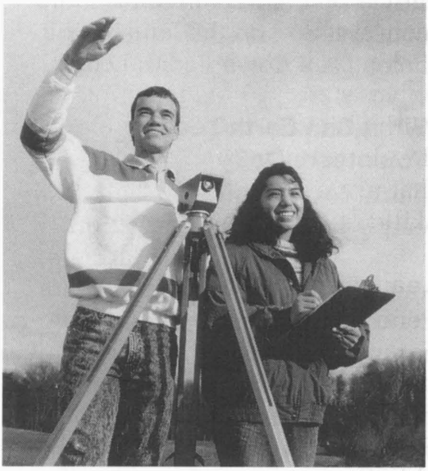
By becoming an Earth Team volunteer, you not only get the satisfaction of doing some of the most important work in the country, you may also:

- Gain professional work experience
- Discover a lifetime career
- Earn academic credit
- Meet new people
- Receive recognition
- Have a chance for personal growth
- See firsthand the problems caused by the careless use of our natural resources
- Gain the satisfaction of knowing you have had a part in preserving the environment.

You will also be protected under the Worker's Compensation Program.

Earth Team volunteers come from many different backgrounds with varying degrees of education, but they share one important trait: They all care about what happens to our natural resources—our soil and water—now and for the future.

If you would like to do your part and make a difference, call 1-800-THE-SOIL. The Earth Needs You—Join Our Team! ■



Volunteers Steve Hoffman (left) and Helena Cuellar (right) help the USDA Soil Conservation Service district office in applying conservation practices on a Virginia farm.
Tim McCabe/USDA 91BW0706

Extension Volunteers Can Help

45

by Rita Rogers, Public Affairs Specialist, Extension Service, USDA, Washington, DC

You'll find them in nearly every county and State—men and women, youth, seniors, and those in between—giving freely of their time, energy, and talents, devoting countless hours to helping others in their communities. They are Extension volunteers—people motivated not by money, but by true care and concern for their fellow neighbors.

Volunteers have aided the Cooperative Extension System (CES) since its inception. Volunteers helped establish many local CES offices, and they continue to serve on advisory groups and planning committees. Currently, Extension has more than 3 million volunteers working across all program areas and contributing significantly to community leadership, Earth Team volunteers come from many different backgrounds with varying degrees of education, but they share one important trait: They all care about what happens to our natural resources—our soil and water—now and for the future.

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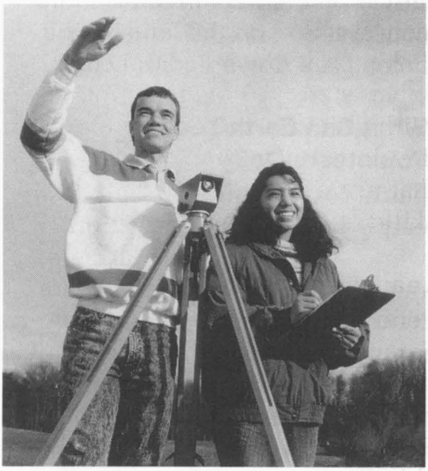

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Almost every volunteer role involves some form of teaching. With this in mind, Extension has developed programs to ensure that its volunteers are properly skilled to assist others.

Leadership Education

Penn State University Cooperative Extension offers a variety of training programs in leadership development. "Developing Your Personal and Community Leadership Potential," a five-part, 13-hour program presented by Clearfield County Cooperative Extension, helps rural residents improve their leadership skills so they can better address issues in their communities. The program focuses on teamwork, motivation, goal setting, and agenda building. "Rural Leadership, Incorporated" (RULE), a 2-year course offered by Penn State at the undergraduate or graduate level, emphasizes communication, public speaking, and group interaction skills. The program also addresses the function of government and how to become more active in it.

RULE's goal is to help mold the leaders needed in rural Pennsylvania. "Family Community Leadership" (FCL), the college's newest leadership development program, encourages people to become active in community issues. FCL instructs groups consisting of a county Extension agent and as many as three volunteers, who in turn instruct other community members to become active in community affairs. FCL groups undergo 30 hours of training in leadership and communication, group processes, issue analysis, teaching methods, volunteerism, and public policy. Each group is obligated to conduct 96 hours of leadership education in their community during the next year.

Master Volunteer Program

Extension's Master Volunteer Program is another method of providing indepth training and assignments centered around the volunteers' interests and skills. After receiving this training, volunteers are asked to share their expertise with others. In this way, Extension cultivates a group of expertly trained volunteers, instead of training all who are interested. The program's success can be attributed to its sound structure, clear definition of subject areas, and precise boundaries within which volunteers should operate.

The concept of Master Volunteers began in the early 1970's in Washington State, when Extension horticultural staff in the counties and at Washington State University-Pullman needed help—during gardening season consumers were bombarding them with questions and requests for information.

Washington State Extension's Master Gardener program became the model for other Master Volunteer programs, including ones related to the environment. The number of training hours and sharing vary by State and type of Master Volunteer.

Palmetto Leadership

Palmetto Leadership is a new training program offered by the Clemson University Cooperative Extension Service. It aims to revitalize rural South Carolina communities by developing leaders from all private and public sectors of a county into a cohesive group, which will help the county solve problems.

Palmetto Leadership focuses on constructive consensus building countywide, encourages facilitation and education among key community leaders, promotes strategic planning by task forces regarding community and county concerns, and enhances community and leadership development through a social action process. Participants engage in a three-phase seminar series: Phase I, Leadership and Community Development; Phase II, Implementation and Strategic Planning; and Phase III, Emerging Leadership and Development.

Palmetto Leadership has helped government leaders, industries, and residents in these counties achieve great successes:

- Abbeville County is consolidating all school districts, and it has established an Adopt-A-Highway program that has cleared over 46,000 pounds of litter from more than 60 miles of roadway.
- Saluda County leaders are establishing a countywide Chamber of Commerce.
- Dillon County initiated a major strategic planning effort for economic development.
- Kershaw County has made great strides in providing affordable housing for its citizens.

Targeting Minority Elderly

The Texas Agricultural Extension Service, in collaboration with the Texas Department on Aging and the National Center for Rural Elderly at the University of Missouri, has developed a peer educator program to train older minorities to teach their peers at centralized nutrition sites. The goal is to enhance the delivery of physical health, nutrition, and mental health education to the older minority participants.

The peer educator strategy involves older nutrition site participants in seeking solutions to problems encountered in later life. Peer educators use four programs consisting of six true-to-life video scenarios to focus on significant problems identified by older minorities. Research-based information is incorporated into the scenarios. The peer educators are trained to lead discussions and reinforce key points from the video programs.

Program objectives include helping peer educators increase their knowledge in content areas taught, value their roles as peer educators, and teach six or more lessons to minorities. The project was piloted in 16 counties. Eventually, Texas Extension plans to make the programs available statewide and nationally throughout the Cooperative Extension System.

Extension Needs You

In the 1990's, the call for Extension volunteers will continue to escalate. Volunteers will be a key to maintaining organizational structure and expanding Extension and USDA programs to greater audiences.

To become part of the winning team of Extension volunteers, contact your local county Extension office. Your support is needed! ■

Dear Smokey, How Can We Help Manage Our National Forests?

46

Everywhere, USA

Smokey Bear
USDA Forest Service
PO Box 96090
Washington, DC 20090-6090

Dear Smokey,

We are a typical American family. We eat at the local "burger palace"—now that it doesn't use Styrofoam anymore! We have a 17-year-old athletic daughter, a 14-year-old computer whiz Girl Scout, and a 10-year-old soccer-playing Boy Scout. My husbands's mother lives at home with us.

We live in the suburbs of a large city. Once a year, we escape the noise, rules, and crowds of urban life by going on a week-long camping trip on a national forest. Our family loves to drive through forests on weekends to enjoy the scenery. I like to watch birds on our family outings.

But we don't want to just camp or drive around on our forests any more—we want to do something for our national forests. We want to give something back for all that we have received from our forests. We care about our future.

How can we be involved in helping to manage our national forests?

Sincerely yours,

Sylvia Forrest

Sylvia Forrest

Public Affairs Office
USDA Forest Service
PO Box 96090
Washington, DC 20090-6090

Sylvia Forrest
Everywhere, USA

Dear Sylvia,

Thank you for writing. The Forest Service needs people like you! Did you know there are 175 national forests and grasslands, covering 191 million acres, in 44 States, plus Puerto Rico? All these lands belong to all of us, but the Forest Service is the steward. Here are some ways to get involved in managing your national forests. We are glad to have your help!

- **Adopt a forest.** Choose a national forest that you enjoy visiting and adopt it as your own. Call the Forest Service and talk with us about what you want to do. Check your local telephone book under "Government Agencies." You will find us listed under United States Government, Department of Agriculture, Forest Service; there you should find the name of your adopted national forest and its ranger districts. If you can't, then just call the nearest Forest Service office.

  When you call us, ask to have your name put on the mailing list. Every national forest has a newsletter or occasional mailing to let the public know when there are meetings, field trips, volunteer projects, or environmental speakers. They send out information about what's going on now and what is planned for the future.

- **Volunteer.** Volunteers are the heartbeat of the Forest Service. Although there are 36,000 employees in the Forest Service, over 97,000 volunteers gave something back to their national forests in 1990. Without volunteers, the Forest Service could not do its work. Over 70 percent of volunteers like to work on recreation projects. Some of the most popular projects are building trails, conducting tours, caring for campgrounds, greeting visitors, and planting trees. The Touch America project is a special, national volunteer program for young people. Scout troops are major participants.

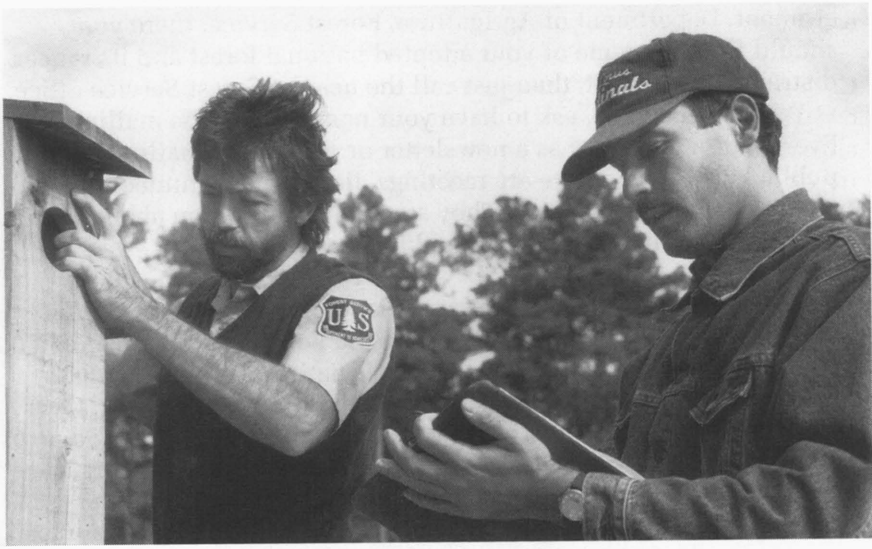
  Did you know that the Forest Service supplies more outdoor recreation than any other Federal agency? There are 100,000 miles of trails, 6,000 picnic areas and campgrounds, 320 swimming sites, 1,100 boat sites, and 300 winter sports sites. So many people use their forests for recreation that it averages out to 12 hours a year for every person in America.

Why do people volunteer on their national forests? There are many reasons people give us: the opportunities for fun, learning, physical activity, meeting people, and sharing knowledge; love of the outdoors; the beautiful scenery; adding variety to life; and the challenge of it!

One of the most popular volunteer activities is that of campground host. In exchange for doing minor campground cleanup and providing information to campers, for an entire summer, the campground host is given a camping site, free of charge.

- **Learn and tell others.** Learn more about the outdoors. How can you use and enjoy your national forest wisely? As you learn, share your knowledge with others.

  Attend an environmental camp for adults. The Forest Service sponsors several camps. There are also environmental camps for children. Invite Forest Service employees to speak with students. Sign up for Forest Service field trips. Experience learning first-hand.



This Cardinals fan is helping another kind of bird by volunteering in a USDA Forest Service program to install nesting boxes for wood ducks on the Long Cane Ranger District of the Francis Marion National Forest in South Carolina.
Mary Lynn Cagle/USDA 90BW2047-26

Almost every national forest has a nonprofit group or interpretive association of citizens like yourselves that works closely with the national forest. Often this group designs and sells books, maps, and other educational materials about the national forest. Contact one of these groups for information, and consider joining yourselves! The Forest Service itself also publishes maps and other information.

Becoming informed is probably one of the most challenging, fun, and rewarding things you can do for yourself and your national forest.

Join or start a club. What about your interests and hobbies? You said you care about camping and bird watching. You can investigate hundreds of national organizations for people who enjoy nature and the out-of-doors in general or share your particular interests of camping and bird watching. Your library or your adopted national forest will usually have a list of local organizations. These groups are involved in a variety of ways in the management of the local national forests and you can choose the one that is right for you.

Girl and Boy Scouts, as well as 4-H Clubs, are the leading organizations outside the schools that teach young people how to use and enjoy their environment wisely. You are helping your national forests when you help organizations such as these.

Call, write, or visit. Call, write, or visit Forest Service people, especially managers who work with planning. Talking to campground attendants may not solve your concern and sometimes that person may not know the answers to your questions. Although any Forest Service employee is glad to share information, when you have project or planning questions, the District Ranger and his or her immediate staff are the key people to contact. They usually manage the field projects, conduct meetings, and work with volunteers. The Forest Service is a decentralized agency, meaning that many important decisions are made at the local district level, not at the national level.

Opportunities exist for being involved in forest, regional, and national planning efforts as well. Your adopted national forest and environmental organizations can put you in contact with the people who handle those programs. Two important documents that will most affect your adopted forest are the forest plan and the Resource Planning Act. Ask for copies, read them, and let us know what you think.

By the way, when you call, write, or visit, we'd like to hear about what you like that we are doing as well as what you don't like. The things that we are doing well need support, so that we can continue to provide those services.

- **Come to meetings.** When Forest Service personnel host public meetings, they want to hear what you have to say, as well as inform you about what they are doing.

  Meetings often deal with planning: How much timber and firewood should be removed? What trails need fixing? Where should a parking lot be built? Should cattle be allowed to graze in an area where recreation use has increased? How can the national forest convince people to stop throwing trash out their windows while the agency's dollars are decreasing for trash pickup?

Scout troops are major participants in USDA Forest Service volunteer programs. These Boys Scouts are learning about plant life in the George Washington National Forest in Virginia.
USDA 88BW0262-20A

You mention that you care about the future. Going to a meeting and telling us your ideas will help us determine the future of the environment together.

- **Do a wildlife project.** Give something back to wildlife. Seeding, fencing, or protecting the bank of a stream from erosion are important wildlife and fisheries projects that can help restore habitat after we have used the land.

  With your interest in birding, you could help the district biologist compile a bird list for the national forest or help with a study of nesting habitats of a particular species. Just ask, and the opportunity will be there.

- **Get a part-time job with us.** Your eldest daughter, your mother-in-law, even you yourself may qualify for part-time work with the Forest Service. Although we have 36,000 permanent employees, many additional jobs are seasonal. The Forest Service hires adults for fire fighting, tree nursery work, tree planting, marking timber for cutting, campground maintenance, and other outdoor jobs.

  Don't forget that your children can also consider careers with the Forest Service. We need research scientists, such as entomologists, biologists, botanists, and archeologists, as well as technical experts in such disciplines as computer science, management, accounting, recreation planning, economics, forestry, and range conservation, to name just a few. If you want your family to have a big say in the future, encourage your children to major in one of the natural resource sciences!

  You may know members of your family or people in your community who would benefit from several worthwhile Forest Service programs for youths and older Americans that provide job training and actual jobs. These include the Youth Conservation Corps (YCC), which provides summer employment as well as training and environmental education for 15- to 18-year-olds; the Job Corps, which provides a full program of training, housing, and wages for 17- to 22-year-olds; and the Senior Community Service Employment Program, which provides part-time employment and training for senior citizens with low incomes.

  Who knows, you or members of your family or community may qualify for a program such as college work-study, vocational work study, vocational rehabilitation, community work experience, and student conservation association programs—all of which provide training and jobs for conservation work.

- **Become a partner.** The Forest Service is glad to establish partnerships, cooperative grants, and agreements with individuals, community organizations, and other agencies that have similar objectives for the environment. The Forest Service often matches or partially matches funds from private organizations.

  Partnerships are a good way for you and your club or organization to stretch funding and tight human resources budgets! The Forest Service has entered into many new partnership programs in the last decade. They include partnerships with volunteer environmental organizations, private corporations, prisons, chambers of commerce, and other organizations. Hundreds of partnerships are established at State, national forest, and ranger district levels; they don't have to be nationwide. Interested? Just ask!

  In addition to all the things you can do to help your adopted national forest and the Forest Service, there are many things you can do that help promote a healthy environment. The first two suggestions involve two of the Forest Service's friends—me and Woodsy Owl.

- **Prevent forest fires.** Your letter was addressed to Smokey Bear. In the United States, I (Smokey) am the second most widely recognized symbol after Santa Claus, and I represent the caring spirit of the Forest Service. However, I am a fire prevention bear. Though I care about the environment, I focus on stopping unplanned, unwanted fires. I realize that some fires benefit the environment because certain trees, shrubs, flowers, and grasses require fire cycles to help them grow. But I also realize that more fires occur than nature intended, and that we must avoid undesirable fires started by humans.

  You can help us by knowing how, where, and when to build a fire properly—and how to put out a fire properly.

- **Give a hoot, don't pollute.** Any help you can give to Woodsy Owl is gratefully appreciated. If you will pick up someone else's trash, Woodsy thanks you. If you can organize others to help pick up trash, Woodsy is exceptionally grateful. Your national forest usually has beautification days for scenic roadsides and campgrounds, when everyone pitches in to pick up litter. Sometimes the national forest can provide volunteer groups with plastic bags, gloves, and/or transportation. The biggest trash problem today on the forests is the nonbiodegradable materials, especially disposable diapers.

- **Recycle.** The more we recycle, the fewer products we need to remove from our forests today and the more products and options we will have for tomorrow. Recycling 1 ton of paper can save as many as 17 trees. Recycling 115 pounds of paper can save one very large, mature tree. Forty percent of what is in the average person's trash can is recyclable paper.

- **Celebrate Earth Day.** Show you care for the environment by setting aside Earth Day, the third Sunday of every April, to do something special for your adopted national forest.

- **Plant a tree.** President George Bush recently instituted a massive national tree planting initiative called "America the Beautiful." His goal is for Americans to plant 1 billion trees every year. By planting a tree, whether in your own backyard or in a forest, you will be giving a lot back to the environment.

Have I overwhelmed you in responding to your simple question? I hope not. Just start, and the rest of the steps will fall into place!

I was very glad to receive your letter. You can see from my letter that yes, the Forest Service needs you. You will make a difference. Let me know how it all works out.

Sincerely,

Smokey Bear
USDA Forest Service
Washington, DC

P.S.: Ann Matejko, Public Affairs Specialist in the Forest Service, USDA, Washington, DC, helped me write this letter.

S.B.

How To Find Environmental Information You Can Use

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As this Yearbook suggests, USDA has a tremendous number of action and research programs that aim to protect our natural environment in numerous ways. If you wish to participate or to learn more, contact the following agencies for information and assistance:

Soil Conservation Service

The Soil Conservation Service (SCS) provides national leadership in the conservation and wise use of soil, water, and related resources through a balanced cooperative program that protects, restores, and improves those resources. SCS carries out this leadership with cooperation of landowners and operators in local soil and water conservation districts and with other government agencies.

It administers USDA's Great Plains Conservation Program and watershed protection and flood prevention program; leads the national cooperative soil survey on which land treatments are based; and exercises departmental leadership in assisting landowners and local groups in resource conservation and development projects. The SCS also sponsors a national volunteer program called "Earth Team" in cooperation with local soil conservation districts, State and Federal agencies, and private groups. This program welcomes participation from anyone interested in natural resource conservation.

For assistance and more detailed information, contact your local conservation district or your local SCS office, which is listed in the telephone directory under United States Government, Department of Agriculture.

Extension Service

The State Cooperative Extension Service at land-grant universities has a local office in each county to provide objective, university-based research information on agriculture, home economics, 4-H and youth, and rural development. Extension agents provide answers to specific questions about production and marketing, farm and home management, nutrition, consumer concerns, and related topics. The Extension Service is the primary educational arm of the U.S. Department of Agriculture, linking research, science, and technology to the needs of people, where they live and work. Federal, State, and local governments share in financing and conducting cooperative extension education programs.

These programs target farmers and ranchers, consumers, communities, public officials, and youth. Volunteers work with Extension staff in delivering these programs.

For assistance and more detailed information, contact your local Extension Service office listed in the telephone directory under county government. Extension is listed under various headings such as "Extension Service," "Cooperative Extension Service," or "State University Extension Service."

Agricultural Stabilization and Conservation Service

The Agricultural Stabilization and Conservation Service (ASCS) administers various conservation and environmental programs to protect soil against erosion and water from pollution, encourage development of private forests, and enhance wildlife habitat.

ASCS's various commodity and land-use programs support farm prices, adjust farm production, and protect natural resources. In addition, ASCS manages the Agricultural Conservation Program and through it provides cost-sharing with farmers and ranchers to prevent soil loss from wind and water erosion, solve water conservation and water quality problems, and preserve forest resources.

ASCS offices are listed under the U.S. Department of Agriculture in the telephone book and are located in about 2,800 counties nationwide.

Forest Service

The Forest Service manages 156 national forests and 19 national grasslands in 42 States, Puerto Rico, and the Virgin Islands. Every forest has a public affairs specialist with information about environmental resources and uses. These specialists provide information about recreation, wildlife, timber, range, minerals, watersheds, Smokey Bear, and Woodsy Owl. They also offer forest maps for sale.

In addition, each forest has from three to six ranger districts with even more detailed information about what to see and do in those districts.

If you wish to become more involved, most forests have newsletters, sponsor public resource work projects, and hold periodic public meetings related to forest issues.

To obtain general information, telephone numbers, and addresses of all national forests and grasslands, write USDA Forest Service, Public Affairs Office, P.O. Box 96090, Washington, DC 20090-6090. To locate your local national forest or ranger district, check the telephone book under U.S. Government, Department of Agriculture, Forest Service.

Food Safety and Inspection Service

Experts agree that food handling education is an important element in preventing foodborne illness. Although some people believe that the importance of education is overrated—and that the "real" answer is reducing microbial contamination during slaughtering, processing, and marketing—in reality both are important.

The problem of microbial contamination depends on actions at many points in the food chain—including food handling—that affect the incidence of preventable foodborne illness.

FSIS staff have developed several innovative educational projects and campaigns that will have a positive influence on the food handling behavior of the general public and institutional food handlers. Examples include a comic strip in English and Spanish on preventing foodborne illness, a video teaching kit directed at junior high students, and a campaign directed at reaching—through the health professional who treat them—those most "at risk" of complications.

A new consumer brochure, "Consumer Guide to Safe Food Handling," describes a few sensible food handling practices that are most effective in protecting consumers from foodborne illness. Single free copies are available from the Consumer Information Center, 574-X Pueblo, CO 81009 (ask for Home and Garden Bulletin No. 248).

For a list of FSIS publications, or for more information about FSIS or its food handling education campaigns, write Information and Legislative Affairs, FSIS, U.S. Department of Agriculture, Washington, DC 20250.

Questions about safe food handling? Call the Tollfree Meat and Poultry Hotline, 1-800-535-4555, 10 a.m. to 4 p.m. Eastern Time, Monday through Friday. Washington, DC, area callers should call 202-447-3333. Both numbers are accessible by Telecommunications Devices for the Deaf (TDD). ■

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Mention of commercial products and organizations in this publication is solely to provide specific information. It does not constitute endorsement by the U.S. Department of Agriculture over other products and organizations not mentioned.

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