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Soil and water are inextricably bound together in most landscapes: thus soil quality is one of the factors that impacts water quality.

Despite many changes in this country's environment and agricultural sector over the years, the United States retains a rich heritage of natural resources and environmental attributes. This section of the report surveys a number of those resources and attributes and discusses issues and concerns related to their conservation and use. The current most comprehensive review of status, condition and trends can be found in Agricultural Resources and Environmental Indicators (Economic Research Service 1997 and 2000).

The soil resource

The United States is blessed with an abundance of productive land, having more than twice the world average of arable land per person. The basis for this productive land is the soil resource. Prime farmland refers to land that has soils with optimal characteristics for crop and forage production. More than 50 percent of U.S. cropland, or about 212 million acres, is considered prime (NRCS 2000a).

The traditional measure of the state of the soil resource has been the potential for and the extent and severity of soil erosion by wind and water. For example, 104 million acres of U.S. cropland, or about 27 percent of the total, is considered "highly erodible," meaning it is subject to potentially damaging soil erosion if not managed properly.

Many traditional conservation programs have been oriented toward preventing soil erosion or mitigating its past impacts. However, research and practical experience in responding to societal demands for commodities such as clean and abundant water, clean air, open space and recreation opportunities demonstrate that more than erosion control is required to maintain a healthy, productive soil resource.

Soils vary in their ability to support crop, forage and timber production; store floodwaters; purify and renew water supplies; and absorb, buffer and transform chemicals and waste. The term "soil quality" is used as a measure of how well a soil performs the above functions.

High-quality soils contribute to myriad benefits from the land — from healthy forestlands, grasslands, wetlands and backyard gardens to a rich heritage of scenic landscapes and wildlife habitats in addition to productive agricultural land.

For agricultural land users, high-quality soil may mean soils that have maximum ability to absorb rainfall and store water needed for crop growth, thus reducing the risk of flooding during storms and ensuring greater resilience to the effects of drought. When used for disposal of agricultural, municipal or industrial waste, healthily functioning soils may mean a greater capacity to purify

Benefits of healthy soil

- improved water quality
- improved air quality
- improved land productivity
- greater resistance to effects of drought and floods
- greater energy efficiency
- enhanced ability to mitigate climate change

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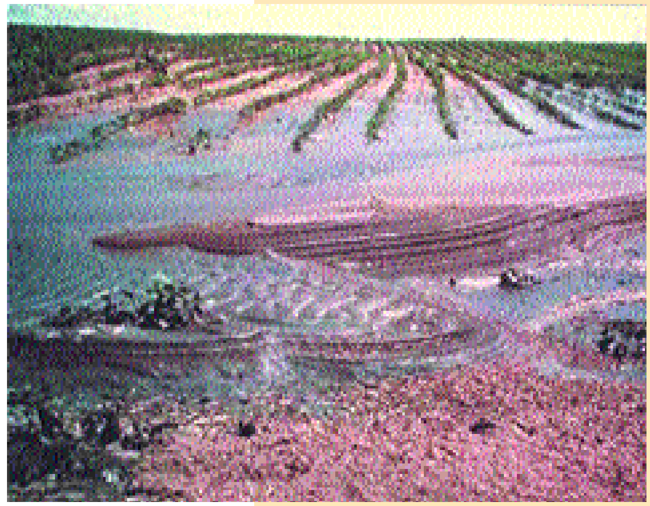
those wastes, resulting in better protection of ground and surface water. High-quality soils resistant to degradation have a greater potential to store carbon as soil organic matter (Lal et al. 1998).

Sound stewardship of the soil resource offers opportunities to maintain the functional capacity of soil — its "quality." Poor land-use practices, on the other hand, can initiate a cycle of soil quality degradation through erosion, compaction, acidification, salinization and other forms of soil deterioration.

Conditions and trends

Soil erosion. One of the major processes that can lead to a decline in soil quality is soil erosion by water and wind. Soil erosion and accelerated sedimentation — often brought about by bringing marginal soils under cultivation or by unwise management of land already under cultivation — are degrading landscapes around the world. These debilitating processes alter natural hydrologic and sedimentation regimes that developed over thousands of years. History has shown that these alterations can be so severe that the entire human population of a region may have to abandon the land and migrate elsewhere.

Soil erosion has been a traditional concern in the United States. Some



Eroded soil material deposited in fields can have adverse impacts on crop production.

Types of soil erosion

Sheet and rill erosion occurs when rainfall and water runoff initially remove a fairly uniform layer or sheet of soil from the surface of the land. Eventually, small channels (rills) form as rainwater collects and flows over an unprotected soil surface.

Concentrated-flow erosion can follow on the heels of sheet and rill erosion. Left unchecked, rills may enlarge and deepen into small channels that, when filled with sediment from adjacent land, are called ephemeral gullies. If the channels continue to enlarge and cannot be filled in with material from adjacent land or obliterated through tillage, a condition known as classic gully erosion develops. It can permanently damage the land. Another form of concentrated-flow erosion is streambank erosion, which often stems from unchecked sheet and rill or gully erosion in uplands and the absence of streamside vegetation.

Irrigation-induced erosion refers to water erosion that results from sprinkler or surface irrigation for agricultural production. It can take the form of sheet and rill or concentrated-flow erosion.

Wind erosion also removes soil. It can, in extreme cases, create huge dust clouds that suspend unacceptable levels of particulates in the air, in addition to damaging the soil.

Soil from corn-soybean rotation in Alabama.Non-tilled soil (left) normally has a darker color and more uniform granular structure than tilled soil (right), primarily because of the greater soil organic matter content in non-tilled soil.

erosion caused by water and wind will always occur as part of the natural cycle. But the natural process of soil development can renew and sustain the soil if society does not place demands on the soil resource that are beyond its capabilities. For most deep soils, an erosion rate less than four to five tons per acre per year is considered a sustainable level of soil erosion. This acceptable or sustainable level is termed the soil loss tolerance, or "T," value. Even at such sustainable rates, however, sediment from eroding lands may lead to decreased water quality in some areas.

Over the past several decades, U.S. agriculture has made significant strides in reducing erosion on cropland through management practices such as conservation tillage, crop rotations, contour strip cropping and use of grassed waterways. Landowners also participate in USDA easement and reserve programs that target lands most susceptible to erosion, provide incentives for conservation and help offset costs associated with such measures.

Several USDA programs make land resource inventory information available to landowners and managers for their use in making soil conservation decisions. The National Resources Inventory (NRCS 2000a) provides information on the extent of land degradation from processes such as erosion and salinization. This enables assessment of the status and condition of the U.S. land resource base, including soils, at any given point in time.

The National Cooperative Soil Survey, a partnership of state, local and federal agencies, provides information about basic soil characteristics in the landscape and their long-term behavior under particular types of use and management, including food, forage and timber production; waste management; and residential and commercial development.

These tools can be used to develop a picture of the health of the land. The information is useful in deciding what must be done to prevent or reduce land degradation, maintain productivity and restore degraded lands to full productivity.

Approximately 170 million acres — 40 percent of all cropland — were eroding at greater than acceptable ("T") levels in 1982 (NRCS 2000a). By 1997, that amount had been reduced to about 108 million acres, or 28 percent of total cropland acreage at that time (Figure 3). However, even with these reductions in erosion, it is estimated that additional U.S. cropland might benefit from management aimed at enhancing soil quality, as outlined below.

Tillage, soil management and soil quality. The potential for decline in the health or overall quality of the soil resource because of processes other than erosion is also a soil resource issue. Because soil quality has a number of facets and is difficult to measure directly, it is not as

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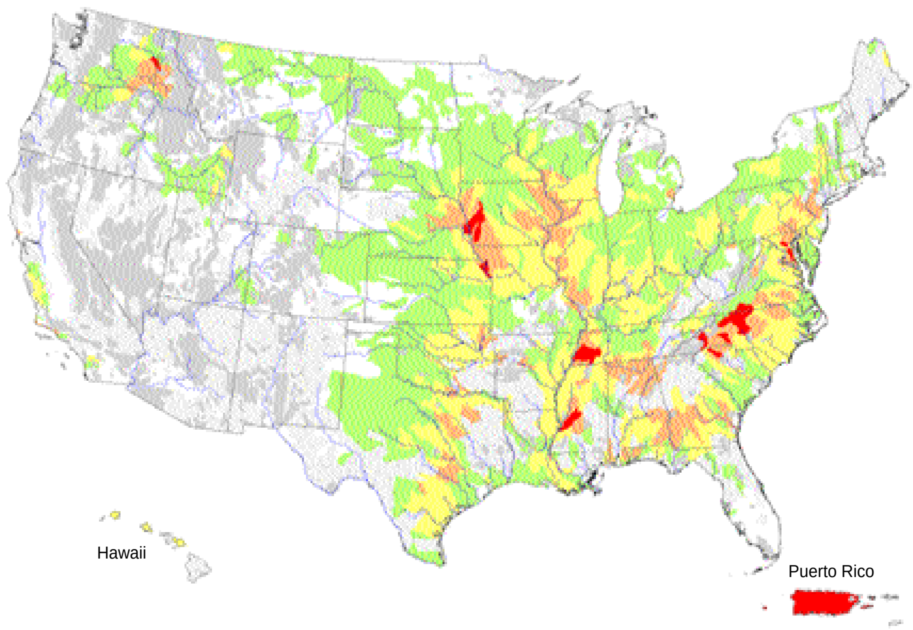
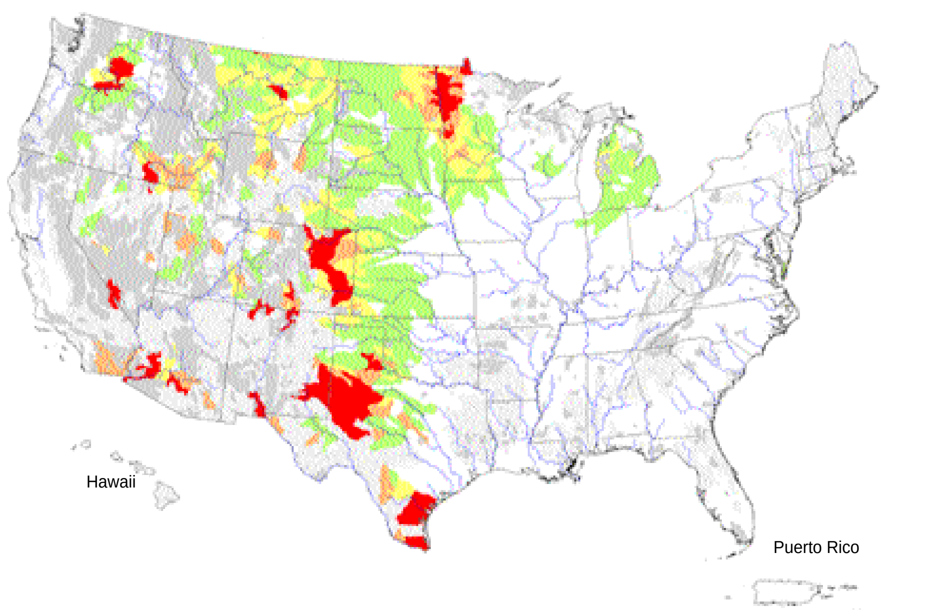
FIGURE 3.

Average annual soil erosion by water (MAP 1) and wind (MAP 2) on cropland and CRP land, 1997



Forty-one million acres are eroding by water at a rate above five tons/acre/year. The national water erosion rate averages 2.5 tons/acre/year. Total soil erosion equals 1,000 million tons. Data are only displayed where cropland and Conservation Reserve Program (CRP) land are five percent or more of the total area. Gully erosion is also excluded from the analysis. Watersheds are defined as U.S. Geological Survey Hydrologic Cataloging Units (8-digit). Source: NRCS 2000a



Forty million acres are eroding by wind at a rate above five tons/acres/year. The national wind erosion rate averages 2.0 tons/acre/year. Total soil erosion equals 840 million tons. Data are only displayed where cropland and Conservation Reserve Program (CRP) land are five percent or more of the toal area. Watersheds are defined as a U.S. Geological Survey Hydrologic Cataloging Units (8-digit). Source: NRCS 2000a easy to quantify as soil erosion. Thus it is difficult to assess its impact at broad scales over extensive areas as can be done with soil erosion.

A natural consequence of cultivating any soil is decomposition of the soil organic matter. This in turn may impact the soil's overall tilth (or workability), its fertility and biological activity and its ability to store adequate water for plant growth, depending on use and management.

Over the years, the level of organic matter in agricultural soils has declined as a consequence of conventional tillage methods. Figure 4 illustrates trends in soil organic matter in the U.S. corn belt since the advent of widespread soil cultivation. It shows a decline in soil organic matter that continued into the 1950s to about 53 percent of the 1907 level — the level present at the start of widespread conversion of

Off-site fate of eroded soil*

- Of the 377 million acres of working U.S. cropland, 28 percent is eroding at rates great enough to have adverse impacts on long-term soil productivity and overall soil quality.
- About three-quarters of the soil eroded by water in a typical farm field, however, is deposited as sediment in the same field from which it eroded. Upon deposition, the eroded soil material causes the soil surface to crust and seal in low areas of the field, resulting in ponding and irregular distribution of nutrients.
- Uneven crop productivity in the field leads to inefficient water and nutrient use, which causes excessive soil nutrient buildup, runoff or deep percolation, all of which can adversely impact water quality.
- Of the approximately one-quarter of soil material from sheet and rill erosion that actually leaves farm fields, most — about 60 million tons annually — is deposited in local streams and waterways of small watersheds. There, it disrupts streamflows, affects streambank stability and accelerates siltation of lakes, reservoirs, ponds and wetlands.
- The relatively small proportion of eroded soil that eventually leaves watershed outlets, estimated at about 14 million tons a year, may carry excessive levels of nutrients and pesticides to larger water bodies such as the Gulf of Mexico and the Chesapeake Bay, contributing to regional water quality problems.
- It is difficult to quantify the off-site fate of soil material lost through wind erosion. But in severe cases, blowing soil contributes to the level of particulate matter in the air, damages fences and other infrastructure through abrasion and drifts over roads where it increases maintenance costs and poses a travel hazard.

*Estimates of sedimentation are from a broad-scale national analysis using NRI-derived sheet and rill water erosion data (NRCS 2000a) coupled with NRCS-assigned sediment delivery ratios for areas in the conterminous United States approximating 2nd-code hydrologic units.

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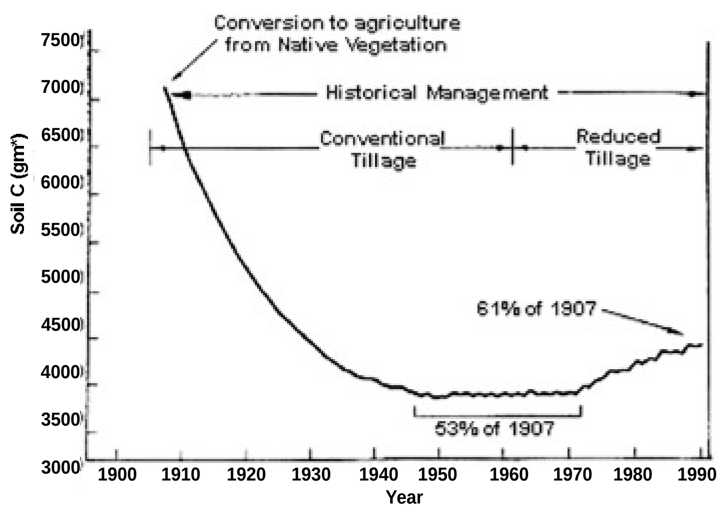
FIGURE 4.

Soil organic carbon pool in U.S. soils and loss from cultivation



Simulated total soil carbon changes (0- to 20-cm depth) from 1907 to 1990 in the central U.S. corn belt. Adapted from information in Lal et al. 1998.

native grasslands and forestlands to cropland in the United States. It also shows gains in soil organic matter to about 61 percent of the 1907 level starting in the 1970s — a time frame that coincides with the onset of adoption of conservation tillage systems by U.S. corn and soybean farmers.

The level of soil organic matter has been proposed as an indicator of soil quality because of organic matter's importance in soil structure, nutrient cycling and biotic activity.

Conservation tillage systems, because they leave crop residue at the soil surface, have the potential to build up soil organic matter in the critical surface layer of the soil, as compared to conventional tillage systems. By estimating the potential for build-up of soil organic matter as a function of crop residue cover derived from NRI data (NRCS 2000a) and modeling the impact of various tillage systems,* it appears that about one-third of the approximately 269 million acres of U.S. cropland not experiencing excessive (greater than "T") erosion might benefit from management systems aimed at enhancing soil quality.

Data from the Conservation Technology Information Center show that in 2000, some form of conservation tillage was practiced on about 37 percent of cropland in the United States, meaning that those lands had more than 30 percent residue cover on the ground after planting (NACD 2001a). This use of conservation tillage has mostly occurred since the early 1980s.

* Results of Environmental Policy Integrated Climate (EPIC) model simulations identify a critical soil C and V factor that correlates with accretion of soil organic matter over a 30-year period under a variety of cropping systems. Query of 1997 NRI cropland data for soil erosion rates <T and where critical C factor is met are used to derive estimated acreage.

Adoption of no-till practices has risen significantly in recent years. No-till is a form of residue management where a new crop is planted directly into the residue-covered soil from the previous crop; there is no additional tillage or seedbed preparation. In 1990, about 16.9 million acres were being managed with no-till systems. By 2000, that number had increased to 52.2 million acres (NACD 2001a).

Soil salinity. Soil salinity is a resource concern in some portions of the United States. Many soils are naturally saline, but some become saline through improper use and management. Naturally saline soils are a result of several factors such as the nature of the underlying geology, natural patterns of water flow in the landscape that favor salt accumulation and drier climates where evapotranspiration exceeds precipitation and thus favors salt accumulation.

Non-saline or slightly saline soils can become so affected by increased salinization that it threatens the productivity of cropland and grazing land. On cropland, this can come about through non-uniform or excessive irrigation and inadequate drainage. Such practices raise water tables in irrigated cropland, causing salts to rise to the root zone of crop plants and impair productivity. Excessive levels of salts in irrigation return flows can even impact water quality in streams and lakes, affecting recreation, aquatic habitat and industrial and drinking water uses.

Saline seeps are another form of salinization. Seeps are saline areas of the landscape that expand over time, taking more and more land out of production. Seeps are usually found on grazing land or fallow cropland in semiarid or arid climates. They are often a response to periods of increased precipitation coupled with management that has altered or changed native vegetation and water-use patterns in the landscape.

According to data in USDA's National Resources Inventory, 3.4 million acres of cropland and 0.9 million acres of pastureland have the potential to be impaired through soil salinization. The same data also suggest that about 1.5 million acres of U.S. agricultural lands are currently affected by salinity.

Preventing salinization and its attendant off-site impacts and restoring productivity to lands damaged by salinization often requires action over wide areas such as entire irrigation districts or river basins. For example, salinity control work under USDA's Environmental Quality Incentives Program assists in the improvement of irrigation systems and management of irrigated lands to reduce salt loading from both natural and irrigation-induced sources to the Colorado River and its tributaries.

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The water resource — quality issues

Although limited in some places, U.S. surface and groundwater resources provide sufficient water for most domestic, municipal, industrial and agricultural uses as well as for most fish, wildlife and environmental purposes.

These water resources are vulnerable to pollution that can degrade water quality and make the water unsuitable for some uses. The degree to which that happens depends in part on how land is used and managed.

Since the passage of the Clean Water Act in 1972, the nation has concentrated on controlling pollution from industrial and domestic discharges that are called point sources of pollution. Recently, there have been increasing concerns about controlling water pollution from nonspecific or diffuse sources, known as non-point sources.

Although conservation techniques, including many that protected water quality, were in effect on farms and ranches long before the Clean Water Act, agriculture has been at the center of non-point source concerns.

Conditions and trends

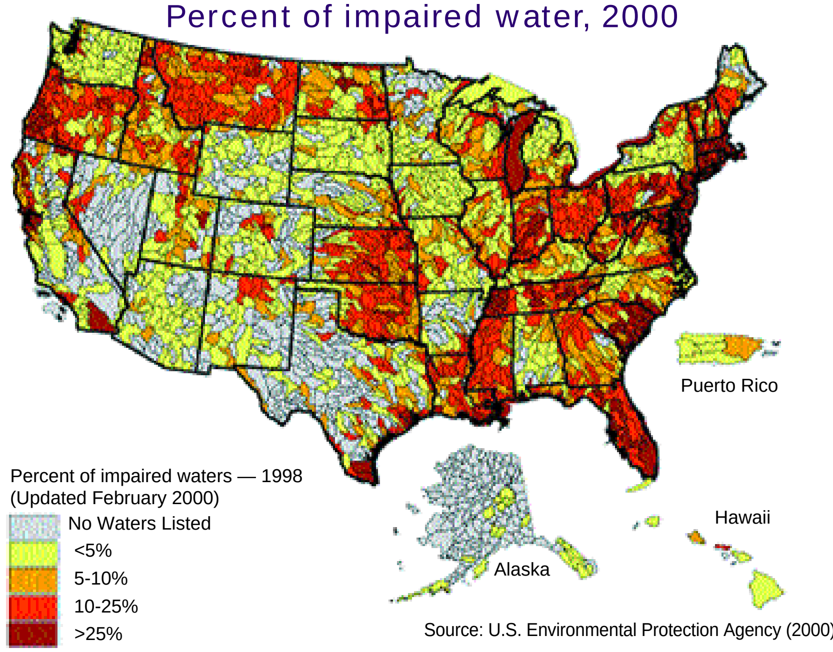
There are no reports or studies that fully describe the health of all waters in the United States. The U.S. Environmental Protection Agency makes periodic reports to Congress based on assessment reports from states, territories, tribes and interstate commissions. Findings from EPA's 1998 Water Quality Inventory and the 2000 Atlas of America's Polluted Waters report indicate the following (Figure 5):

- Of the 23 percent of the nation's rivers and streams that were assessed, 35 percent were impaired for one or more of three primary uses (drinking, fishing and swimming).
- Of the 42 percent of lakes, reservoirs and ponds that were assessed, 45 percent were impaired.
- Of the 32 percent of the country's estuaries that were assessed, 44 percent were impaired.

According to EPA, more than 20,000 individual river segments, lakes and estuaries are impaired with one or more pollutants from all sources. Approximately 218 million people — the majority of the U.S. population — live within 10 miles of the impaired waters. EPA reported that the principal pollutants causing water quality

FIGURE 5.

Percent of impaired water, 2000



Source: U.S. Environmental Protection Agency (2000) problems include nutrients, sediment, metals and pathogens.

Most states and jurisdictions identified agriculture as a leading source of many of these pollutants. Studies by USDA, the U.S. Geological Survey, numerous federal and state agencies and other public and private research institutions have also documented agriculture's impacts on water quality.

The impact of agriculture on water quality should be considered in the context of the amount of land supporting agricultural activities. About 900 million acres, or 41 percent of the continental United States, are on farms and ranches. Through their stewardship of the land, farmers and ranchers can help ensure safe drinking water, clear-flowing streams and clean lakes, wildlife habitat and scenic landscapes.

Where best agricultural management practices are not used, nonpoint sources of pollution from agriculture can occur. Several effects are described below.

Sediment effects. Sediment is eroded soil deposited on the land and in streams, rivers, drainageways, and lakes. Sediment degrades water quality by increasing turbidity and transporting attached nutrients, pesticides, pathogens and toxic substances. It clogs waterways, reservoirs, estuaries and harbors, thereby reducing the use of these water bodies and often requiring expensive clean-out, maintenance and repair.

EPA reports that sediment is the most common pollutant affecting assessed rivers and streams and that agriculture is the leading source. As documented in local soil surveys, soils have varying degrees of erosion potential and capacity to allow sediment movement in streams. Because pesticides and nutrients can attach to soil particles, reducing soil erosion through on-farm conservation techniques can improve the condition of surface water and groundwater.

Nutrient effects. Nutrients are fundamental to life. Plants and animals need certain amounts of nutrients to grow and reproduce. Insufficient amounts of certain nutrients may stunt growth or cause death, while in some environments, excessive amounts of certain nutrients can cause unnatural or excessive growth or death.

In agriculture, nutrients — mainly nitrogen, phosphorus and potassium — are applied to promote plant growth. If they are applied inappropriately or in excessive amounts, they

Good soil quality enhances water quality

As described in the soil section of this report, there can be a relationship between soil quality and water quality in many landscapes. Good soil quality produces good water quality in several ways. Soils rich in organic matter and biological activity promote infiltration over excessive runoff and can be more resistant to erosion.

Organic matter also has an affinity for some of the chemicals used in agriculture production, binding the residuals to the soil and preventing them from running off or leaching. Healthy soil supports biological activity that can degrade pesticides and pathogens before they can migrate from the land to the water.

When soil quality is poor, the potential is greater for loss of soil and chemicals from farm fields.

Improving soil quality through reduction in soil erosion, increases in soil organic matter content and decreases in compaction and acidification promotes improvement in the condition of surface water and groundwater, in conjunction with sound management practices.

can be transported to surface water or groundwater.

Nitrogen is added to soils from commercial fertilizers, animal manure, legumes such as alfalfa and soybeans and from atmospheric deposition. Some soils with sufficient clay content slow down leaching of nitrates through the soil, enough to retain nitrogen near the surface and keep it available for plant uptake. Other soils, particularly sandy ones, allow for rapid leaching and in some cases provide a pathway for excess nitrogen movement into stream systems and groundwater.

Nitrogen compounds in excessive amounts can accelerate eutrophication in surface waters, which depletes oxygen, kills fish and results in cloudy water with an unpleasant smell. Elevated concentrations of nitrate in drinking water pose a potential threat to human health, particularly among infants.

The phosphorus ion phosphate, while not as mobile as nitrate, tends to be carried on soil particles that move off the land. Recent studies show that phosphate can also leach to groundwater, especially where commercial fertilizers or manure have been applied to the land over many years. Phosphate can also contribute to eutrophication in fresh surface waters.

Irrigation effects. Irrigation has become more widespread as producers take advantage of productive soils in arid regions or attempt to offset the impacts of drought. Water quality can be degraded by irrigation systems that are not well designed or properly maintained and operated. Knowledge of soil properties such as those documented in soil surveys can reduce the risk of irrigation-induced pollution through proper design of irrigation systems.

Irrigation-induced erosion creates a sedimentation problem in some areas. There is also concern that deep-water aquifers will become contaminated with agricultural chemicals as the water used for irrigation percolates down and carries chemical residuals to aquifers.

Irrigation water's natural base load of dissolved mineral salts becomes concentrated as the water is consumed by plants or evaporated. Deep percolating irrigation water may also become contaminated through contact with shale or highly saline aquifers and the return flows convey the salts to the receiving streams or groundwater. As the same water is used over and over again and more water evaporates, the salinity level increases, and that can impair water quality.

Pesticide effects. Pesticides are used to control weeds, insects, rodents, diseases and other organisms that may reduce production of agricultural commodities. Since 1979, according to NASS surveys, the agricultural sector in this country has accounted for about 80 percent of all pesticide use each year.

Pesticides may contaminate water by leaching through the soil or as a result of being washed from the field surface in solution or adsorbed to soil or organic material into nearby water bodies. Only a small proportion of pesticides migrate from farm fields, however. In general, monitoring results show that most agricultural pesticides occur in low concentrations in surface water and groundwater, even in regions where agricultural use is high.

Farmers and ranchers are modifying their management practices by using more environmentally friendly pesticides, applying pesticides only when the pest is likely to cause economic damage to crop production and reducing their reliance on agricultural pesticides through integrated pest management techniques.

By practicing prevention, avoidance, monitoring and suppression of pests — either through cultural, physical or biological means — dependence on chemicals has decreased. According to NASS surveys, insecticide use per acre on corn dropped 52 percent from 1991 to 1999. Also by 1999, more than half of the corn and 80 percent of all cotton grown in the United States were produced using integrated pest management techniques.

Livestock and poultry manure effects. Livestock and poultry manures have the potential to degrade water quality because they contain nutrients, organic matter and pathogens. Also, the aggregate effect of odors and gaseous emissions from applying manure, the decomposition of dead animals and wet feed pose nuisance and public health problems.

These manures have emerged over the past several years as a major environmental issue. As the Congressional Research Service described the situation in a May 1998 report, "Social and political pressure to address the environmental impacts of livestock production has grown to the point that many policy-makers today are asking what to do, not whether to do something."

In 1999, EPA found that 35 states regulate large, concentrated animal feeding operations, and at least 36 states require manure management plans. Numerous counties and local governments have ordinances related to this issue. In response, national livestock and poultry producer groups have started initiatives to address manure-related environmental problems.

A USDA analysis using farm-level data from the 1997 Agriculture Census shows that the structure of animal agriculture has changed dramatically over the last two decades. Small and medium-sized livestock and poultry operations have been replaced by large operations at a steady rate. The total number of animals has remained relatively unchanged, but more of them are being confined and concentrated in the high-production regions of the country.

A major concern is that in some areas, livestock and poultry operations surpass the capacity of the land to assimilate manure nutrients. This means it is necessary to export the manure from the farm or ranch or find other manure uses.

There are more than 900,000 beef, dairy, hog and poultry animal feeding operations in the United States. About 3,300 have more than 1,000 confined animal units. USDA and its conservation partners estimate that up to 272,600 animal feeding operations will need assistance to develop comprehensive nutrient management plans

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over the next several years to address non-point source pollution issues.

At the same time, ongoing conservation partnerships in water quality projects across the country are helping to reduce the amount of harmful animal waste nutrients and other potential pollutants from agriculture that reach water bodies.

Examples include a 90 percent reduction in nutrient runoff in five West Virginia counties, the prevention of 4,500 tons of nitrates from entering the Suwannee River Basin in north central Florida every year and the participation of most local dairy farmers in the Skaneateles Lake Watershed Agricultural Program, which allows Syracuse, New York to boast the second-best drinking water supply in the nation (the glacial waters of Anchorage, Alaska are first).

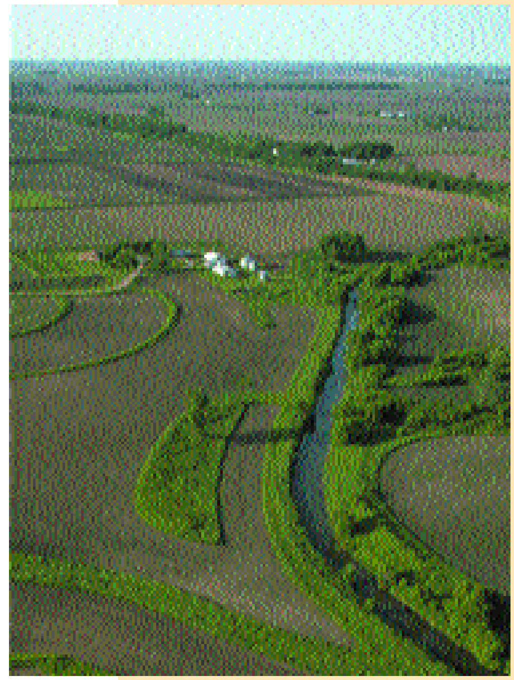
Buffers enhance water quality

Conservation buffers are narrow strips of permanent vegetation — grass, trees and shrubs — planted to protect water bodies and other environmental and human-created elements on the landscape from the adverse consequences of agricultural production. Among the most common types are filter strips and riparian buffers, contour grass strips, crosswind trap strips, grassed waterways, field windbreaks, shelterbelts and living snow fences.

Some experts contend that a buffer of one kind or another might be appropriate for use on almost every farm or ranch. A 1993 report by the National Research Council's Board on Agriculture concluded that strategic placement of buffers on cropland and grazing land was among the most promising and cost-effective ways to protect soil and water quality.

A 1997 estimate of buffer needs by NRCS regional office personnel suggested that nearly 12 million acres of riparian (streamside) and upland buffers could be eligible for enrollment in the Conservation Reserve Program, an admittedly conservative figure. Assuming that only 20 percent of the 3.5 million miles of permanent and seasonal streams in the United States may require treatment with filter strips or riparian buffers, the amount of land that would benefit from these two buffer types alone is 15 million or more acres (depending on which assumptions are made regarding buffer width). This does not take into account additional buffers around or along other permanent water bodies such as lakes, drainage ditches and irrigation canals, nor does it account for any upland buffer needs.

Buffers are not the sole answer to water quality or other conservation challenges. They work best when integrated into comprehensive conservation systems that also incorporate practices such as conservation tillage, nutrient management and integrated pest management. However, buffers are time-tested technology that could be used more extensively to help landowners meet their stewardship goals.



Vegetated buffers build up soil organic matter and help stop sediment, nutrients and some pesticides from entering waterways. They also create riparian (streamside) habitat for wildlife. As of December 2000, approximately 1.4 million miles of conservation buffers had been enrolled in the Conservation Reserve Program continuous sign-up.

The water resource — quantity issues

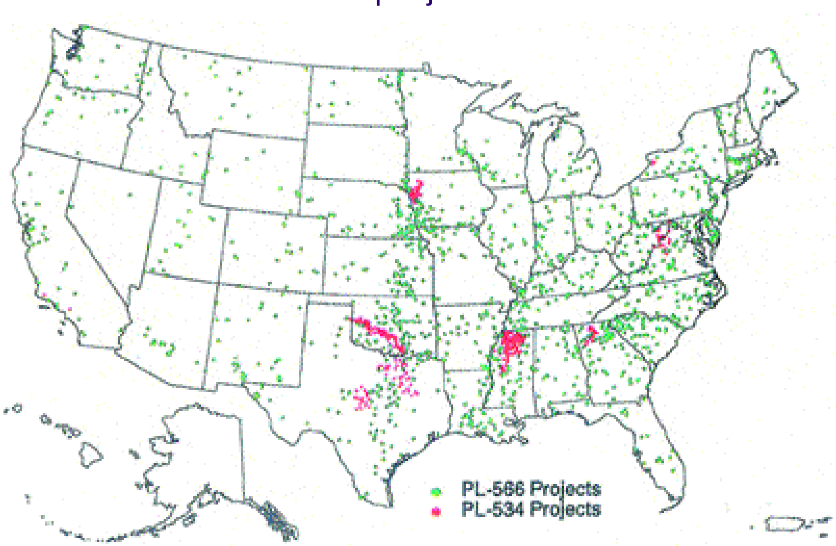
Across the country, agricultural producers are faced with either too much water during flood conditions, too little water or not enough access to what exists during drought conditions and decisions about efficient irrigation. Competing interests — from increasing domestic, commercial and industrial uses to recreation and wildlife habitat — further complicate the situation.

Conditions and trends

Flooding. Floods have an immediate impact and the consequences are usually severe for the economy, the environment and human welfare. The floods that followed on the heels of hurricanes Dennis and Floyd in 1999, for example, exceeded $15 billion in damages. They also left a ravaged countryside — already suffering from drought — with tens of thousands of animal carcasses and the debris from flooded-out towns. Existing USDA small watershed dams provided flood protection for many communities during these storms and also mitigated the flood damages in communities that received the greatest amount of rain.

FIGURE 6.

Watershed project locations



Watershed projects. In watersheds across this country, in Puerto Rico and in the Pacific Basin, USDA has assisted partners to develop or begin more than 2,000 water management plans covering 160 million acres. In watershed project areas (Figure 6), upwards of 15,000 separate land treatment measures have been applied on 30 million acres, contributing to environmental improvement, economic development and social well being.

USDA's authority for watershed projects stems from national laws dating back to the 1940s. Many of the original watershed projects sought to reduce flooding, improve water management and increase irrigation efficiencies. In the 1960s, high priorities were placed on projects that provided jobs to combat poverty and encourage rural development. Many of those projects established recreation areas.

In recent years, projects have focused on land treatment measures to resolve natural resource issues such as substandard water quality and loss of wildlife habitat. Landowners and USDA technical specialists plan the projects, which are based on the application of on-farm conservation management systems that are tailored to address specific resource objectives for a given watershed.

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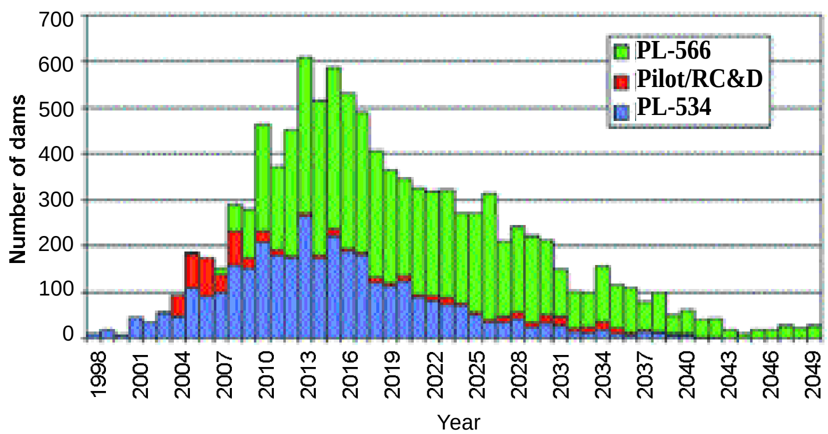
The projects represent a $14 billion investment and yield annual benefits of nearly $1 billion to rural communities from flood reduction and watershed protection. They have become an integral and irreplaceable part of the communities and the environment that they were designed to protect. There is currently a $1.4 billion unfunded federal commitment to approved watershed projects.

However, many existing projects are at or near the end of their 50-year planned life (Figure 7), and there is growing national concern that they may pose a public safety concern. A recent survey of known rehabilitation needs in 22 states revealed that more than 2,200 dams need rehabilitation at an estimated cost of more than $540 million (NRCS 2000b). Failure of 650 of these dams could threaten the health and safety of people downstream or disrupt local drinking water supplies.

FIGURE 7.

Dams per year at end of planned design life



Dams created under Public Law-566, Public Law-534, Pilot and under the Resource Conservation and Development Program. As this chart indicates, a large number of dams will come to the end of their planned design life from about 2010 to 2030.

Emergency Watershed Program. Watershed projects are proactive by design, and they are an important tool for consideration in risk-management decisions. They only cover a small portion of the United States, however. Congress established the Emergency Watershed Protection Program to help people and conserve natural resources by relieving imminent hazards to life and property caused by floods, fires, windstorms and other natural occurrences.

USDA administers the program. All projects undertaken — except for the purchase of floodplain easements — must be sponsored by a political subdivision of a state such as a city, country, general improvement district or conservation district.

Eligible work includes removing debris from stream channels, road culverts and bridges; reshaping and protecting eroded stream and river banks; fixing damaged drainage facilities; repairing levees (primarily agricultural) and other structures; reseeding damaged areas; and purchasing floodplain easements.

Drought. Every year, demand for water exceeds supply in some parts of the country, and other areas are beginning to experience water shortages. When drought occurs, those shortages may become critical and competition for water increases.

The more severe consequences of drought include huge economic losses in agriculture, shipping and other water-dependent businesses; drinking water shortages, particularly in small rural communities; and environmental stresses, including loss of or damage to wildlife habitat and downshifts in wildlife populations. Drought may also force tough decisions in regard to water allocations among competing interests such as fisheries, agriculture and communities.

In years when drought has occurred, USDA programs have helped to make the difference between a marginal and disastrous year. Farmers who irrigate have reduced their water applications by 4.7 million acre-feet of water each year (enough to cover the nearly 700,000 acres of Rhode Island with seven feet of water), primarily through adoption of management practices that conserve water and reduce the potential for soil salinity.

Wildfire is often more intense and widespread in areas affected by drought, and it can cause enormous damage to land resources and water quality. The huge fires across the western states, many of them in drought conditions, during 2000 cost billions of dollars in damages and suppression activities, eliminated wildlife habitat for many species and precipitated water quality concerns from sediment and mudslides.

Such conservation practices reduce the risk associated with drought, especially if improvement in soil quality has been a primary objective. Healthy soils absorb and store more water than do degraded soils.

A number of tools can assist in preparing for drought and floods, including USDA's SNOTEL and SCAN systems that provide real-time climate information and information concerning soil moisture and water yield conditions (see pages 32 to 33). Such tools are not widely available to all who need them. The majority of the landscape, which is still mostly rural and agricultural in nature, lacks both an adequate number of climate data instruments and real-time monitoring — a finding of the National Drought Policy Commission (2000).

Irrigation. According to NASS (1998), irrigated crops, while raised on only 16 percent of all harvested cropland in the country, account for 49 percent of total U.S. crop sales. In the West (including the 17 western contiguous states, Hawaii and Alaska), irrigated crops make up 72 percent of all crop sales.

For the past 20 years, approximately 43 million acres of cropland have been irrigated in the western states. While that figure has remained fairly constant, there has been a shift of about three million irrigated acres from the more arid Southwest and southern plains primarily to the less arid and more abundant groundwater areas of central and eastern Nebraska.

In addition, a five-million-acre net increase in irrigated farmland occurred over the past two decades, all of which is located east of the 100th Meridian where 12 million acres of cropland — an increase of 72 percent over 1980 levels — are now irrigated. Factors driving this increase are the potential for greater and more stable yields, opportunities for alternative crops and reduction of risks inherent in dryland farming areas.

Irrigation withdrawals as a share of total freshwater withdrawals in this country declined from 46 percent in 1960 to 40 percent in 1995, where they remain today. Most irrigation withdrawals occur in the West, where 44 percent of withdrawals are from on-farm, private or state-owned surface water supplies; 24 percent from Bureau of Reclamation surface water supplies; and 32 percent from groundwater.

On-farm wells are the primary source of water for irrigation in the East where groundwater depletion is becoming a major concern, particularly in the Mississippi Delta and Southeast. Over-use of groundwater also occurs in many areas of the Great Plains, Southwest and Pacific Northwest. Major impacts are high pumping costs, land subsidence, saltwater intrusion along coastal areas and loss of aquifer capacity.

Throughout the United Stated, irrigation for crops may have significant environmental impacts, including:

- Diversions from some streams impair aquatic communities and migration of anadromous fish.
- Return flows from irrigated areas may contain biocide residues, nutrients (phosphates and nitrates), total dissolved solids (salinity) and sediment and may reduce the quality of surface water and groundwater.
- Seepage from irrigation systems creates fish and wildlife habitat and recharges aquifers.

Irrigators continue to adopt and apply water management practices based on on-site soil and climate information that allow for more efficient use of water and a reduction in the magnitude of adverse environmental impacts. Since 1979, use of gravity systems decreased by 20 percent, while use of sprinkler and drip/trickle systems increased by 25 percent and more than 500 percent, respectively.

Other practices include a shift to crops that require less water, improved on-farm water-conveyance systems, precision field leveling, shortened water runs, surge flow, reuse of tail water, more precise water and soil moisture measurements and the conversion of high-pressure sprinkler systems to low-pressure systems.

These practices, along with shifts in irrigation to less arid climates, are having an impact. Since 1969, the national average irrigation application rate declined by 4.5 inches, or 20 percent. That is enough to offset the increase in irrigated acreage and maintain the total water applied near the level of 25 years ago. Farmers are simultaneously increasing yields of irrigated crops (for example, rice yields increased 1.2 percent per year over the last 30 years), making the conservation results in relation to water use per unit of agricultural product even more dramatic.

Water supply forecasting and soil moisture measurements

A number of tools are available to provide critical information needed in risk management for flooding, drought, cropping decisions and efficient irrigation. Among them are the following.

Snow survey. Snowmelt provides approximately 80 percent of the streamflow in the West. NRCS and its conservation partners currently conduct snow surveys in 12 western states and Alaska. Natural resource data from 1,100 manual snow measurement courses, 660 automated SNOTEL (SNOwpack TELemetry) sites, 575 stream gauges, 310 major reservoirs and 3,200 climate observation stations are integrated to create basin and watershed analyses and water supply forecasts using an automated database and forecasting system. SNOTEL is the only provider of this critical climate data from the major water yield (high elevation) areas of the mountainous West.

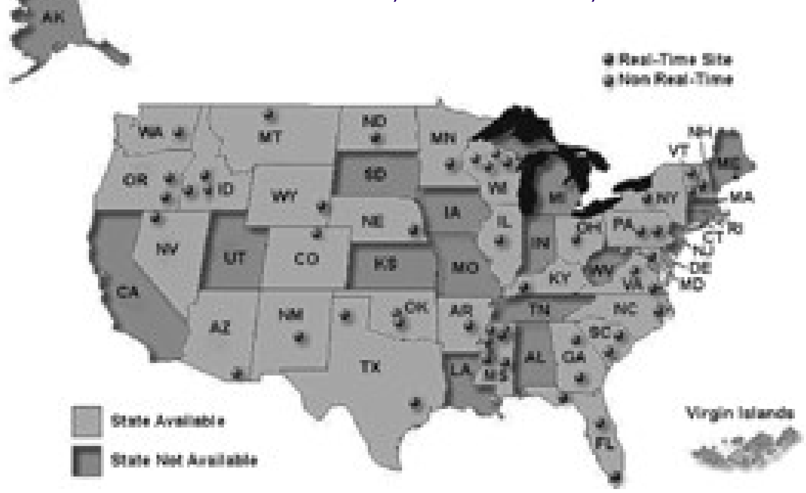
The SNOTEL data collection system plays a key role in irrigation water management, drought assessment and during flooding and other life threatening snow events. The SNOTEL network provides real-time precipitation, temperature and snowpack depletion information that improves current flood stage forecasts. This assists emergency management agencies in effective mitigation of drought and flood damages.

A major focus of program activities is to improve measurement precision, reliability, data quality, increased sampling frequency and timely data availability and to add additional sensors such as soil moisture, soil temperature, wind and solar radiation.

Water supply. USDA's National Water and Climate Center, in partnership with the National Weather Service, produces water supply

FIGURE 8.

SCAN Network, October 31, 2000



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forecasts monthly, January through June. During the 2000 forecast season, 7,580 seasonal water supply forecasts for 827 locations in 12 western states were issued to support water resource management. The forecasts are coordinated with and reviewed by several federal agencies and program collaborators, including the Bureau of Reclamation, Corps of Engineers, Bonneville Power Authority, state and local agencies, power utilities, irrigation districts, tribal governments, the Provincial Government of British Columbia, Alberta, the Yukon Territory and Mexico, to ensure the highest quality and accuracy.

Agricultural, municipal, industrial, hydropower and recreational water users are the primary recipients of these forecasts. Because of recent federal legislation related to endangered species protection, an increasing number of fish and wildlife management agencies also use the data.

SCAN. The Soil Climate Analysis Network (SCAN) supports drought monitoring, assessment of flood potential, crop risk-assessment and productivity models, watershed planning, weather forecast modeling, soils research, water balance monitoring and a wide variety of USDA global change activities. Conservation partnerships have expanded SCAN to 46 remote soil/climate stations operating in 30 states (Figure 8). When fully deployed, SCAN will provide nationwide coverage.

Soil Climate Analysis Network (SCAN) station in Dorchester, New Hampshire. This facility collects real time weather and snow pack data along with soil moisture, temperature and other soil temporal properties.

Air quality issues

Agricultural production can be a source of atmospheric pollutants such as particulates — dust-sized pieces of soil minerals, agricultural chemicals and plant and animal organic material — and greenhouse gases, including carbon dioxide, nitrous oxides and methane.

Farms and ranches may also contribute noxious odors from animal wastes and agricultural chemicals, and they can feed the processes that drive global climate change (increased atmospheric carbon dioxide, changing land-use patterns, weed and pest invasions and water availability).

While agriculture contributes to atmospheric pollutants, crops and livestock are also impacted by climate change and atmospheric ozone.

Conditions and trends

Because of the effects that agricultural producers and other owners of private land have on air quality, this issue is an important focus of USDA conservation programs and technical assistance. In the last three months of 2000 alone, partners in conservation districts across the country produced 23 group or area-wide plans — covering 109 million acres — that featured mitigation of air quality problems.

During that same time period, conservation measures that help address air quality were applied on 695,000 acres. Approximately five percent of

Conservation improves air quality

A number of conservation techniques on agricultural land that are usually designed to improve soil and water quality are also effective in mitigating conditions that can adversely effect air quality. Among them are:

- ✔ contour buffer strips
- ✔ contour strip cropping
- ✔ cross-wind ridges and strip cropping
- ✔ cover crops
- ✔ field borders
- ✔ hedgerows
- ✔ efficient irrigation
- ✔ residue management
- ✔ waste management systems

resource inventories and evaluations (primarily in the Midwest, Northern Plains and South Central regions) reflected air quality issues.

Other forward strides include formation of the first USDA Agricultural Air Quality Task Force in 1996. This group works to assess the extent to which agricultural activities contribute to air pollution, determine cost-effective ways for the agricultural sector to improve air quality and coordinate research on agricultural air quality issues to avoid duplication.

Particulate matter in the air has been linked with respiratory illness and is viewed as a growing public health concern. EPA has identified agricultural activities as significant sources of fine particulates. The agency estimates that fugitive dust from crop production totals 3.3 million tons annually and that, under current controls, these emissions will increase to about 3.8 million tons by 2005. EPA also projects that fugitive dust from livestock operations, now contributing an estimated 181,400 tons every year to the atmosphere, will rise to 193,400 tons a year by 2005.

In 1998, EPA identified fewer than 10 air quality non-attainment areas that included rural lands. In 2000, after additional surveys, there were more than 100 such rural areas, and EPA projects the number to rise significantly by 2002. (In non-attainment areas, air quality is below the limits set by Clean Air Act regulations.)

USDA's Agricultural Air Quality Task Force recommended voluntary, incentive-based compliance programs to address agricultural impacts on air quality. The group proposed that state air pollution regulatory agencies adopt such programs to reduce particulates from agricultural operations in non-attainment areas while sustaining long-term agricultural production.

These incentive-based programs would include both accountability and backstop provisions. The backstop provisions would be the means for states to regulate agricultural operations that do not comply with the agreed-upon plans.

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Climate Change

As a natural part of the earth's atmosphere, gases known as greenhouse gases such as carbon dioxide, water vapor, methane and nitrous oxides reflect heat to the earth's surface in much the same way that glass or transparent plastic help warm a greenhouse. Without them, the earth would be too cold for life as we know it.

Human activities such as burning fossil fuel for domestic and industrial purposes are increasing the amount of greenhouse gases in the atmosphere. Agricultural practices such as land conversion from grass, forest or wetlands to cropland, conventional cultivation, fertilization, and livestock production also release greenhouse gases.

Recent acceleration in the accumulation of these gases in the atmosphere is causing changes in temperature, precipitation and other aspects of climate. Figure 9 shows the increase in frequency of intense rainfall events in the United States, which increases the risk of flooding, water pollution and erosion. In 1995, a group of more than 2,000 of the world's leading scientists (the Intergovernmental Panel on Climate Change) concluded, "The balance of evidence suggests a discernible human influence on global climate." Since that time the evidence has increased.

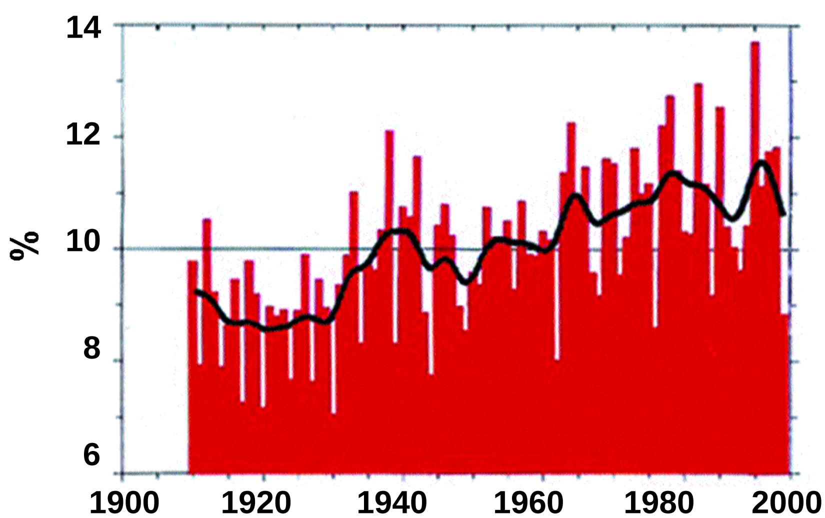
Computer models of future climate indicate that general atmospheric warming will be faster and greater than at any time in the last 10,000 years — indeed, since the dawn of agricultural societies. These changes in climate will likely affect everything from the length of the growing season and available water to pests and weed infestation. Agriculture can respond to global climate change by reducing its greenhouse gas emissions, adapting to the change and offsetting greenhouse gas concentrations in the atmosphere through carbon sequestration.

Agricultural producers may readily adapt to small, steady increases in temperatures or gradual shifts in water regimes by shifting to crops that are better suited to new climate regimes. Extreme weather events will require farmers to manage risk with, for example, a greater diversity of crop species.

Greater risk of drought, floods and ensuing erosion from wind or water can be ameliorated by increasing the soil's resilience through conservation techniques such as reduced tillage,

FIGURE 9.

Percent of United States experiencing extreme one-day precipitation events, 1909-2000



Source: Karl et al. 1996

rotations, cover crops and buffer strips. Still, the climate in some areas of the South may become too hot and dry to continue some crops, and other areas are likely to be inundated with water, making them unsuitable for agriculture. It is expected that farming for some crops may shift northward over time, where soil conditions are suitable.

Which changes are made and how they are accomplished will depend on the driving economic and ecological forces of the production system. Key actions in preparing for climate change are: (1) improve capabilities for predicting potential changes and their impacts and (2) develop the means to manage the risks.

Conditions and trends

On the global scale, agriculture accounts for about one-fifth of the annual human-caused increase in greenhouse gas emissions, primarily methane and nitrous oxide, but contributes only about four percent of global carbon dioxide emissions.

Methane (agriculture accounts for one-third of the U.S. total) is produced from the digestion of low-quality forage by grazing livestock and anaerobic storage of manure in concentrated feeding operations. Nitrous oxide (agriculture accounts for about two-thirds of the U.S. total) is produced as a by-product of the application of nitrogen fertilizers and manures to the land. Carbon dioxide production from agriculture (three percent of the U.S. total) is a result of practices that disturb the soil and accelerate the decomposition of soil organic carbon. Burning agricultural residues also releases carbon dioxide. The use of fossil fuels in farming operations, and the production of agricultural petrochemicals also directly and indirectly contribute to carbon dioxide emissions.

Agricultural practices that decrease greenhouse gas emissions offer multiple economic and environmental benefits. For example, reducing the number and intensity of field operations saves money, time and labor while reducing fossil fuel use, and in the case of reduced tillage, reducing soil organic carbon loss. Improved nutrient management and substitution of renewable organic nutrients (manures and composts) for fossil fuel-based nutrients reduce emissions while maintaining yields and addressing water quality issues. Better management of nitrogen fertilizers could result in a 15-percent to 20-percent reduction of nitrous oxide emissions from cropland, according to the U.S. Department of Energy. This means that fields lose fewer nutrients to ground and surface waters.

Methane recovery from manure storage systems may pay for itself within a few years because the methane can be used on the farm as a renewable energy supply. Methane emissions from grazing livestock can be reduced by 20 percent to 25 percent through improved grazing systems and increased individual animal and herd performance. Such systems also reduce operating costs and help keep water and air cleaner.

This nation has demonstrated a capacity to reduce emissions from agricultural systems through efforts

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such as the Ruminant Livestock Efficiency Program, AGSTAR, methane-capture pilot projects and the Nutrient Efficiency Program. Work is underway to develop, refine and use carbon inventory, measurement and prediction tools such as the Iowa Soil Carbon Management Project, CQESTR, CENTURY, EPIC and carbon probes. But much remains to be done to apply these systems on a broad scale.

Carbon Sequestration

Carbon is a component of carbon dioxide and methane, two of the most important greenhouse gases. Storing, or sequestering, carbon in soil as organic matter and in trees, shrubs and other permanent vegetation helps reduce the amount of carbon dioxide in the atmosphere. This is why soil and vegetation are sometimes called carbon "sinks."

Practices that increase the amount of soil carbon also reduce soil erosion and are generally associated with improved soil quality. As their organic carbon content increases, most soils are better able to hold and supply water and nutrients to growing plants. This increases the soil's resilience under stress, reducing the negative impacts of flooding and drought. More efficient irrigation and nutrient use are also possible, contributing to improved water quality and supply and sustainable productivity of the land.

Keeping crop residues on fields, maintaining vegetated buffers and using agroforestry practices improve air and water quality by reducing erosion and runoff. These practices enhance wildlife habitat and can provide additional farm income.

Farmers and ranchers have adopted many conservation techniques, usually for other benefits, that also increase carbon storage. These include reduced tillage or no-till cultivation systems; crop rotations that incorporate small grains, hay and legumes; planting of cover crops; minimizing or eliminating summer fallow; managing nutrients and irrigation efficiently and effectively; and adoption of improved livestock grazing management systems. Initial financial incentives in addition to outreach and education may be necessary to encourage farmers to increase their amount of carbon sequestration. Public assistance is warranted because of the multiple ancillary public benefits.

These and similar mitigation activities can reduce the amount of carbon in the atmosphere by somewhere between 90 and 300 million tons per year over the next 25 to 40 years (Lal et al. 1998, Follett et al. 2001). In total, reducing greenhouse gas levels through better management of agricultural production systems could offset total U.S. emissions by 10 to 15 percent, increase on-farm profitability and enhance environmental quality.

Sprawl, land use and planning

Sprawling development and land consumption patterns have accelerated changes across this nation's landscape. Many once-thriving city centers have experienced losses in business, industry and populace, while a growing population drives the continuing conversion of agricultural land for residential and commercial uses.

Thirty-three percent of the nation's farms and 16 percent of all farmland are located near metropolitan areas. These urban-influenced farm areas produce about one-third of the value of all U.S. agricultural products and control 39 percent of farm assets. This highlights two important issues. First, because there is significant production in urban-influenced areas, there is a need to address the unique conservation needs of these producers. Second, a significant portion of nation's prime agricultural land is at risk.

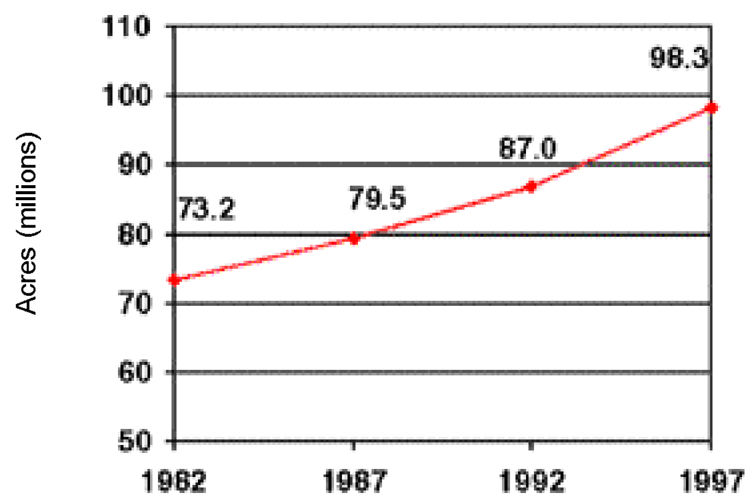
Conditions and trends

Sprawling city suburbs and "exurbs" have accelerated the conversion of farmland to other uses and have caused the development of working lands suited for other purposes. The National Resources Inventory (2000a) found that between 1982 and 1997, the amount of urban and built-up land increased by 26 million acres (Figure 10), an area roughly the size of Ohio. On average, 645,000 acres of prime farmland are converted each year to non-agricultural uses. About 45 percent of new construction between 1994 and 1997 occurred in rural areas, and nearly 80 percent of that bordered urban areas.

Of the more than 2.8 million acres of farmland being converted every year, two million are devoted to

FIGURE 10.

Cumulative trends in private land converted to developed areas



Source: National Resources Inventory (NRCS 2000a)

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housing. Nearly 94 percent of acreage converted to housing development is attributed to lots one acre or larger in size — 37 percent on lots between one and 10 acres and 57 percent on lots of 10 or more acres. Large-lot (10 or more acres) housing and increasing affluence have accelerated the conversion of agricultural land to non-agricultural uses. More homes on less acreage, called "splatter" development, typically encourage more sprawl, while large-lot housing development removes an inordinate amount of farmland from production.

The consequences of converting agricultural land to non-agricultural uses include the fragmentation of contiguous open land that results in degradation of wildlife habitat, an increase in automobile travel that results in the degradation of air quality and an increase in septic tanks and well-heads that threaten groundwater resources. Land conversion causes widespread impervious areas that increase the amount and intensity of storm water runoff, thus affecting flood and surface water quality. As well, conversion of grazing land near urban areas in the West has created increased fuel and fire hazards and contributed to recent wildfires.

The conversion of farmland to residential use also translates into higher public costs. Studies show that residential development contributes less in tax revenues than it consumes in public service expenditures (schools, utilities and roads). On the other hand, farmland, forestland and open space tend to contribute more in tax revenues than they consume in public service expenditures (Kelsey 1997).

Consequently, federal, state, tribal

Urban/rural interface and USDA

A recent National Association of Conservation Districts survey indicated that in 14 percent of its districts, at least half of the workload was associated with urban and development issues (NACD 2001a). The General Accounting Office (2000) reported 29 percent of cities and 37 percent of counties strongly supported technical assistance from the federal government regarding urban impacts on natural resources.

USDA technical assistance is available to help urban and suburban communities with a variety of conservation tasks such as managing storm water runoff and sediment control in developing areas. Through the Farmland Protection Program, the Department cooperates with tribal, state and local governments and landowners to protect strategically located prime farmland near urban areas.

These efforts are important because agricultural lands contribute to scenic beauty and community character in both urban and rural landscapes. They also provide many environmental benefits — from wildlife habitat to reductions in flood damages, increases in groundwater recharge and absorption of carbon and other greenhouse gases — that are beneficial in both developed and rural landscapes.

and local governments and landowners are acting to protect farmland. To date, 70,246 acres on 367 farms, with an estimated easement value of more than $126.5 million, have been permanently protected from conversion to non-agricultural uses through USDA's Farmland Protection Program. And there is a large unmet demand for additional assistance to local communities. American Farmland Trust estimates that more than half a million acres have not been enrolled in the Farmland Protection Program because of the lack of funding.

Many areas of the country are turning to planning as one way to address concerns about growth. Almost one-third of cities and counties responding to a General Accounting Office survey said they expected to increase their involvement in planning over the next five years (General Accounting Office 2000). Even states such as California, where planning is mandated by state legislation, maintain that existing land-use plans are outdated and that they lack requirements to thwart unplanned growth.

Every day across this country, housing and commercial development encroaches on agricultural lands.

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Wetlands

Wetlands ecosystems provide a variety of goods and services that are valued by society. These include filtering nutrients, trapping sediments and associated pollutants, providing fish and wildlife habitat, dampening floodwater runoff peaks, buffering shorelines from storm impacts, and producing food and fiber for human consumption and use.

Historically viewed as obstacles to productive agriculture and expanding development, wetlands systems are now protected at federal, state and local levels. Many wetlands protection programs specifically address whether human activities unnecessarily eliminate or severely degrade wetlands functions and thus impair their ability to deliver valuable goods and services to society at large.

For example, the Swampbuster provisions of the Food Security Act of 1985, as amended by the Food, Agriculture, Conservation, and Trade Act of 1990, make landowners ineligible for USDA program benefits if they convert wetlands for agricultural commodity production or, after November 28, 1990, if they convert wetlands to make agricultural commodity production possible (NRCS 1997).

The Federal Agriculture Improvement and Reform Act of 1996 provided landowners flexibility in complying with the wetlands conservation provisions of the 1985 Act. The 1996 Act allows landowners to remain eligible for USDA program benefits even if their actions result in conversion of wetlands as long as wetlands functions and values are adequately mitigated (determined by NRCS) and the mitigation meets certain conditions stipulated in the 1996 Act.

In addition, the 1996 Act extended the Wetlands Reserve Program to 2002, with an enrollment cap of 975,000 acres. The Agriculture Appropriations Act for fiscal year 2001 raised the enrollment limitation to 1,075,000 acres. Landowner efforts to restore wetlands on agricultural land resulted in 1,048,629 acres enrolled in the Wetlands Reserve Program as of March 2001 (NRCS Wetlands Reserve Program data).

In 1989, national policy, called “no net loss” of wetlands, was initiated to address the decline of wetlands acreage and functions. That policy continues to be the minimum target for federal agency programs and activities affecting wetlands.

Conditions and trends

The National Resources Inventory estimates there were 111,156,000 acres of wetlands on U.S. non-federal lands in 1997 (Table 3, page 42; NRCS 2000a). The total 1997 acreage of wetlands in the six NRCS administrative regions varied widely. Nearly 31 percent of that total was in the Southeast Region (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia and Puerto Rico). Six percent of that total was in the West Region (California, Hawaii, Idaho, Nevada, New Mexico, Oregon, Utah and Washington).

Approximately 59 percent of the national wetlands acreage existed on forestland and 16.5 percent on agricultural land (cropland, pasture land and land enrolled in USDA’s

Conservation Reserve Program; Table 4). Wetlands extent on forestland was greatest in the Southeast Region, although the East Region exhibited the greatest percentage of wetlands on forestland relative to the total wetlands extent within the region.

Nationally, there was a net loss of 162,800 acres of wetlands from 1992 to 1997, for an average annual net loss of 32,600 (+/-12,900) acres (NRCS 2000a). National gross wetlands losses of 506,000 acres were somewhat offset by gross wetlands gains of 343,200 acres on non-federal lands. These acreage gains resulted from restoration and creation activities and natural causes and as unintentional by-products of various activities (NRCS 2000a).

While wetlands extent is lowest in the urban and developed land class (Table 4), approximately 49 percent of the national gross loss was attributable to development between 1992 and 1997.

This was a change from historical patterns in which agricultural activities have been identified as the major cause of wetlands losses. As Figure 11 on page 44 shows, agricultural activities accounted for average annual losses of 398,000 acres of wetlands from 1954 to 1974 (Frayer et al. 1983) and 157,000 acres from 1974 to 1983 (Dahl and Johnson 1991). The average annual loss rate of 26,800 (+/-4,500) acres from 1992 to 1997 was the smallest average annual loss rate attributed to

TABLE 3.

Changes in wetlands acreage, 1992-1997

(NRCS 2000a; changes within NRCS administrative regions; numbers in parentheses = 95 percent confidence intervals of the estimates; data in thousands of acres)

	Region						
	East	**Southeast**	**South Central**	**Midwest**	**Northern Plains**	**West**	**Total**
1997 Acreage	14,262.8	34,377.9	18,884.9	27,032.1	10,183.3	6,415.0	111,156.0
Gross losses	-57.6 (+/-11.0)	-216.9 (+/-33.4)	-84.1 (+/-14.7)	-74.2 (+/-12.1)	-37.0 (+/-12.8)	-36.2 (+/-11.8)	-506.0 (+/-43.6)
Gross gains	15.4 (+/-5.1)	110.5 (+/-30.9)	78.4 (+/-10.9)	48.4 (+/-8.2)	34.3 (+/-8.0)	56.2 (+/-30.7)	343.2 (+/-46.6)
Net change	-42.2 (+/-12.1)	-106.4 (+/-46.9)	-5.7 (+/-18.3)	-25.8 (+/-14.6)	-2.7 (+/-15.2)	20.0 (+/-32.6)	-162.8 (+/-64.7)
Loss due to agriculture	-5.2 (+/-3.5)	-42.0 (+/-16.1)	-18.3 (+/-5.6)	-38.5 (+/-8.0)	-18.0 (+/-9.7)	-11.8 (+/-6.5)	-133.8 (+/-22.4)
Loss due to silviculture	-9.4 (+/-3.6)	-27.1 (+/-5.4)	-3.8 (+/-1.9)	-14.3 (+/-5.3)	-1.7 (+/-1.2)	-3.8 (+/-2.1)	-60.1 (+/-9.0)
Loss due to development	-38.7 (+/-7.9)	-125.8 (+/-20.6)	-49.9 (+/-12.1)	-21.3 (+/-7.3)	-1.4 (+/-2.6)	-10.4 (+/-7.0)	-247.5 (+/-27.3)
Loss due to miscellaneous activities	-4.3 (+/-4.5)	-22.0 (+/-15.4)	-12.1 (+/-5.7)	-0.1 (+/-0.2)	-15.9 (+/-7.7)	-10.9 (+/-4.9)	-64.6 (+/-19.3)

agricultural activities reported to date (NRCS 2000a).

Losses resulting from silvicultural and miscellaneous activities were almost evenly divided and contributed less to overall wetlands losses than either development or agricultural activities (Table 3).

Gross wetlands losses and gains and net change in wetlands extent also varied among the six NRCS administrative regions (Table 3). Gross losses were greatest in the Southeast Region, comprising almost 43 percent of the national gross loss, and gross losses caused by development were also greatest in that region.

The nation has yet to achieve no net loss of wetlands acreage, but progress is evident. Analysis of changes in the status of wetlands between 1992 and 1997 in the six NRCS administrative regions shows that the West Region came closest to the no net loss goal with a net change of 20,000 (+/-32,000) acres, followed by the Northern Plains Region with a net change of -2,700 (+/-15,200) acres and the South Central Region with a net change of -5,700 (+/-18,300) acres. The other three regions all exhibited net losses.

Wetlands gains were greatest in the Southeast Region, but that region also had the highest net loss (Table 3; NRCS 2000a). The other four regions exhibited net losses.

While human activity has altered and degraded extensive areas of wetlands over a long period of time, wetlands restoration and enhancement have gained popularity and resulted in federal, state and local investments in restoration programs.

TABLE 4.
Wetlands acres by land cover

(NRCS 2000a; land cover type within NRCS administrative regions; number in parentheses = the percent of the total wetlands acreage for each land cover type; data in thousands of acres)

Region	Cropland, pasture land and CRP land	Rangeland	Forestland	Urban and developed land	Other land	Wetlands acreage
East	1,323.3 (9.2%)	0.0 (0%)	11,022.3 (77.2%)	218.9 (1.5%)	1,698.3 (11.9%)	14,262.8 (12.8%)
Southeast	2,269.0 (6.6%)	1,209.1 (3.5%)	25,719.0 (74.8%)	493.3 (1.4%)	4,687.5 (13.6%)	34,377.9 (30.9%)
South Central	3,599.9 (19.0%)	1,069.5 (5.6%)	10,071.6 (53.3%)	309.9 (1.6%)	3,834.0 (20.3%)	18,884.9 (16.9%)
Midwest	4,846.4 (17.9%)	0.0 (0%)	17,083.2 (63.2%)	251.8 (0.9%)	4,850.7 (17.9%)	27,032.1 (24.3%)
Northern Plains	4,083.9 (40.1%)	4,141.1 (40.6%)	339.1 (3.3%)	94.6 (0.9%)	1,524.6 (14.9%)	10,183.3 (9.1%)
West	2,236.8 (34.8%)	1,443.0 (22.4%)	893.3 (13.9%)	39.0 (0.6%)	1,802.9 (28.1%)	6,415.0 (5.7%)
Total	18,359.3 (16.5%)	7,862.7 (7.0%)	65,128.5 (58.5%)	1,407.5 (1.2%)	18,398.0 (16.5%)	111,156.0 (100%)

Thousands of acres of wetlands have been "restored," but many restored wetlands do not provide the same functions and values of the original wetlands.

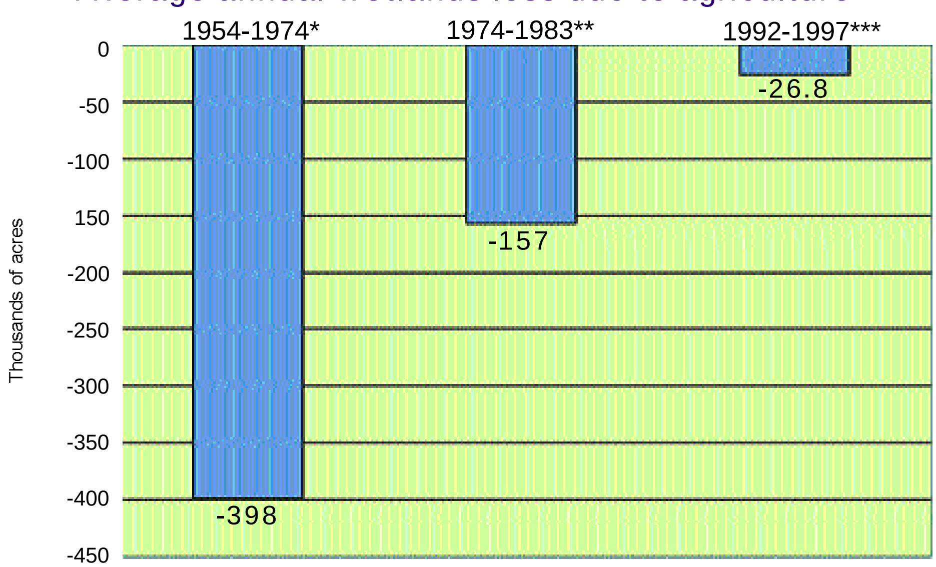
Restoration of wetlands functions is hampered by a lack of knowledge and understanding of the complexities inherent in wetlands ecosystems and their role in the landscape. Natural, unaltered wetlands ecosystems developed over long periods of time in landscapes where ecosystem and physical processes were highly integrated. Many wetlands restoration sites are located on former wetlands that no longer have the benefit of an integrated infrastructure because human activity has altered the landscape on a regional scale. This adversely affects the ability to replicate site-specific characteristics of former wetlands.

Expectations for wetlands restoration and the science of restoration are often at odds. Most restoration programs are short-term and conducted on a local scale. Meaningful restoration requires many years (possibly decades), long-term monitoring, adaptive management practices and attention to the regional landscape.

The lack of controlled experiments limits the knowledge of which restoration techniques successfully return wetlands functions to different levels. Monitoring and adaptive management practices serve as a safety net to document and ensure that former wetlands are in fact restored. Control of invasive species, maintenance of restored hydrology, revegetation and control of human disturbance are just a few of the management investments that must be made if wetlands and their functions are to recover.

FIGURE 11.

Average annual wetlands loss due to agriculture



*1954-74 data from Frayer et al. 1983
**1974-83 data from Dahl and Johnson 1991
***1992-97 data from NRCS 2000a [1997 NRI, which excludes federal lands]
See bibliography in full report for complete references.

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Grazing lands

Grazing lands constitute the largest land use on America's private lands. Grazing lands contribute significantly to the economies of many regions in the United States and play a key role in environmental quality.

Privately owned grazing lands, pastures and rangeland cover more than 500 million acres in this country. An additional 60 million acres of privately owned woodland and forestland also support grazing. Many of these lands provide abundant and clean water supplies in addition to livestock forage. They also improve the aesthetic character of the landscape, provide wildlife habitat and recreational opportunities and protect the soil from water and wind erosion.

Conditions and trends

Rangelands are managed as natural ecosystems to produce the benefits noted above, while pastures are managed more intensely — fertilization and irrigation to attain maximum forage production are common, for example. USDA technical assistance programs have helped to improve nearly 20 million acres of grazing land (Grazing Lands Conservation Initiative data). However, a number of critical resource concerns must still be addressed so that grazing lands can continue to provide diverse benefits.

Maintenance of appropriate plant cover (including natural plant communities) is a primary resource concern on grazing land in this country. Over-use of grazing lands and concentrated livestock numbers place stress on vegetation on grazing lands, particularly in riparian areas or during times of drought. Without proper grazing management — in addition to proper nutrient management on pastures — the quality and quantity of plant cover declines. This causes productivity losses, exposes the soil to damaging wind and water erosion and can impair water quality.

Because grazing land occupies such a large portion of the landscape, degradation of the vegetative cover on grazing lands can have a potentially significant impact on U.S. soil and water resources. It is estimated that about 280 million acres — more than 50 percent — of U.S. grazing lands may be susceptible to such degradation and in need of some form of conservation management (SRM 2000, Smith and Koala 1999). Approximately 50 percent of U.S. pastures, or 60 million acres, is on land that is subject to erosion and other soil limitations if adequate

Juniper and creosote bush invasion on rangeland.

Rangeland in Utah.

ground cover is not maintained (NRCS 2000a).

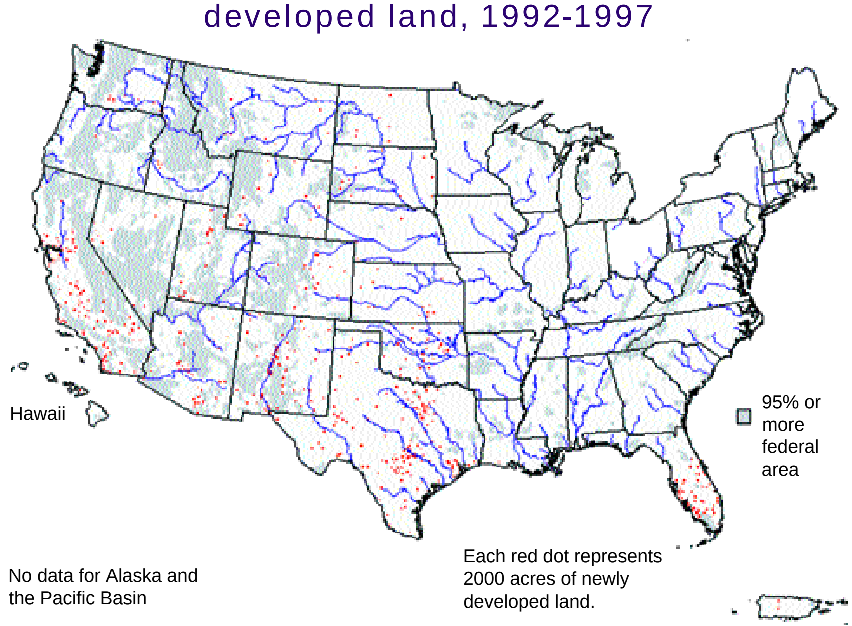
Establishment of invasive species on grazing lands is another resource concern, and it is gaining increased attention. Productivity of grazing lands declines and management becomes more difficult upon the invasion of non-native woody shrubs and trees, noxious weeds and plant species of low forage value. As invasive species take over a site and displace native or introduced forage species, landscape hydrology can be altered. This can adversely affect water quality and quantity, which increases the potential for soil erosion and the risk of damaging floods.

Some invasive species increase the risk of fire. Other impacts include loss of critical wildlife habitat and a reduction in the natural diversity of the landscape. Natural diversity is crucial to an ecosystem's ability to recover from stresses such as fire, drought or flooding.

Loss of grazing land through conversion to other land uses such as cropland and urban development also threaten grazing land resources. About 23 million acres of grazing

FIGURE 12.

Acres of rangeland converted to developed land, 1992-1997



Source: NRCS 2000a

land were converted to cropland over the last 15 years, and about six million acres have been converted to urban and other uses (Figure 12; NRCS 2000a).

More than 90 percent of the original grasslands in a large part of the central United States have disappeared, mainly as a result of conversion to cropland to help meet the nation's food and fiber needs. Remnant grazing lands are the sole repositories of habitats that are critical to the existence of many species. They also represent reservoirs of biodiversity in landscapes affected by urban and agricultural development and the invasion of non-native species (see sidebar on Gray Ranch).

Conserving fragile landscapes and habitats — the Gray Ranch

The Gray Ranch is a 321,000-acre working ranch in the shrub-steppe country of southwestern New Mexico. Within its confines, the ranch captures a large portion of the environmental variability in the region and thus is representative of the region as a whole. The ranch contains grassland, shrubland and woodland; a variety of biophysical environments; and a high level of plant and animal species diversity. The ranch provides habitat and refuge for a large concentration of federal and state threatened and endangered species.

As part of its efforts to preserve the biological heritage of this country, the Nature Conservancy purchased the Gray Ranch — the largest purchase in the history of the Conservancy at that time. The ranch is now owned by the Animas Foundation, which has undertaken long-term research on the impacts of grazing and fire on the flora and fauna of the ranch.

Private forestland

Fifty-eight percent of this country's forestland is private land (Figure 13; Smith et al. In press), and 84 percent of that is in small non-industrial tracts owned by more than 10 million individuals. USDA analyses indicate that the amount of forestland has been relatively stable since the 1920s because losses of forestland to development and other land uses have been offset by reforestation and natural reversion of abandoned cropland and pastures to forest (USDA 2000a).

Small non-industrial forestlands currently produce 59 percent of the annual timber supply (Smith et al. In press). But these lands, when managed in a sustainable way, do much more than provide wood. They store carbon, shelter diverse wildlife, offer recreational opportunities and help cleanse the nation's waters.

FIGURE 13.
Percent of non-federal areas in forest, 1997

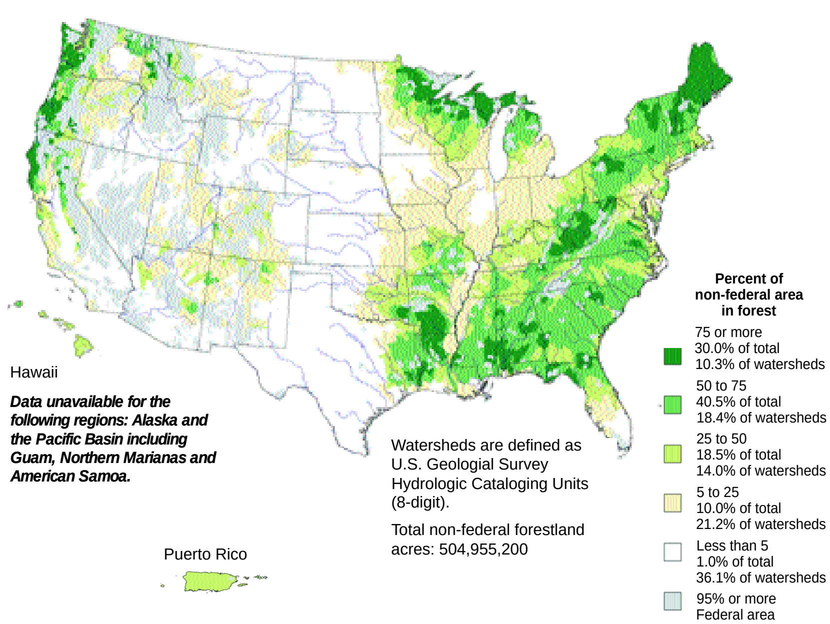
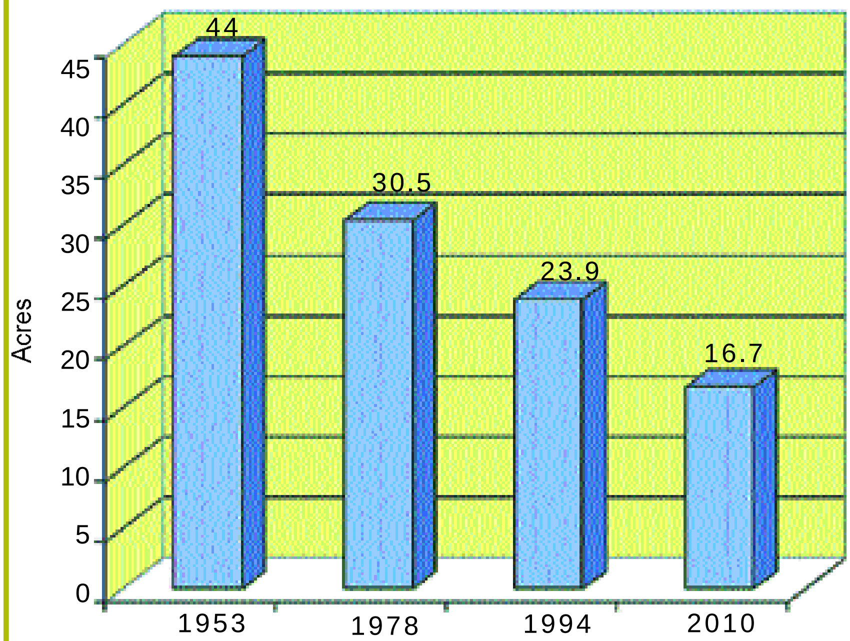


FIGURE 14.
Average size of forest parcels owned by individuals, 1953-2010



Sources: 1953-1994 estimates from Birch 1996, extrapolation to 2010 from Sampson and DeCoster 1997

Conditions and trends

While the forestland base is expected to remain relatively stable in the future, population increases will lead to greater conversion of forests for development purposes. Studies show that forestland is becoming increasingly fragmented as large- and medium-sized forest tracts are subdivided into smaller parcels owned by more people.

The average size of individual holdings is declining steeply. About 70 percent of all new forestland owners in recent years, for example, acquired parcels between 10 acres and 49 acres in size, many of which were formerly part of larger tracts (Birch 1996, Sampson and DeCoster 1997). The average size of all private non-industrial forests tracts dropped from 44 acres in 1953 to 24 acres in 1994 and is expected to drop to 17 acres by 2010 (Figure 14; USDA 2000a).

Every year, about 100,000 owners harvest 2.5 million acres of timber from parcels in the 10- to 49-acre size range. USDA estimates that nearly 15 million acres of small non-industrial forestland is subject to a timber harvest within the next few years (Sampson and DeCoster 1997).

Approximately 40 percent of private forestland would benefit from conservation practices. But only about 10 percent of private forestland acres are managed through conservation planning. One report indicates that owners of smaller tracts view forest management for conservation and timber as only occasionally necessary, primarily because of the lower economic returns and higher costs associated with managing small tracts (USDA 2000b). Increasingly, owners of these smaller parcels make the decision that it is not cost-effective for them to implement conservation techniques such as planting new trees, improving existing timber stands or facilitating natural regeneration of trees. Thus, smaller parcel sizes, increased management costs and landowner decisions have had an impact on the availability of timber from private land. These factors have also led indirectly to degradation of associated soil, water and air quality, as well as a reduction in habitat for certain wildlife species and an increase in fire hazards.

In most cases with small acreage parcels, timber harvest will be a once-in-the-ownership experience, which makes it likely that landowners will have little or no experience with various aspects of timber and resource management. Without experience or knowledge of forest dynamics, landowners may make expensive or damaging errors. A case in point is when a landowner purchases land and simply allows "nature to takes its course." In many such instances, invasive tree species, insect epidemics and wildfires have created detrimental forest conditions that harm the public. As a result, educational, technical and financial assistance for this growing constituency is critical to maintain forest health.

Public benefits are not the only benefits that accrue from proper forest management. A North Carolina study found that where consulting foresters were used, landowners' income from timber sales increased by 20 percent (Cubbage 1996, Sampson and DeCoster 1997).

As the population and the economy continue to grow, U.S. demand for domestic wood products is expected to increase. Historically, more than 88 percent of wood products used in this country have been produced domestically (Haynes et al. 1995). As demand for additional housing space grows and a cutback of timber supplies on national forests occurs, it becomes more likely that small forest tracts will be used for both non-timber and timber purposes. These factors make skilled timber harvest and long-term sustainability critical to the health of the U.S. economy and its natural resources.

In some regions of the country, voluntary cost-share and easement programs such as the Forest Legacy Program (see page 11) have proved to be effective in encouraging landowners to engage in forestry practices to cope with existing resource problems. The goal is to foster income that rewards landowners for the social, environmental and community benefits provided by sustainable management of their forest tracts.

Since 1978, owners of small forest tracts have cooperated with state forestry agencies and USDA to improve more than five million acres of private forestland through the Forestry Incentives Program (see page 11). In Fiscal Year 2000, there was only enough money in this program to fund about 50 percent of the applications received for cost-share projects.

Every year, about 100,000 landowners harvest 2.5 million acres of timber from parcels in the 10- to 49-acre size range. USDA estimates that nearly 15 million acres of small non-industrial forestland is subject to timber harvest within the next few years.

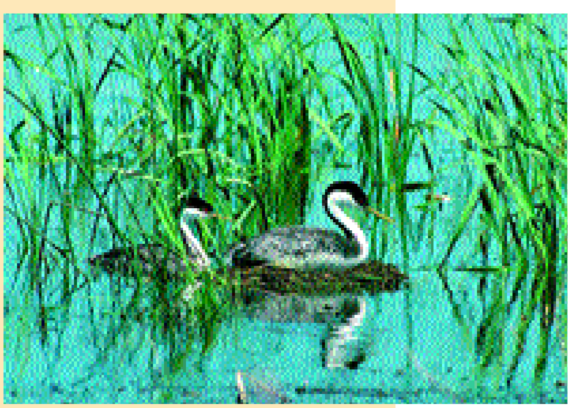
Depending on the amount of acreage they own, different landowners have different needs. USDA researchers have found that those with less than 10 acres generally request educational materials about proper tree care and wildlife. Those with holdings between 10 acres and 100 acres in size also request educational materials along with occasional technical assistance to help them with ecosystem planning and general forest and timber management. The Forest Stewardship Program (see page 11) provides the needed technical assistance to such landowners through forest management planning, restoration of riparian areas, wildlife enhancement and improved supplies of tree seed for reforestation.

Owners of 100-acre to 499-acre forestland tracts — who are traditionally assisted by USDA — often request both technical and financial assistance. Owners of parcels larger than 500 acres in size may hire their own forestry consultants, but still look for research assistance and tax incentives for timber management (Sampson and DeCoster 1997).

In a survey conducted by North Carolina State University, the majority of respondents favored some type of forestry incentives (Megalos and Blank 1997). Nearly 57 percent favored income or property tax incentives, while one-third would likely to participate in cost-share programs, green investment accounts and low-interest loans. More than 50 percent indicated a willingness to participate in on-site visitation by technical experts.

Wildlife habitat

Working lands in this country are the storehouse of many vibrant ecological communities, including wetlands and other aquatic habitats, riparian areas, forests and grasslands. Management of these lands plays a critical role in sustaining healthy fish and wildlife populations. How the land is used is the principal factor determining the abundance of wildlife species. There are multi-resource consequences from land management decisions, whether lands are managed for multi-resource objectives (economic agriculture, soil sustainability, water quality, wildlife habitat, etc.) or for a single purpose objective. The purpose of technical assistance to land users is to expand their vision for the conservation of the broad resource base (soil, water, wildlife and related resources).



Waterfowl benefit from conservation practices on agricultural lands.

A number of USDA programs (described more fully on pages 6 to 13) assist landowners to improve wildlife habitat on their lands, while other programs discourage practices that degrade wildlife habitat. The Wildlife Habitat Incentives Program provides financial incentives to develop fish and wildlife habitat. In 1999, approximately 720,000 acres — comprising upland, wetlands, riparian and aquatic habitats — were enrolled

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in this program, bringing the total number of acres in the program to 1,392,000.

The Conservation Reserve Program offers incentives to establish conservation cover on environmentally sensitive cropland and to carry out conservation practices such as riparian forests buffers, filter strips, hedgerows and grassed waterways. Enrolled lands provide food and cover for upland wildlife species and reduce sediment delivery to streams, which helps improve habitat quality for fish and other aquatic life. Currently, nearly 33.5 million acres are enrolled in the program.

The Wetlands Reserve Program provides incentives to restore formerly degraded wetlands to more naturally functioning conditions, with emphasis on high-quality wildlife habitat. As of March 2001, there were 1,048,629 acres enrolled in the program. Concomitantly wetlands conservation provisions discourage land users from converting wetlands for agricultural production.

Other conservation programs such as the Environmental Quality Incentives Program, Forestry Incentives Program and Farmland Protection Program hold the potential for substantial fish and wildlife habitat benefits.

Conditions and trends

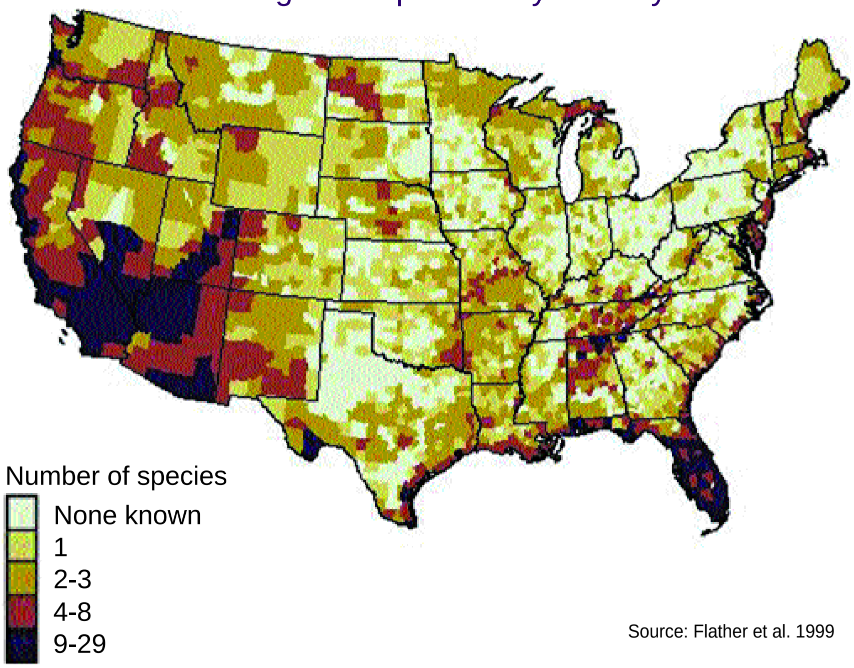
Management of land affects wildlife habitat in two principal ways. Some land management actions result in direct changes in land use (kinds of vegetation) while other actions result in changes in management practices. Changes in habitat quality and availability directly affect wildlife at both individual and population levels. Fragmentation and loss of habitat from urban and suburban development, intensive agricultural uses and the introduction of invasive species, among other factors, contribute to the decline in populations of many game and non-game species.

In many cases, these effects have resulted in the need to list declining species as threatened or endangered under provisions of the Endangered Species Act. Eighty-five percent of listed species are threatened or endangered because of loss and degradation of their habitat (Wilcove et al. 2000).

In the United States, there are now 1,234 species of plants and animals listed by the federal government as threatened or endangered (U.S. Fish and Wildlife Service 2000). While approximately 33 percent of known populations of threatened and endangered species occur on federal land, the majority of listed species occur on non-federal land (or water). The occurrence of threatened and endangered species is not uniform across the United States but is clustered in "hotspots" of species endangerment (Figure 15, page 52; Flather et al. 1999).

Grasslands represent an important habitat type providing crucial habitat for more than one-half of this country's nesting ducks, as well as many other grassland-dependent wildlife species. Grasslands used within their capability continue to support multiple activities such as livestock grazing in addition to wildlife habitat. When used beyond their capability, their

FIGURE 15.
Distribution of threatened and endangered species by county



Source: Flather et al. 1999

value as habitat diminishes. Pasture and rangeland habitats declined by 7.5 million acres from 1992 to 1997 (NRCS 2000a) as 6.1 million acres of pasture and 1.4 million acres of rangeland were converted to other uses. The change from 1982 to 1997 was a decline of 22.8 million acres — 12 million acres of pasture with rangeland accounting for the remainder.

During the period 1966 through 1996, there were also substantial declines in grassland and shrubland nesting birds. Twelve of 27 (44 percent) grassland nesting species and 26 of 85 (31 percent) shrubland nesting bird species exhibited significant decreasing population trends during this period (Flather et al. 1999).

The northern bobwhite (quail) is an example of a bird that has exhibited rangewide declines in abundance over the last three decades. Based on data from the USGS Breeding Bird Survey (estimating mean abundances over a minimum of three years within five-year windows centered on specific years), bobwhite distribution has undergone reduction and centers of abundance have become more fragmented (Figure 16). These declines in abundance are the result of direct habitat losses as well as degradation in quality of existing habitat. It is presumed that technological advances have made possible more intensive use of the land in addition to competition from other land uses.

Population trends for some species from 1985 to 1996 show signs of possible recovery. The proportion of grassland nesting birds with decreasing trends dropped to 22 percent and shrubland-nesting birds with decreasing trends to 19 percent (Resources Planning Act data on file with Flather and Brady). CRP has likely played an important role in the observed changes in the population trends of these two groups. In a summary of the literature, Heard et al. (2000) found that grassland bird abundance and nest density in midwestern CRP fields exceeded abundance and nest density in surrounding cropland habitats and that nesting success on CRP lands equals or exceeds that in alternative nesting cover.

Grassland habitats on land enrolled in CRP have also proven valuable to nesting waterfowl in the Prairie Pothole Region of the upper Midwest. For example, CRP lands in the Pothole area of North Dakota,

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South Dakota and Montana represent only six percent of the nesting cover in this area. But they account for 31 percent of all duck nesting activity (Heard et al. 2000). Studies show that between 1992 and 1997, those CRP lands contributed to a 30-percent improvement in duck production, or 10.5 million additional ducks (Heard et al. 2000).

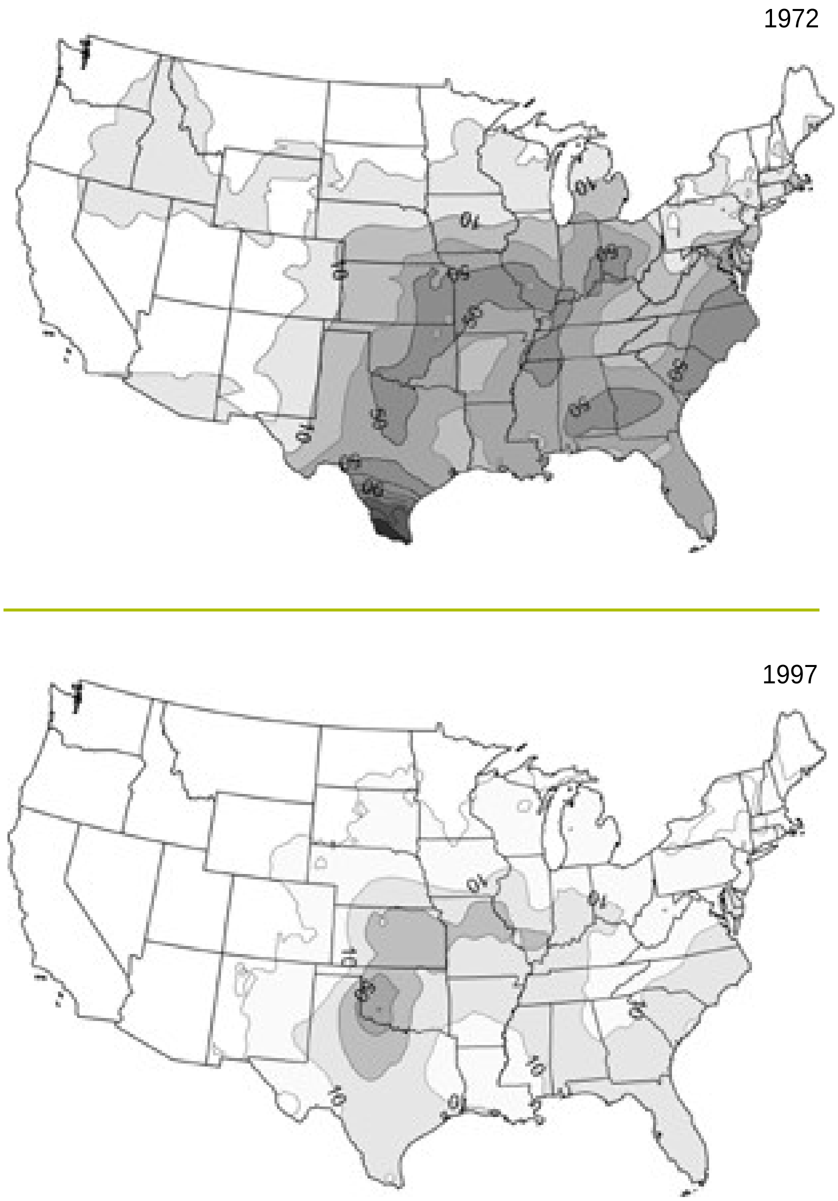
While such gains in grassland habitats can be attributed to CRP and other habitat conservation programs, they may also be offset by continued conversion of grasslands to other uses.

The structure and function of forests, riparian and wetlands areas on working lands support a broad diversity of terrestrial and aquatic wildlife species, many of which are listed as threatened or endangered. But these habitats have been affected by conversion to cropland and urban development, drainage, pollution, overgrazing and invasive species. In the eastern portion of the country, less than one percent of original old-growth forest remains, and 99 percent of grasslands and more than one-half of pre-colonial wetlands have been converted to other uses (Wildlife Management Institute 2001). While non-federal forest area has increased by 3.6 million acres since 1982, the additional acreage is not all suitable habitat. Forests that provide suitable wildlife habitat generally consist of a broad array of tree and shrub species adapted to the site. Stands planted to single species (for example, pines) for intensive cultivation generally result in poor habitat.

Approximately 2.7 million acres are enrolled in CRP in the southeastern states, with more than 62 percent of the total acreage dedicated to tree

FIGURE 16.

Distribution and relative abundance of the northern bobwhite, 1972 and 1997



Relative abundance was estimated from the USGS Breeding Bird Survey (BBS) based on three-year averages of each route within a five-year window centered on the year of interest. Contour lines represent the average number of bobwhites observed on BBS routes and were drawn at intervals of 0, 10, 30, 50, 70 and 90 bobwhites per route.

planting. However, much of this area is planted in monoculture pine stands, and potential wildlife benefits in the region remain unrealized (Heard et al. 2000). Wetlands restored through programs such as the WRP are making a significant contribution to wetlands wildlife conservation, particularly in areas of high enrollment such as the lower Mississippi Valley and are partially offsetting past losses of wetlands wildlife habitat (Heard et al. 2000).

Efforts such as the Wildlife Habitat Incentives Program, Conservation Reserve Program and Wetlands Reserve Program have done much to conserve and establish habitat for wildlife. However, they reach only a small proportion of the non-federal land base. Effective habitat management for wildlife is best achieved when integrated into the overall land management plan. Generally as soil-conserving measures increase, wildlife habitat quality also improves. Some soil conservation techniques directly benefit habitat quality in that they provide one or more critical habitat elements incidental to their erosion control function. Often, conservation technical assistance is all that is needed to change an economic enterprise into an ecologically sustainable operation with multiple resource benefits.