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RCA Appraisal

Soil and Water Resources Conservation Act

2011

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RCA Coordinator: Dan Mullarkey, NRCS

USDA RCA Interagency Working Group Members

Ted Beauvais, FS
Jim Benson, NRCS
Andrea Clarke, NRCS
Denise Coleman, NRCS
Margaret Connelly, FS
Anthony Crooks, RD
Noel Gollehon, NRCS
Sharon Hestvik, RMA
Skip Hyberg, FSA
Kevin Ingram, NRCS
Rich Iovanna, FSA
Linda Langner, FS
Patty Lawrence, NRCS
Daryl Lund, NRCS
Mervalin Morant, NIFA
Dan Mullarkey, NRCS
Tommie Parham, NRCS
Renee Picanso, NASS
Mary Ann Rozum, NIFA
Steven R. Shafer, ARS
Michael Shannon, ARS
William Smith, RD
Patrick Sullivan, ERS

Key to agencies: ARS—Agricultural Research Service, ERS—Economic Research Service, FS—Forest Service, FSA—Farm Service Agency, NASS—National Agricultural Statistics Service, NIFA—National Institute of Food and Agriculture, NRCS—Natural Resources Conservation Service, OCE—Office of the Chief Economist, RD—Rural Development, RMA—Risk Management Agency

Conservation is a state of harmony between men and land.

—Aldo Leopold

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Soil and Water Resources Conservation Act

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Foreword

The Soil and Water Resources Conservation Act (RCA) provides broad natural resource strategic assessment and planning authority for the U.S. Department of Agriculture (USDA). The RCA calls for—

- A continuing *Appraisal* of the Nation's soil, water, and related resources that documents the current status and trends of soil, water, and related natural resources; the capability of these resources to meet current and projected demands; the effects of regulations, policies, and programs on these resources; and the cost and benefits of conservation measures applied under USDA conservation programs and alternative conservation approaches.
- A *National Conservation Program* to guide USDA assistance to landowners for conserving soil, water, and related resources on non-Federal land. The Program evaluates the Nation's natural resource problems; effectiveness of current authorities and programs; alternative methods for achieving conservation objectives; and costs and benefits of alternative conservation practices.

Congress reauthorized the RCA in 2008, making targeted changes in the language, adjusting the timing of reports, and retaining the hallmark public RCA process. To obtain the views of the public, USDA conducted a series of listening sessions, focus groups, and nationwide surveys in 2009 and 2010. Comments and ideas about the most pressing natural resource concerns, the workability of the existing USDA program of soil and water conservation, and new program and policy needs were gathered from about 2,200 individuals—from farmers, ranchers, and forest landowners to interest groups, State and local agency officials, and many others. From this diverse array of interested individuals emerged a clear picture of priority natural resource concerns. Water resources (quality and availability) topped the list of the most pressing natural resource issues facing agriculture and the environment. Companion concerns of soil quality, invasive species, and wildlife habitat were also among the highest concerns identified.

This 2011 RCA Appraisal provides an overview of land use and the U.S. agricultural sector; of the status, condition, and trends of natural resources on non-Federal lands; and USDA's program for soil and water resources conservation. Looking ahead, it examines interrelated issues that have implications for U.S. agriculture and forestry: climate change, biofuels production, and the quality and availability of water.

Executive Summary

Most of the area of the United States remains rural despite the accelerating trend toward urbanization since the early 1980s. Rural land and water make up well over 90 percent of the non-Federal area of the United States, and most of the rural area is agricultural or forested land.

The dynamic nature of rural land-use change was evident over the 25-year period 1982 to 2007 as the land shifted among agricultural and forested uses. Over the period, the net acreage of non-Federal forest land remained stable, the net acreage of non-Federal rangeland declined slightly, and the net acreages of cropland and pastureland declined more sharply.

The exception is development of rural lands for urban and transportation uses, which increased steadily throughout the period. More than 1 out of every 3 acres of developed land, was developed between 1982 and 2007.

Middle-sized farms are losing ground to smaller as well as larger size operations. The percentage of farmers who are tenants or part-owners is increasing, as is the share of farmers' income derived from off-farm sources.

Technology is improving the productivity and sustainability of U.S. farms. Genetically engineered crops, improved fertilizers and pesticides, and management innovations such as conservation tillage and improved irrigation efficiency have combined to increase farm output.

New and expanded markets for U.S. farm goods—both domestically and internationally—continue to challenge not only farmers' capacity to produce commodities but also their conservation ethic.

Agriculture has been described as a "leaky" system. That is, some tradeoffs are unavoidable among the competing demands that we place upon our farmers, ranchers, and foresters: To produce food, feed, and fiber for consumption in the United States and for export. To provide habitat for wildlife. To provide scenic vistas and recreational opportunities. To do all of these things and more with minimal impact on the natural environment.

By and large, producers have responded positively and well to these challenges. Since the early 1980s, total soil erosion on cropland has declined by more than 40 percent in total and by more than 30 percent on a per-acre basis.

Nevertheless, soil erosion on highly erodible cropland remains a concern. Fifty-two percent of all cropland erosion occurred on the 27 percent of the cropland that was classified as highly erodible land.

Nearly 80 percent of U.S. non-Federal rangeland is in stable condition. Soil erosion by water or wind and the presence of invasive species degrade the condition of the remaining 20 percent to some degree.

Wetland gains outpaced losses during the decade 1997 to 2007—an unprecedented occurrence. Gross annual gains of 69,000 acres outpaced gross annual losses of 44,000 acres.

The United States invests billions of dollars each year in an ongoing soil and water conservation program. These investments and the strong partnerships with State and local governments, private land owners and managers, and many other organizations and groups have helped to improve the state of the Nation's natural resources.

USDA uses a variety of approaches for natural resource conservation. Nine USDA agencies have some conservation responsibility. Program approaches include research, technical assistance, working lands programs, land retirement programs, land preservation programs, landscape scale programs, emergency response programs, and rural development programs.

Climate change and biofuels development will have growing influence on land use patterns and natural resource conditions in the agriculture and forestry sectors.

Average temperatures are expected to climb by up to 2 degrees Celsius from 1990 levels over much of the United States by 2030. As climate changes, agriculture and forestry will need to adapt to those changes and help to curb future changes by sequestering carbon and reducing greenhouse gas emissions.

Agriculture in the American Southwest, an area already chronically short of water, could be severely challenged if precipitation declines by up to the predicted 5 percent. Extreme weather events could become more common, and the range of weeds and insect pests could expand. Increased precipitation along with warmer temperature in the East, Midwest, and Northern Plains, however, could provide a longer growing season and a more agreeable climate for crop production.

Agriculture and forestry sequester atmospheric carbon dioxide. From 2000 through 2005, carbon sequestration increased in cropland soils, forests, urban trees, and harvested wood products.

Biofuels production is expected to grow in response to policy drivers that emphasize energy independence. Most biofuels are currently produced from corn, but future bioenergy feedstocks are expected to come from cellulosic materials, switchgrass, crop residues, wood, and other sources.

Water resources are the foundation for meeting demands for food, feed, and fiber today and in the future. Current and future challenges in water resource management are amplified by new demands on agricultural and forest landscapes and the effects of climate change.

Agriculture remains the Nation's principal water user. Some 57 million acres of U.S. cropland are irrigated; farmers use efficient pressure irrigation systems on about 40 percent of these acres.

Competition for water, especially in arid regions of the West, is expected to increase pressure on irrigated agriculture. Many of the areas experiencing the greatest population growth are those where water supplies already are facing challenges.

Despite progress in recent years, agriculture remains a source of water quality concern. Movement of sediment, nutrients, pesticides, and pathogens into surface water supplies and leaching of nutrients into groundwater remain concerns.

Potential exists to improve irrigation water use while sustaining yields in every basin. Conservation applied on all irrigated cropland could provide nationwide improvement, while the largest potential gains are concentrated in four basins.

Conservation treatment need to minimize potential for nutrient and sediment loss varies widely by material and basin. Comprehensive conservation treatment of the critically under-treated 20 percent of cultivated cropland acres could deliver 54 percent and 45 percent of potential sediment and nutrient reductions, respectively.

CHAPTER 1

Land Use

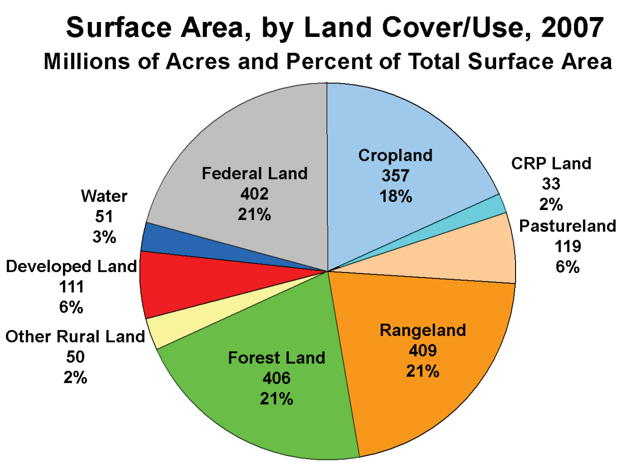
CHAPTER 1

Land Use

The United States and associated territories cover more than 2.3 billion acres of land and water (3.6 million square miles). The conterminous 48 States comprise more than 1.9 billion of these acres, about two-thirds of which are privately held working agricultural and forest lands used mainly for the production of food, fiber, and energy (fig. 1-1). Most Federal lands are in the western United States. Tribal lands, also mostly in the West, are reflected in figure 1-1 in the respective major land uses. U.S. towns, cities, transportation corridors, and other developed areas cover about 6 percent of the total area of the conterminous 48 States (USDA-NRCS 2009).

Figure 1-1.

Distribution of land uses, conterminous 48 States, 2007



NOTE: When data were gathered for the 2007 National Resources Inventory (NRI), there were about 33 million acres of cropland under Conservation Reserve Program (CRP) contracts; as of September 2010, about 31.3 million acres were under CRP contracts.

NOTE: National Resources Inventory (NRI) data on land use for Alaska, Hawaii, and the U.S. territories are unavailable. For 2007, the USDA Census of Agriculture reported approximately 309,000 acres of cropland, 2.1 million acres of grazing lands, and 121,000 acres of non-Federal forest land in Alaska and Hawaii.

Sources: USDA-NRCS/2007 NRI; USDA-NASS/2007 Census of Agriculture; USDA-FSA.

Sources of data

USDA agencies draw upon many sources for information. The principal source of information in chapters 1 and 3 is the National Resources Inventory (NRI), a statistical survey of land use and natural resource conditions and trends on non-Federal land conducted by the Natural Resources Conservation Service. NRI data are physically and biologically based and are statistically designed to accurately represent national and State natural resource conditions and trends. Other sources include the Census of Agriculture conducted by USDA's National Agricultural Statistics Service and data from the Forest Service's Forest Inventory and Analysis (FIA) National Program, as well as non-USDA data sources such as the Bureau of the Census and other Federal and State agencies.

Differences in land use and other estimates are due mainly to differences in definitions. For example, the NRI "developed land" category differs from that used by some other data collection entities. For the NRI, the intent is to identify which lands have been permanently removed from the rural land base. Therefore, the developed land category includes (1) large tracts of urban and built-up land; (2) small tracts of built-up land of less than 10 acres; and (3) land outside of these built-up areas in roads, railroads, and associated rights of way (rural transportation lands). Another example: For the NRI, land is considered irrigated if irrigation occurs during the year of inventory, or during 2 or more of the 4 years prior to the inventory. Other entities typically consider land to be irrigated only if irrigation water is applied during the year of interest.

Land uses change over time (table 1-1) and vary from region to region (fig. 1-2). Cropland makes up 52 percent of the Corn Belt and 44 percent of the Northern Plains. Forest land is the dominant land cover in the Northeast, Appalachian, Southeast, Delta States, and Lake States regions. Federal land is concentrated in the Mountain and Pacific Regions, and rangelands occur primarily in the Mountain, Southern Plains, and Northern Plains regions.

Examining net change in land use reveals general trends but masks the real extent of land use change over time. Rural land uses frequently shift among cropland, pastureland, rangeland, and forest land. These land-use changes can affect erosion potential, contiguity of habitat, hydrologic features of the landscape, and other natural processes or functions. Conversion of rural lands for development is the exception; such conversions generally do not revert to other uses.

Table 1-1.

Net changes in major land cover/uses, conterminous 48 States, 1982–2007

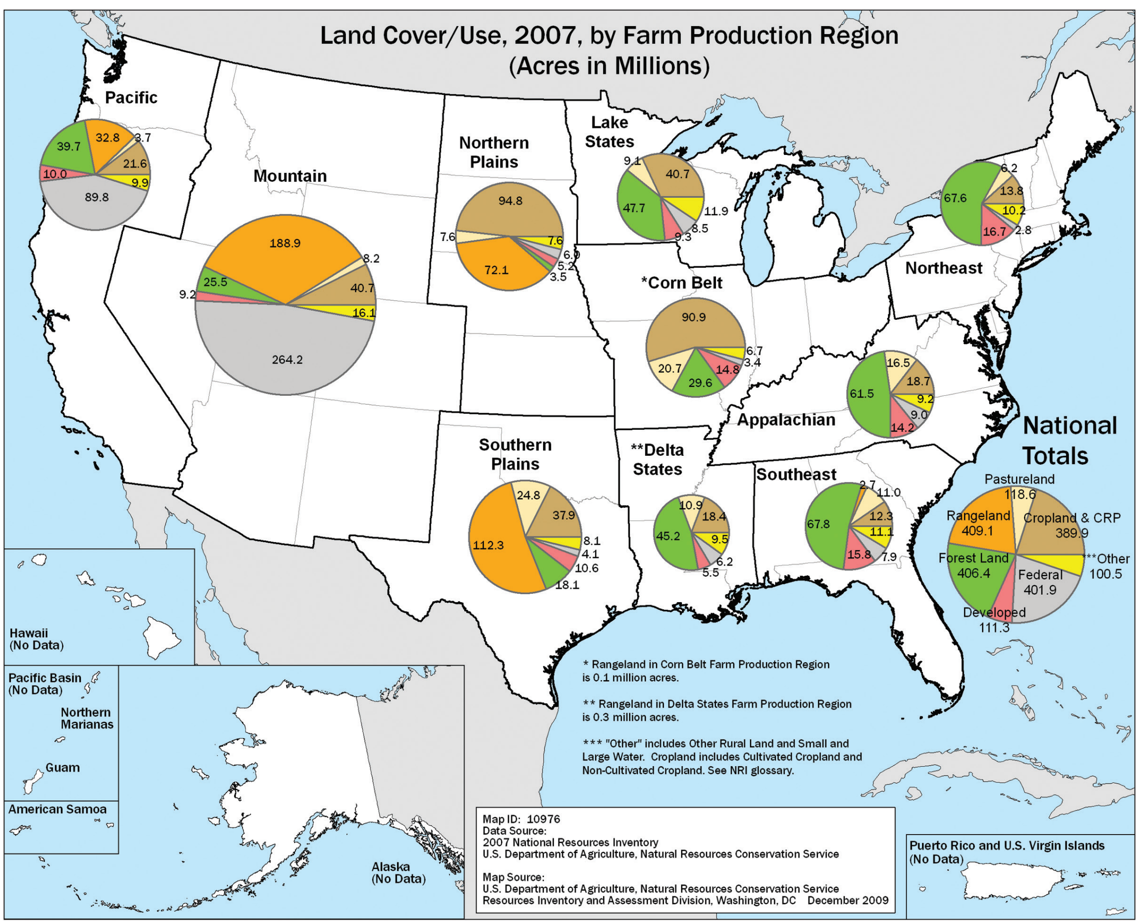
		2007 land cover/uses (million acres)						
		Cropland	Pastureland	Rangeland	Forest land	Developed land	Other land cover/uses	1982 total
1982 land cover/uses (million acres)	Cropland	326	30	7	9	11	37	420
	Pastureland	19	78	5	18	7	4	131
	Rangeland	7	3	392	3	5	8	418
	Forest land	2	5	2	372	17	5	403
	Developed land	--	--	--	--	70	1	71
	Other land cover/uses	3	3	3	4	1	481	495
	2007 total	357	119	409	406	111	536	1,938

"Other land cover/uses" includes land under contract in the Conservation Reserve Program, other rural land, water areas, and Federal land areas.

To read this table: The number at the intersection of rows and columns with the same land cover/use represents acres that were in the same land cover/use category in both 1982 and 2007. The numbers to the left or right of this number represent acres lost to another land use during the period. The numbers above or below this number represent acres gained from another land use during the period. Comparing the "1982 total" column to the "2007 total" row represents the net acres gained or lost over the 25-year period. For example, total cropland acreage declined from 420 million acres in 1982 to 357 million acres in 2007. Some 19 million acres of pastureland were converted to cropland while approximately 30 million acres of cropland were converted to pastureland over the period.

Figure 1-2.

Distribution of land uses, by farm production region, conterminous 48 States, 2007



Source: USDA-NRCS/2007 NRI

Cropland

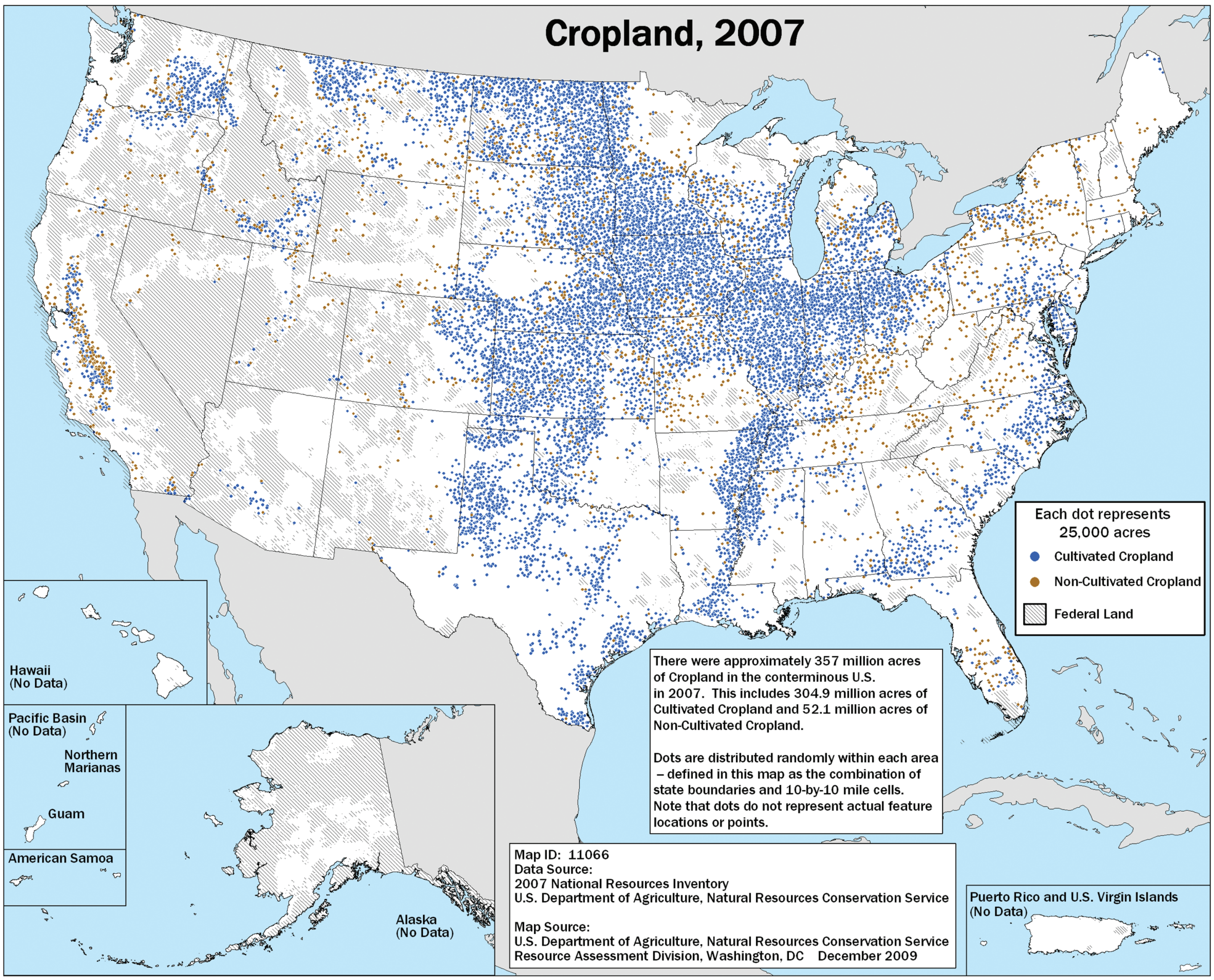
Cropland includes land in cultivated and noncultivated crops. Cultivated cropland is in row crops or close-grown crops and noncultivated crops grown in rotation with cultivated crops. Noncultivated cropland includes permanent hayland and horticultural crops such as fruits, nuts, and ornamental plants.

Cropland in the United States is concentrated in the Northern Plains, Corn Belt, and Delta States (fig. 1-3). Nationally, cropland acreage declined from 420 million acres in 1982 to 357 million acres in 2007—about 15 percent over the period (fig. 1-4). The reduction in cropland acreage includes 33 million acres enrolled in the Conservation Reserve Program (CRP), many of which could be cropped again in the future. In addition, between 1982 and 2007 over 30 million acres of cropland were converted to pastureland while 19 million acres were converted from pasture to cropland (fig. 1-5).

The percentage of cropland that is not cultivated has increased since 1982. Noncultivated cropland—hayland and land in orchards, horticultural crops, and the like—increased from 44 million acres in 1982 to 52 million acres, or 15 percent of cropland acreage, in 2007. Net cropland acreage declined

Figure 1-3.

Location of cropland, conterminous 48 States, 2007



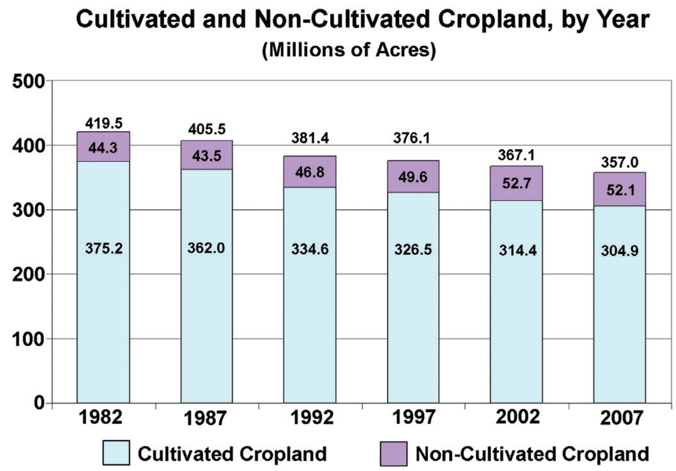
Source: USDA-NRCS/2007 NRI

in each of the 10 farm production regions between 1982 and 2007. The greatest losses were in the Southern Plains (12 million acres), Mountain region (10 million acres), Northern Plains (7 million acres), and Southeast (7 million acres).

Between 1982 and 2007, more than 11 million acres of cropland were developed for urban, suburban, and transportation use and essentially lost to agricultural use; about 18 percent of these losses were in the Corn Belt, with substantial losses also in the Appalachian, Northeast, Southeast, and Lake States regions. The smallest losses of cropland to development occurred in the Delta States and Northern Plains regions.

Figure 1-4.

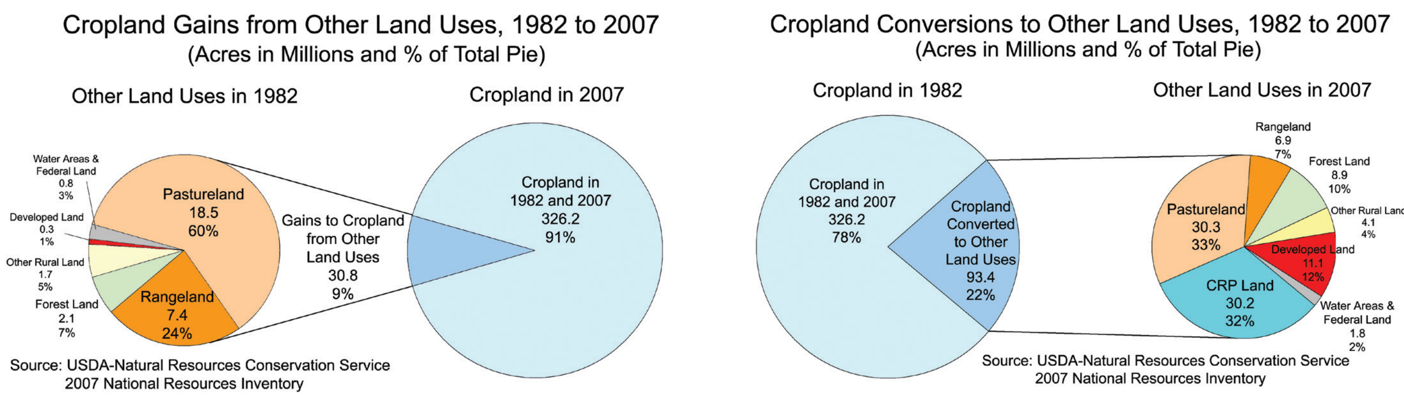
Trends in acreage of cultivated and noncultivated cropland, conterminous 48 States, 1982–2007



Source: USDA-NRCS/2007 NRI

Figure 1-5.

Gains and losses of cropland, conterminous 48 States, 1982–2007



Source: USDA-NRCS/2007 NRI

These charts show net changes in land use over the 25-year period 1982–2007. Additional shifts in land use occurred during the intervening years. See also table 1-1, page 3.

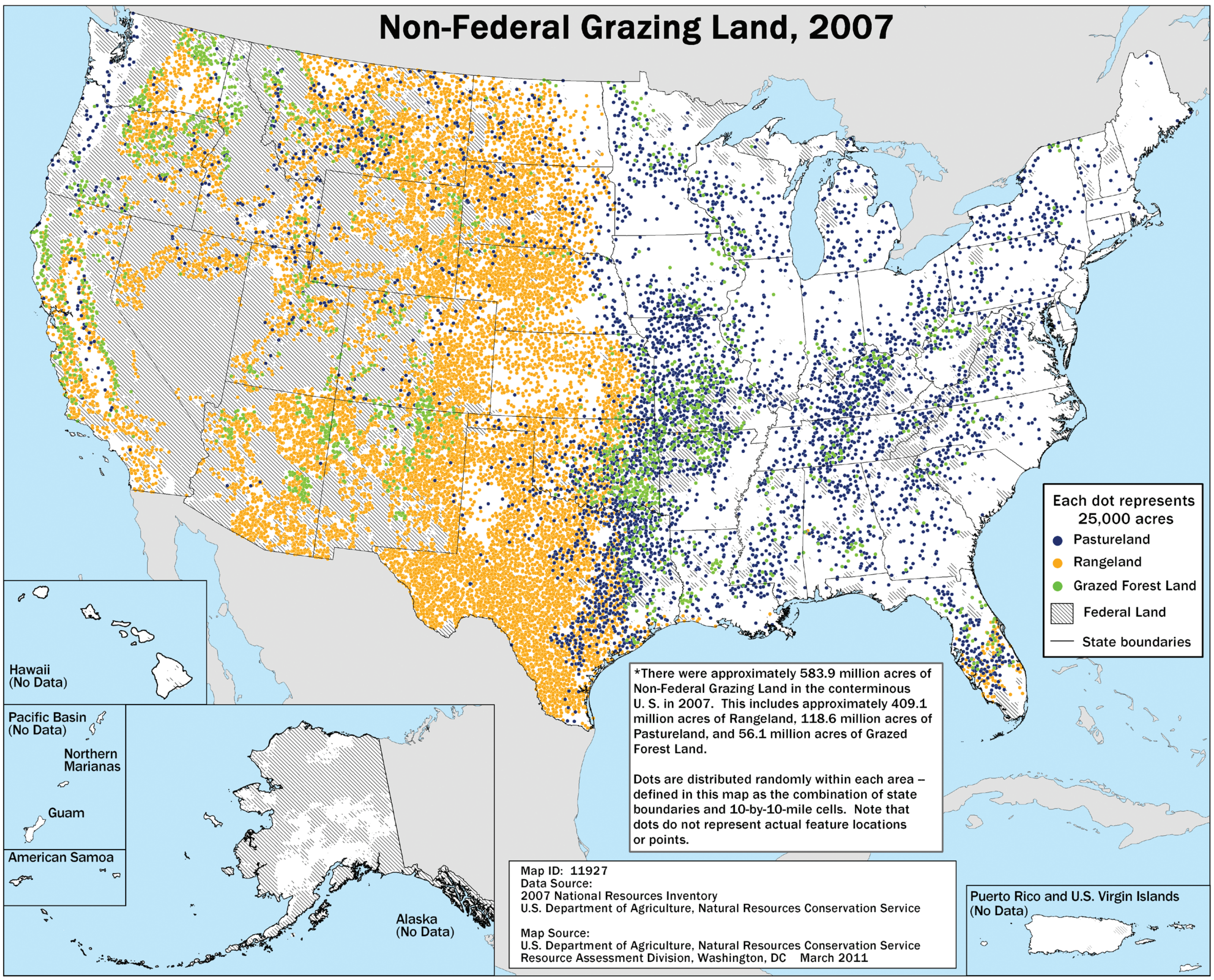
Non-Federal grazing lands

Grazing lands include rangeland, pastureland, and grazed forest. Pastureland is used primarily for the production of introduced forage grasses for livestock grazing. Rangeland is land on which the climax or potential plant cover is composed of plants suitable for grazing and browsing. Grazed forest land includes understory plants that can be grazed without significantly impairing other forest values. (See the Glossary for more complete definitions.) There are 584 million acres of non-Federal grazing lands in the conterminous 48 States—409 million acres of rangeland, 119 million acres of pasture, and 56 million acres of grazed forest (fig. 1-6).

During the 25-year period 1982 to 2007, the acreage of U.S. grazing lands declined gradually until 2002 and then stabilized (fig. 1-7); rangeland acreage declined by about 2 percent; pastureland acreage, by 9 percent; and grazed forest land acreage, by 15 percent. Some 6.8 million acres of pastureland and 5.2 million acres of rangeland were developed for urban, suburban, and transportation uses (figs. 1-8 and 1-9).

Figure 1-6.

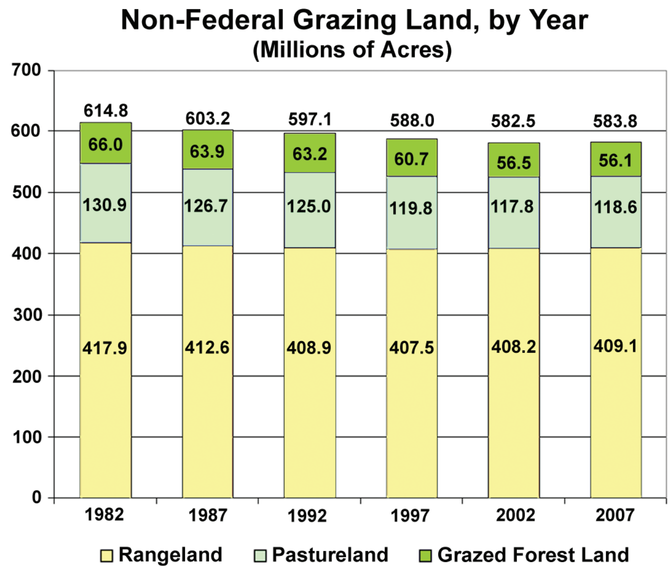
Location of non-Federal grazing lands, conterminous 48 States, 2007



Source: USDA-NRCS/2007 NRI

Figure 1-7.

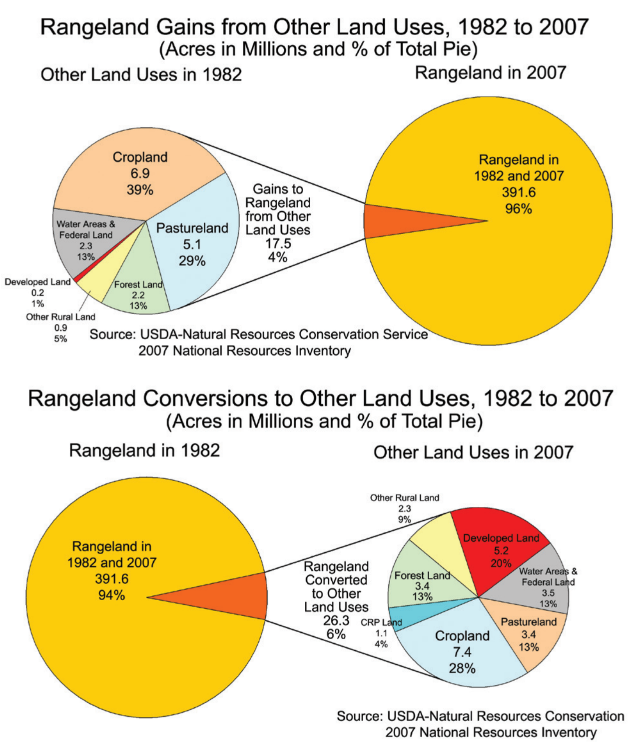
Trends in acreage of non-Federal grazing lands, conterminous 48 States, 1982–2007



Source: USDA-NRCS/2007 NRI

Figure 1-8.

Gains and losses of non-Federal rangeland, conterminous 48 States, 1982–2007

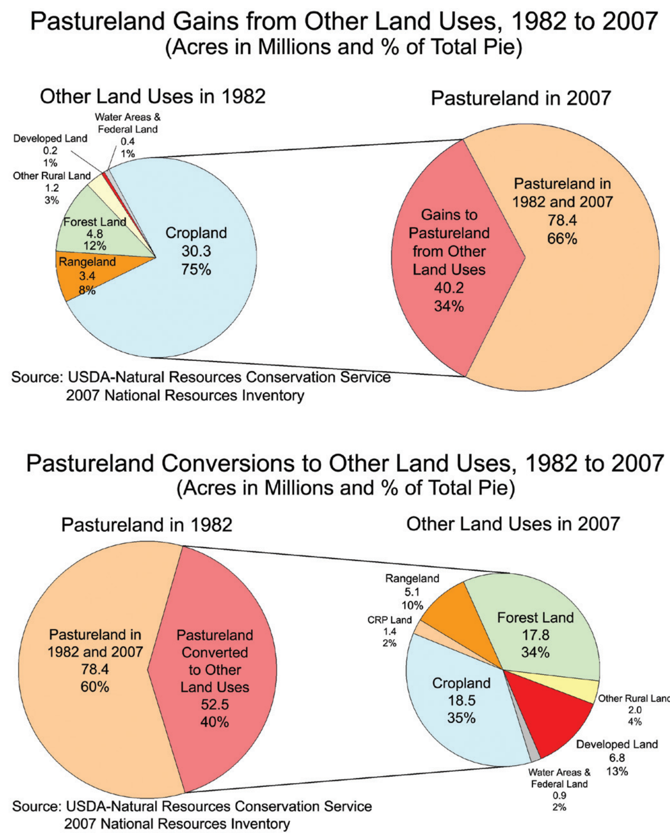


Source: USDA-NRCS/2007 NRI

These charts show net changes in land use over the 25-year period 1982–2007. Additional shifts in land use occurred during the intervening years. See also table 1-1, page 3.

Figure 1-9.

Gains and losses of non-Federal pastureland, conterminous 48 States, 1982–2007



Source: USDA-NRCS/2007 NRI

These charts show net changes in land use over the 25-year period 1982–2007. Additional shifts in land use occurred during the intervening years. See also table 1-1, page 3.

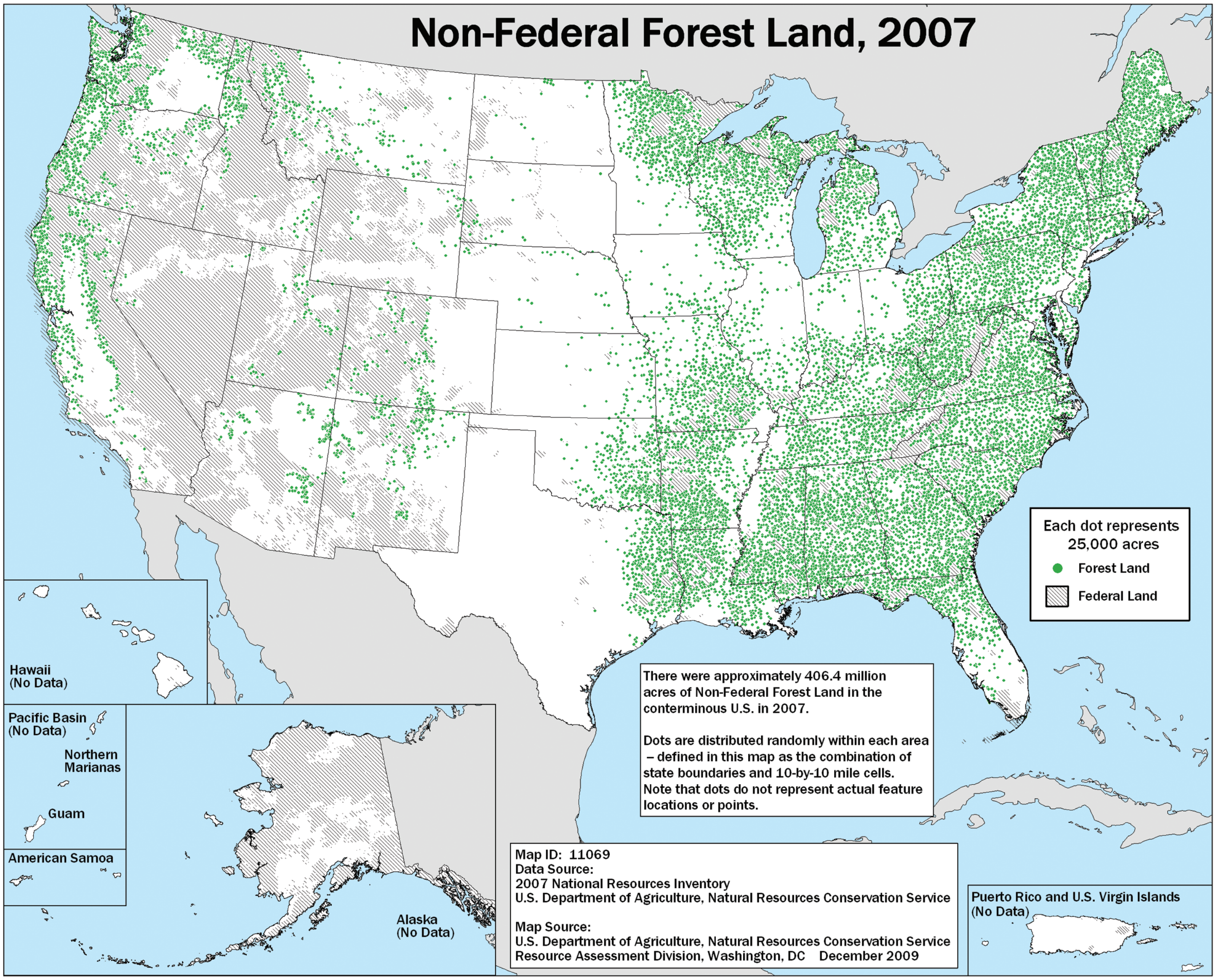
Non-Federal forest land

Forest land, as defined by the National Resources Inventory (NRI), includes land parcels of at least 1 acre that support single-stemmed woody species that are at least 4 meters tall at maturity and whose canopy covers at least 25 percent of the surface area. The Forest Service uses a slightly different definition of forest land,[1] but the NRI definition of forest land is used in this Appraisal for consistency with definitions of other land uses.

It has been estimated that in 1630 forest land covered just over 1 billion acres—about half the total land area of what is now the conterminous United States (Smith et al. 2009). Since 1630, a net of nearly 300 million acres of forest land have been converted

Figure 1-10.

Location of non-Federal forest land, conterminous 48 States, 2007



Source: USDA-NRCS/2007 NRI

[1] The Forest Service defines forest land as land at least 120 feet wide and 1 acre in size with at least 10 percent cover (or equivalent stocking) by live trees of any size, including land that formerly had such tree cover and that will be naturally or artificially regenerated. Forest land includes transition zones, such as areas between forest and non-forest lands that have at least 10 percent cover (or equivalent stocking) with live trees and forest areas adjacent to urban and built-up lands. Roadside, streamside, and shelterbelt strips of trees must have a crown width of at least 120 feet and continuous length of at least 363 feet to qualify as forest land. Unimproved roads and trails, streams, and clearings in forest areas are classified as forest if they are less than 120 feet wide or an acre in size. Tree-covered areas in agricultural production settings, such as fruit orchards, or tree-covered areas in urban settings, such as city parks, are not considered forest land. This definition is consistent with the forest definition used by the United Nations Food and Agriculture Organization for global forest assessment.

to other uses—mainly agricultural. Nearly two-thirds of the net conversion to other uses occurred in the eastern United States in the last half of the 19th century, when 13 square miles of forest were cleared every day on average (MacCleery 2002).

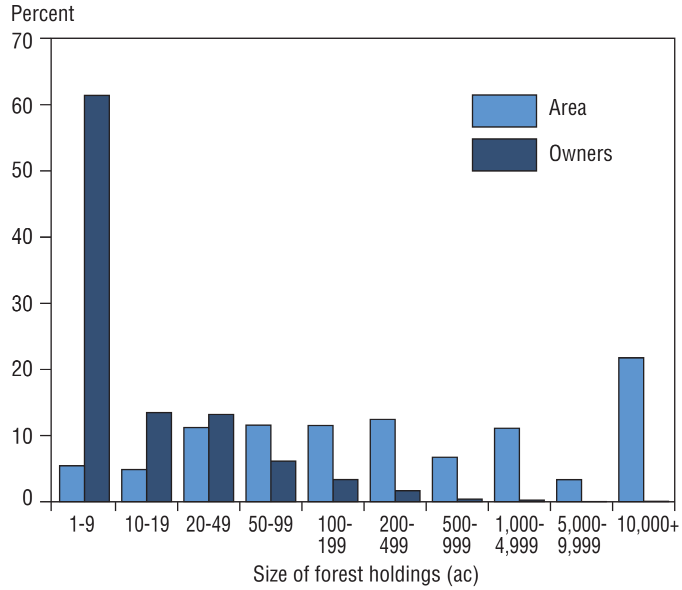
The last 100 years have seen relative stability in the Nation's forest acreage. Stability, however, should not be interpreted as "no change"—there is 50 percent more forest in the Northeast now than there was in 1900, slightly less along the southern and western coasts, and more in the interior West. This is the result of social and economic pressures as well as natural events. Urban development, fires and fire suppression, timber production, improved farming practices, natural disasters, and major Federal assistance programs have all influenced the size, location, and contiguity of today's forests.

According to the NRI, non-Federal forest land covered about 406 million acres of the conterminous 48 States in 2007—a slight increase from 403 million acres in 1982 (USDA-NRCS 2009). About 84 percent of all non-Federal forest land is in the eastern United States (fig. 1-10). Although during the 25-year period 1982 to 2007 more newly developed land came from forest land than from any other single land use, conversions of cropland, pastureland, or rangeland to forest land more than kept pace (fig. 1-11).

Nearly 11 million forest owners hold private forest land in the United States (Butler 2008, Smith et al. 2009). About 67 percent of private forest land is in parcels of 100 acres or more, and forested parcels of 10,000 or more acres account for 22 percent of the private forest land (Butler 2008) (fig. 1-12).

Figure 1-12.

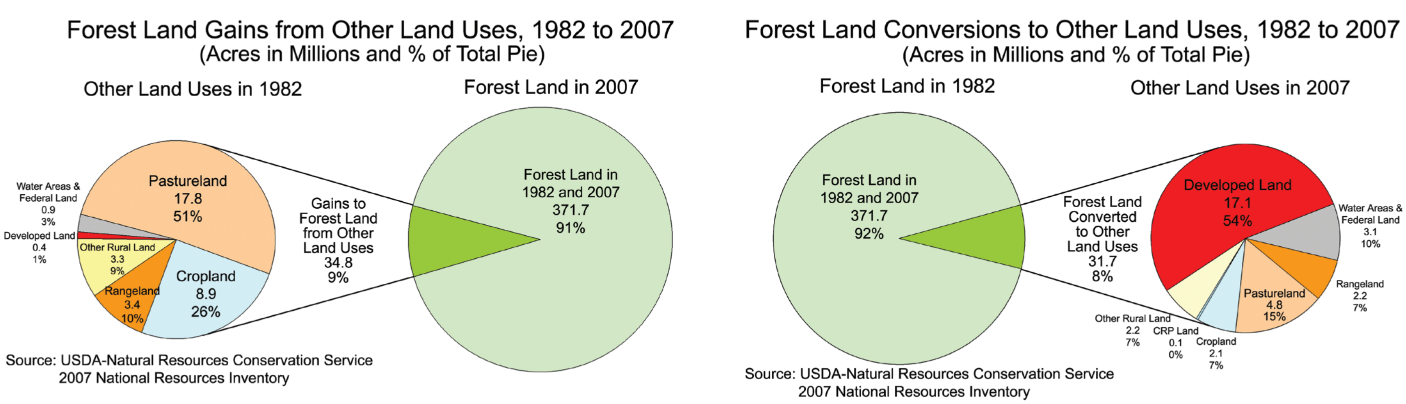
U.S. private forest land, by size and ownership



Source: USDA-Forest Service

Figure 1-11.

Gains and losses of non-Federal forest land, conterminous 48 States, 1982–2007



Source: USDA-NRCS/2007 NRI

These charts show net changes in land use over the 25-year period 1982–2007. Additional shifts in land use occurred during the intervening years. See also table 1-1, page 3.

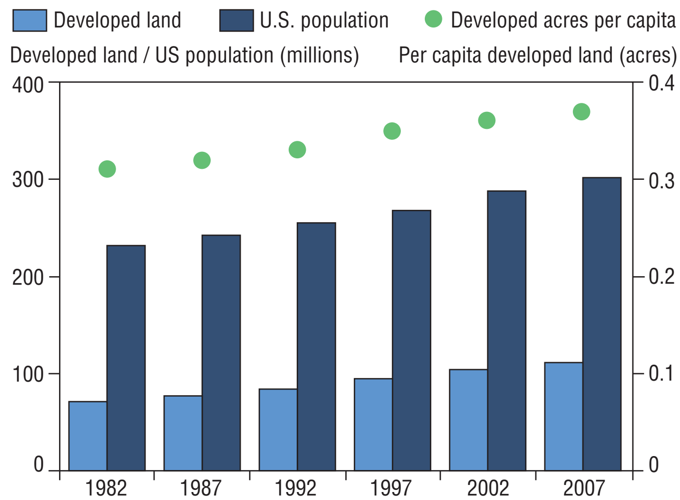
Developed land

Developed land includes not only large urban and built-up areas of 10 acres or more but also small built-up areas and transportation corridors. Land in residential, industrial, commercial, and institutional uses, including such uses as cemeteries, golf courses, small parks, landfills, railroads, and highways, is considered to be developed. Areas of less than 10 acres that are completely surrounded by urban and built-up land are also considered to be developed land.

As America's cities grow in population, they grow in area as well. It is not uncommon for a large city's commuting area to stretch many miles into the countryside. Nor is it rare to see tightly clustered and large-lot developments many miles from the city center. These developments—including the roads and service facilities that support them—take up many acres of land and increase farmland conversion pressures. Figure 1-13 shows that the developed area of the United States has grown faster than the population. Figure 1-14 shows the change in areas of urban and built up land between 1982 and 2007. In rapidly urbanizing areas such as greater Atlanta, GA, these

Figure 1-13.

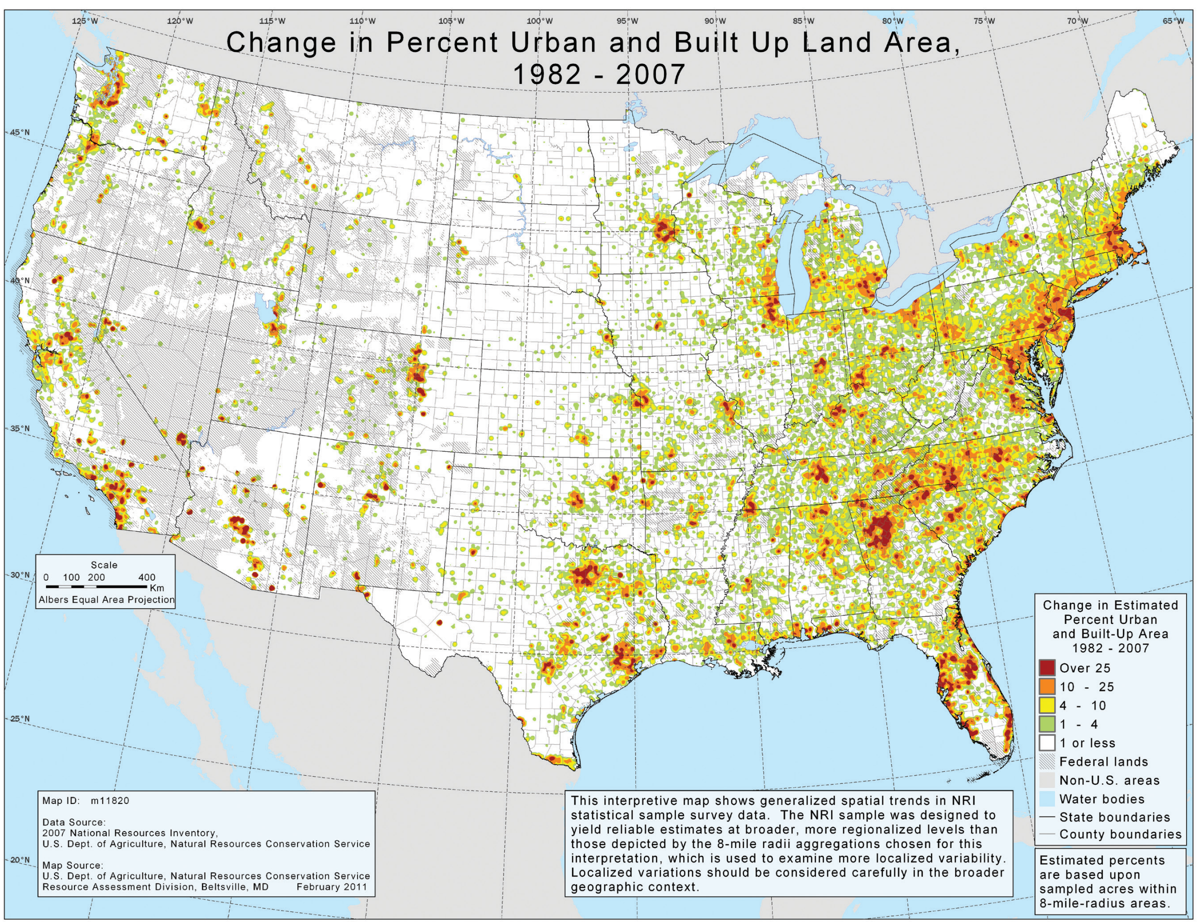
Trends in growth of developed land and population growth, conterminous 48 States, 1982–2007



Sources: USDA-NRCS/2007 NRI, Census population estimates program, 2009

Figure 1-14.

Newly developed land, conterminous 48 States, 1982–2007



Source: USDA-NRCS/2007 NRI

areas show up as rings around the existing inner city. The green areas on the map show that many rural areas, especially in the East, are also experiencing development pressure.

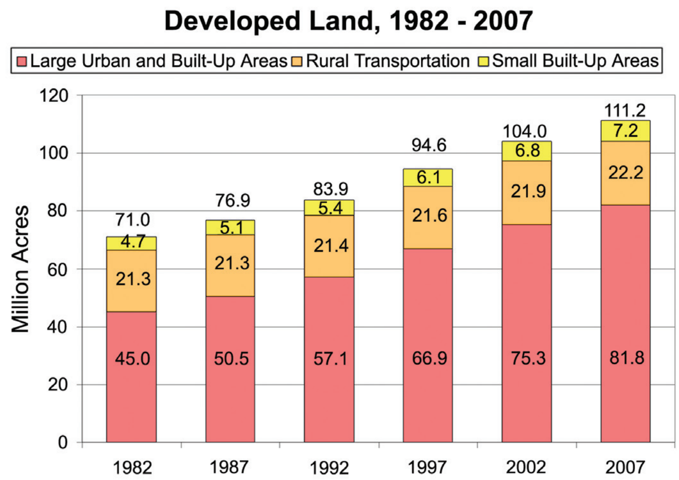
U.S. urban lands remain a fraction of the Nation's total land area, but the total acreage of developed land in the conterminous 48 States increased by more than 56 percent between 1982 and 2007—from 71 million acres to 111 million acres. Although the rate of development slowed toward the end of the period, more than one-third of all land ever developed in the United States, was developed between 1982 and 2007 (fig. 1-15).

About 41 percent of all land that was developed during the period 1982 to 2007 was forest land, 27 percent was cropland, 17 percent was rangeland, 13 percent was pasture, and the rest was other rural land. These percentages held fairly constant throughout the period. Some 14 million acres of prime farmland—about 4 percent of the best current and potential farmland in the United States—were developed between 1982 and 2007; the acreage of prime farmland converted for development was almost equal to the area of West Virginia. The Corn Belt lost more than 2 million acres of prime farmland during this period, and the Appalachian, Southern Plains, Northeast, and Southeast regions each lost between 1.3 and 1.9 million acres of prime farmland. The smallest losses of prime farmland occurred in the Northern Plains and Delta States.

Nearly 40 percent of the value of U.S. agricultural production occurs on farms within the boundaries of metropolitan areas. Another 18 percent occurs in nonmetropolitan counties adjacent to metropolitan areas. Between 1982 and 2002, nonmetropolitan areas lost a higher percentage of their farms (7 percent) than did metropolitan areas but a smaller percentage of farmland (5 percent).

Figure 1-15.

Trends in acreage of developed land, conterminous 48 States, 1982–2007



Source: USDA-NRCS/2007 NRI

Conclusion

Despite an increasingly urban population, most of the United States remains rural. Rural land and water make up well over 90 percent of the non-Federal area of the United States, and most of the rural area is agricultural or forested land.

The dynamic nature of rural land-use change was evident over the 25-year period 1982 to 2007. Over this period, the net acreage of non-Federal forest land remained stable, the net acreage of non-Federal rangeland declined slightly, and the net acreages of cropland and pastureland declined more sharply. However, rural land uses frequently shift among cropland, pastureland, rangeland, and forest land. These land-use changes can affect erosion potential, contiguity of habitat, hydrologic features of the landscape, and other natural processes or functions. The area of developed land increased steadily throughout the period, and such conversions generally do not revert to other land uses.

Development pressure is only one of many factors that affect land use. The changing structure of agriculture in the United States, the global economy, technological innovation, and other factors combined with individual decisions made by land owners and operators will shape tomorrow's landscapes. See chapter 2 for an overview of trends in U.S. agriculture.

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CHAPTER 2

An Overview of Agriculture in the United States

CHAPTER 2

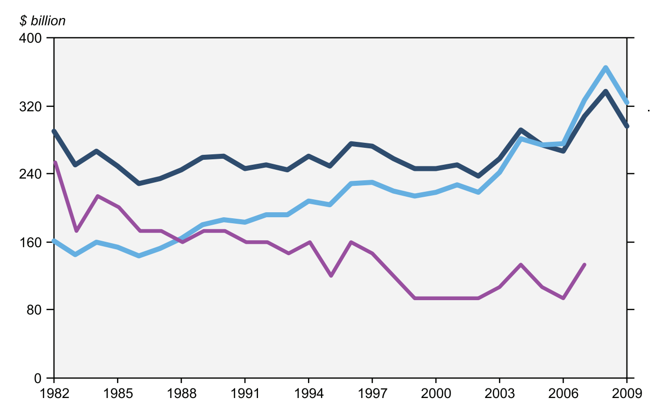
An Overview of Agriculture in the United States

Agriculture provides abundant food and fiber for American consumers and for export markets. Because agricultural land uses[1] occupy most of the area of the United States, their impact on the environment—both positive and negative—can be profound. This section provides an overview of the economic factors and public policies that affect agriculture.

The *extent* of land and labor in production agriculture has declined slowly but steadily over the past 30 years. The *amount* of food and fiber produced on this land, however, increased substantially over that time due to the combined influences of technological advances, more efficient management, and increased use of chemicals and machinery. Because the *value* of agricultural production has been outpaced by increases in the prices of nonfarm goods and services, the contribution of agricultural production to the Nation's gross domestic product fell gradually from roughly 2 percent in 1980 to less than 1 percent in 2008 (fig. 2-1). Farming provided over 2.6 million jobs in 2008, or about 1.5 percent of all U.S. jobs (down from 3.3 percent in 1980). Still, agricultural exports consistently exceed agricultural imports; since 1990, agriculture has accounted for 6 to 10 percent of the annual value of U.S. exports.

Figure 2-1.

Value of agricultural sector production and farm share of gross domestic product



Source: Economic Research Service, USDA and National Economic Accounts, Bureau of Economic Analysis. Constant dollar figures are based on the GDP chain-type price index with 2005 as the base year.

[1] In this context, agricultural lands include Federal and non-Federal cropland, rangeland, and pastureland.

The structure of agriculture

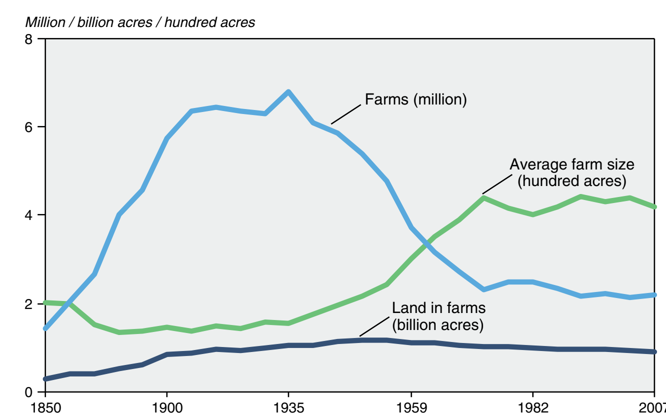
Until recently, the value of U.S. agricultural sales was split almost evenly between crops and livestock. In 2009, however, the share of farm cash receipts from crop sales increased to 59 percent, up from 48 percent in 2005. This growth was driven by increasing sales of feed grain and oil crops, due both to increased global demand and to their increasing use in biofuels production. As feed prices rose, production of meat animals and dairy products declined. These shifts in production can impact natural resources by changing the use of inputs, including water for irrigation, and by changing conservation practices.

Farm size, farm income, and landownership

After peaking at 6.8 million in 1935, the number of U.S. farms fell sharply until 1978 before stabilizing at about 2.2 million (fig. 2-2). Although the total number of farms has changed little over the past 30 years, the numbers of very small and very large farms have increased while the number of mid-sized farms has declined. Farm operations with annual sales of $1 million or more (in constant 2007 dollars) more than doubled between 1982 and 2007 and accounted for 59 percent of total farm sales. In 2008, over 90 percent of the total value of U.S. agricultural production occurred on just 17 percent (378,172) of all farms (table 2-1).

Figure 2-2.

Farms, land in farms, and average acres per farm, 1850–2007



Source: Census of Agriculture, NASS, USDA.

Table 2-1.

Average farm size, tenure, value of production, and household income by farm typology, 2008

Category	Farm typology grouping								
	Limited resources	Retirement	Residential/ lifestyle	Farming-occupation/ lower sales	Farming-occupation/ higher-sales	Large	Very large	Nonfamily	All
Farms, number	231,561	320,144	872,748	389,220	106,412	93,832	115,952	61,976	2,191,844
Farms, percent of U.S. total	10.6	14.6	39.8	17.8	4.9	4.3	5.3	2.8	100.0
Value of production, million dollars	2,999	4,191	12,314	10,736	21,196	39,026	173,546	46,399	310,407
Value of production, percent of U.S. total	1.0	1.4	4.0	3.5	6.8	12.6	55.9	14.9	100.0
Average farm size, acres	185	169	163	315	970	1,210	1,980	1,392	408
Land operated, percent of U.S. total	4.8	6.0	15.9	13.7	11.5	12.7	25.7	9.7	100.0
Farms by tenure, percent									
Full owner	73.2	85.0	70.7	65.9	33.3	21.7	23.0	68.1	65.7
Part owner	20.7	13.2	24.4	28.0	56.7	66.5	63.7	19.9	28.3
Tenant	6.0	*1.8	4.9	6.1	10.0	11.8	13.3	12.0	6.0
Acres by tenure, percent									
Full owner	49.2	74.9	55.4	51.7	24.9	15.1	10.5	39.0	34.0
Part owner	43.3	20.4	37.7	40.8	64.4	75.0	74.8	43.6	55.3
Tenant	*7.4	*4.7	6.9	7.5	10.7	9.9	14.7	*17.4	10.7
Mean household income	6,478	66,975	90,491	52,144	68,313	99,409	250,359	NA	78,803
On-farm earnings[1]	-9,458	*-1,505	-8,448	*-5,137	23,920	58,045	196,045	NA	8,770
Off-farm income	15,936	68,480	98,939	57,282	44,393	41,364	54,314	NA	70,032
Households with:									
Negative farm earnings, percent	79.6	66.0	80.1	62.7	28.6	21.9	20.7	NA	66.4
Negative total household income, percent	24.1	3.0	1.8	8.1	15.5	14.2	14.5	NA	7.5

Source: 2008 USDA Agricultural Resource Management Survey.

[1] Farm earnings are based on cash items only, with the exception of a deduction for depreciation. Farm earnings also exclude the share of net income generated by the farm paid to other households, such as those of partners.

See box below for definitions of terms used in this table.

Farm typology

USDA defines a farm as any place that produced and sold—or normally would have produced and sold—at least $1,000 of agricultural products during a given year. USDA uses acres of crops and head of livestock to determine if a farm or ranch with sales of less than $1,000 could normally produce and sell that amount.

Small family farms (sales less than $250,000)

Limited resource farms. Low income in both the current and previous year (less than the poverty level for a family of four with two children, or less than half the county median household income); and low sales in both the current and previous year (less than $100,000 in 2003 and indexed thereafter).

Retirement farms. Small farms whose operators report that they are retired, although they continue to farm on a small scale.

Residential/lifestyle farms. Small farms whose operators report a major occupation other than farming.

Farming-occupation farms. Small farms whose operators report farming as their major occupation.

Lower-sales. Gross sales less than $100,000.

Higher-sales. Gross sales between $100,000 and $249,999.

Large family farms. Farms with gross sales between $250,000 and $499,999.

Very large family farms. Farms with gross sales of $500,000 or more.

Nonfamily farms. Any farm where the operator and persons related to the operator do not own a majority of the business.

In 1980 the average farm household received roughly 23 percent of its total income from farming, with the other 77 percent coming from nonfarm sources. By 2008, the average farm household received only 11 percent of its income from farming (Economic Research Service 2010a). However, these averages mask the striking distinctions in farm income by operation type. The typical very large family farm (see farm typology box on page 15) received 78 percent of its income from farming in 2008. The 1.8 million smaller farms—limited resource, retirement, residential/lifestyle, and family farms with annual gross sales under $100,000—on average received almost all of their income from off-farm sources (table 2-1).

This diversity of farm types suggests a range of production and conservation motivations among owners and operators. Conservation programs that appeal to large producers may not be attractive to these smaller producers, who control more than 40 percent of farm and ranch lands. Some small acreage farmers may conclude that the paperwork burden outweighs the potential gains of applying for financial assistance. The prevalence of off-farm employment suggests that smaller operators may have less time to devote to labor-intensive conservation practices, and small farm sizes and sales may limit their opportunity to invest in capital-intensive practices. To the extent that many of these operators are new farmers who have limited experience with USDA and with conservation (as was often stated in public listening sessions and focus groups conducted to inform this Appraisal), this trend implies an increasing demand for education, outreach, and technical assistance.

Farms operated by part owners (those who both own and rent land) and tenants (those who rent all their land) were larger, on average, than similar operations of 30 years ago, and on average are larger than those operated by full owners. In 2007, part owners operated 915 acres on average (up 17 percent since 1978) while tenants operated 582 acres (up 52 percent). In addition, constant dollar sales per farm grew for both tenure classes—doubling for part owners and tripling for tenants between 1978 and 2008. This trend away from full ownership could have implications for conservation to the extent that operators have less control over the land and less incentive to conserve natural resources.

Location of production

Production patterns emerge and evolve as producers learn which climates and soil types are best suited to specific products. The Northeast and Lake States had long been known for dairy production; the Corn Belt, for corn and hogs; the Northern Plains, as a major source of wheat; and the Pacific Coast, for fruits and vegetables. Over the period 1982 to 2007, historic production patterns changed. For example, corn production outside the Corn Belt increased, wheat production shifted northward, and cotton production shifted eastward. Dairy production has shifted westward (MacDonald et al. 2007), North Carolina experienced a large increase in hog production during the 1980s (Key and McBride 2007), and poultry production increased in the South (MacDonald 2008).

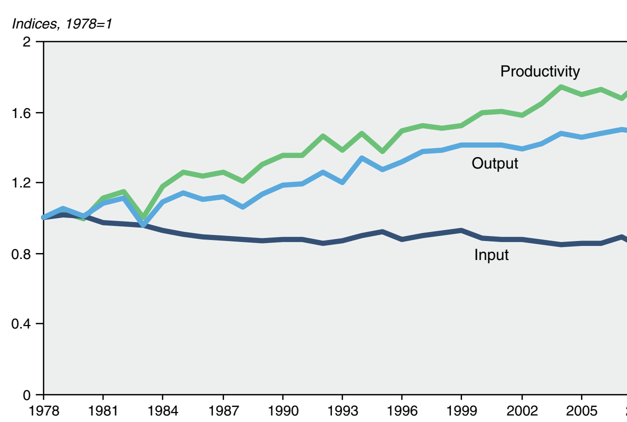
Commodity production shifts into new areas can impact local and regional natural resource conditions as well as policies affecting the use of those resources. For example, in 1997, following rapid growth in its hog industry, North Carolina imposed a moratorium on confined hog operations with 250 or more animals in response to concerns about odor and impacts on water quality. Since each crop has its own input requirements, changing production patterns can have positive or negative impacts or natural resources. As farmers responded to shifting price signals over the last decade by growing more corn and less cotton, application of both fertilizer and pesticides declined in affected areas, reducing stress on water resources. As corn production increased outside the Corn Belt into areas that previously grew wheat, so too did the amount of fertilizer being applied to fields, along with associated nutrient run-off and leaching problems (Malcolm et al. 2009).

The impact of technology

Agricultural output can increase in a number of ways—through, for example, heavier use of agricultural inputs such as fertilizer, the adoption of new technologies such as genetically modified crops, better animal husbandry, refinements in irrigation technology, or improvements in machinery and chemicals. Between 1978 and 2008, total factor productivity—a measure of the effect of technology changes and improved use of inputs—grew 78 percent. As a result, even as the amount of land and labor used in farming declined, total farm output grew by nearly 50 percent (fig. 2-3). Technological developments have often increased the economies of scale enjoyed by larger farms, so productivity trends and the concentration of production on fewer, larger farms have reinforced each other.

Figure 2-3.

U.S. agricultural output, input, and total factor productivity



Source: Economic Research Service, USDA.

Genetically engineered crops

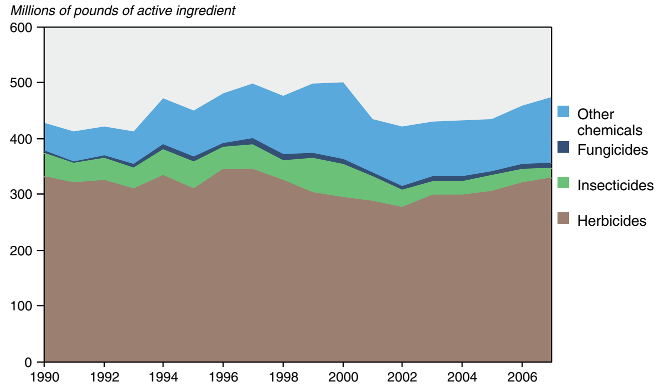
U.S. farmers have widely adopted genetically engineered crops since their introduction in 1996. USDA survey data show that herbicide-tolerant crops accounted for 93 percent of U.S. soybean acreage, 78 percent of cotton acreage, and 70 percent of corn acreage in 2010 (Economic Research Service 2010b). Insect-resistant crops containing the gene from the soil bacterium Bt (*Bacillus thuringiensis*) have been available for corn and cotton since 1996. Bt produces a protein that is toxic to specific insects. Plantings of Bt crops accounted for 73 percent of U.S. cotton acreage and 63 percent of corn acreage in 2010.

Pesticide use

During the period 1990 to 2007, total use of herbicides, fungicides, and other chemicals on five major crops—corn, soybeans, cotton, wheat, and fall potatoes—increased modestly, while use of insecticides declined (fig. 2-4). Changes in herbicide application rates in corn, soybeans, and cotton were due to the increased use of herbicide-tolerant seed varieties. The shift toward herbicide-tolerant crops has been accompanied by increased use of the herbicide glyphosate and a shift away from more toxic herbicides (National Research Council 2010). The adoption of Bt resulted in reductions of insecticides applied to corn and cotton.

Figure 2-4.

Active chemical ingredients applied to corn, soybeans, cotton, wheat, and fall potatoes



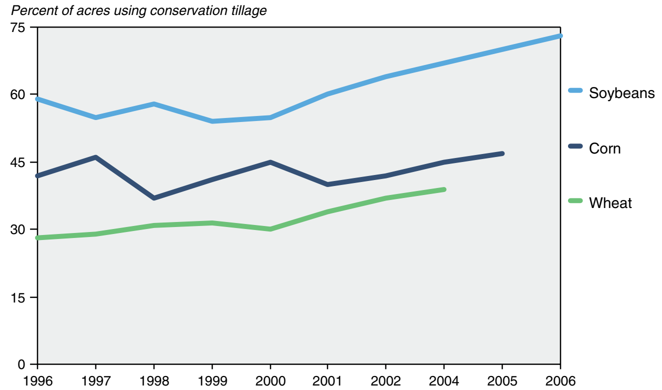
Source: Agricultural Chemical Usage: Field Crop Summaries, NASS, USDA, supplemented with data from Aspelin (2003) and Padgitt et al. (2000).

Reduced tillage

Conservation tillage typically reduces runoff, which in turn reduces soil erosion, sedimentation, and surface losses of nutrients and pesticides. The soil water-holding capacity increases, soil organic-matter content and populations of beneficial organisms are maintained or enhanced, and soil stability improves. Stimulated by the prospects of higher economic returns and by public policies and programs promoting its conservation benefits, conservation tillage is practiced on an increasing share of the major crops grown in the United States (fig. 2-5). Conservation tillage adoption is highest for soybeans because soybeans have a very little low yield risk under conservation tillage when compared to either corn or wheat production. Conservation tillage, especially for no-till soybeans, is a simple technology system compared to the more complicated management system for no-till corn or wheat production. Additionally, pest pressures (weeds, insects, and diseases) are more prevalent in conservation tillage corn and wheat than in soybeans.

Figure 2-5.

Conservation tillage practices



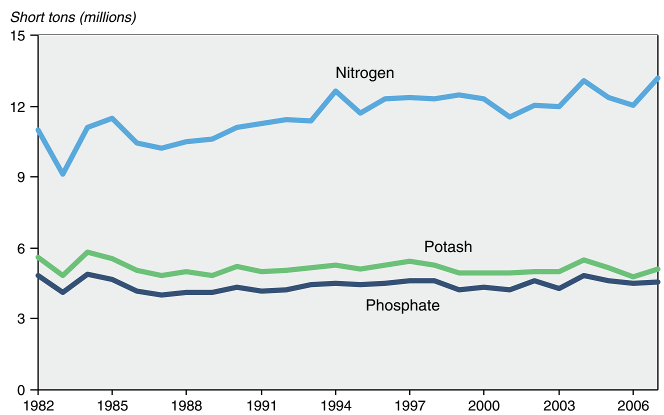
Source: Agricultural Resource Management Survey, ERS/NASS, USDA.

Nutrient application

U.S. consumption of nitrogen has trended upward since 1982, while consumption of potash and phosphate has remained steady (fig. 2-6). Based on total fertilizer costs per acre, corn, sugarbeet, rice, peanut, and cotton crops receive the most fertilizer. Corn receives the most nitrogen, and the recent trend

Figure 2-6.

Consumption of U.S. fertilizer nutrients

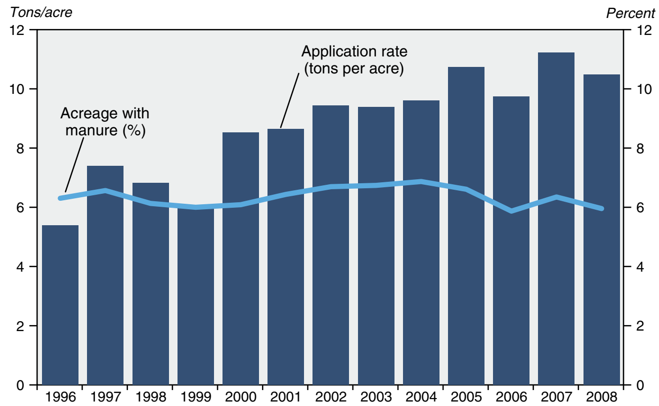


Source: Economic Research Service, USDA using data from Association of American Plant Food Control Officials and The Fertilizer Institute.

of using corn as an ethanol feedstock has pulled more land into corn production and increased application of nitrogen. Manure can also be used as a source of nutrients. Nearly twice as much manure was added to about the same number of crop and pasture acres in 2008 as in 1996 (fig. 2-7). Due to corn's high nutrient demand and use efficiency relative to other major crops, corn producers apply roughly 60 percent of all manure and at higher rates than most other users.

Figure 2-7.

Manure use



Source: Agricultural Resource Management Survey, ERS/NASS, USDA.

USDA assists producers in developing and implementing nutrient management plans that reduce the loss of applied nutrients through leaching and runoff. Careful planning and attention to the management of nutrient rate or amount, the form of the product, the timing of application, and the proper placement of the material improve the use efficiency of added nutrient materials and reduce the over-application of nutrients. Nutrient management plans can evolve with time and experience into specific adaptive adjustments that successfully produce food, forage, fiber, and fuel products while applying less nutrients and reducing the quantity of material that escapes from the production system.

Irrigation

Farms with irrigated crops produced 40 percent of the value of agricultural products sold in 2007. Farms with at least some irrigation were larger than the average farm and had annual sales more than four times higher than their dryland counterparts. Traditionally, most of the Nation's irrigated land has been concentrated in the Mountain, Pacific, and Plains States. While these regions still account for nearly 75 percent of the U.S. irrigated acreage, irrigation has grown in the East—particularly in the Delta States, Corn Belt, and Northern Plains—over the past 25 years. As a result, Nebraska now has more irrigated farmland than does California.

Markets for agricultural products

Farmers and ranchers respond to short- and long-term changes in markets and shifts in demand in the United States and internationally. Changing times require not only different production and marketing directions but also different approaches to protecting the natural resource base.

International trade

U.S. agricultural exports have exceeded imports since 1960. Export values and the agricultural trade surplus reached record highs in 2008 but declined in 2009 as the worldwide recession dampened international trade. Historically, bulk commodities—wheat, rice, coarse grains, oilseeds, cotton, and tobacco—accounted for most U.S. agricultural exports. Since 1991, however, exports of high-value products—meats, poultry, live animals, oilseed meals, vegetable oils, fruits, vegetables, and beverages—have exceeded bulk commodities in value. Still, because of favorable land resources and capital-intensive production, the United States is comparatively better at producing bulk commodity crops than are most other countries. The adoption of biotechnology and consolidation of farm operations have further boosted productivity in bulk commodities and the livestock sector.

Emerging trends

Consumption. The U.S. population is growing at just under 1 percent per year, requiring more food and fiber to be produced on agricultural lands. In addition, the average American eats more food every year—1,911 pounds per person in 2008 compared to 1,689 pounds per person in 1980 (Wells and Buzby 2008). During this period, per capita consumption of poultry, milk products such as cheese, vegetables, vegetable fats and oils, corn sweeteners, and flour and cereal products increased while consumption of red meat, animal fats, fruit, and other sugars and sweeteners, particularly refined sugar, declined. Some of these changes are in response to relative price trends, and others are the result of longer run changes in population age and demographics. Finally, some of these changes reflect emerging shifts in consumer food preferences. Examples include growing demands for organic foods, prepared foods for home consumption, and ready-to-eat convenience food products.

Vertical integration. A growing share of U.S. farm output is produced and sold under agricultural contracts as food processors and distributors attempt to gain greater control over their products and ensure market outlets. In 2005, contracts covered 41 percent of the total value of agricultural production, up from 11 percent in 1969 (MacDonald and Korb 2008). By reducing price risk, rewarding contract farmers for increasing production efficiency, and in many cases, becoming more specialized, contract sales have encouraged large farmers to increase capital investments and further consolidate production. This geographic concentration of production can indirectly increase pressure on specific natural resources if it concentrates the use of particular inputs.

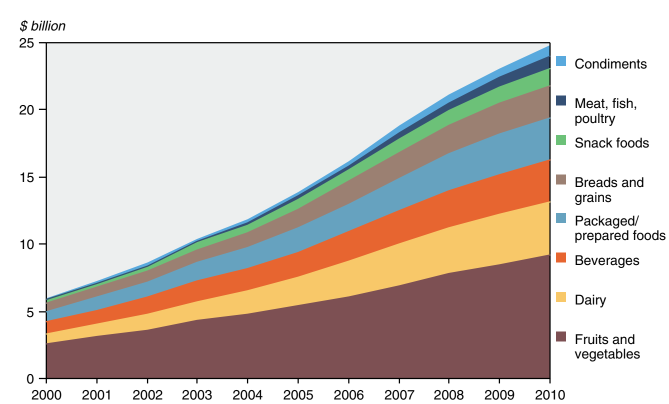
Contracts may also encourage the adoption of certain farming practices (for example, by requiring more stringent food safety practices), and discourage or prohibit the adoption of other practices, including some conservation practices. For example, the Resource Conservation District of Monterey County surveyed 600 irrigated row-crop growers throughout the Central Coast region of California in 2007, and reported that growers were under significant pressure from buyers to remove filter strips and other wildlife and water conservation practices (Beretti and Stuart 2008). Fifteen percent of growers in that study reported having removed or discontinued conservation practices in response to suggestions made by food safety auditors or buyers, and more than half reported using bare-ground field buffers rather than vegetated buffers. Fear that wildlife may contribute to e-coli contamination primarily affects growers of leafy greens and other vegetables, but fear of the spread of contagious diseases may also lead livestock producers to avoid adopting practices that could bring wildlife into contact with domesticated animals.

USDA is taking a co-management approach to resolve conflicts between food safety and conservation practices by evaluating food safety risks associated with conservation practices. Information about pathogen vectors (including irrigation water, amendments, domestic animals, and wildlife) and the potential interaction with commonly used conservation practices has been provided to conservation planners, farmers, and food safety auditors in an effort to improve the science-based risk-evaluation of farm management alternatives.

Organic agriculture. The demand for and supply of organic food has grown rapidly over the past decade (fig. 2-8). By 2009, organic products accounted for more than 3.5 percent of food sold for at-home consumption. Organic sales account for much higher percentages of specific commodities, particularly fruits and vegetables. While the supply of organic food has grown to meet demand, certified U.S. organic crops still accounted for less than 1 percent of total crop acreage in 2008 (Greene et al. 2009). Organic farms tend to be smaller than farms using conventional practices, but a much higher proportion of organic farm operators consider farming to be their primary occupation.

Figure 2-8.

U.S. organic food sales

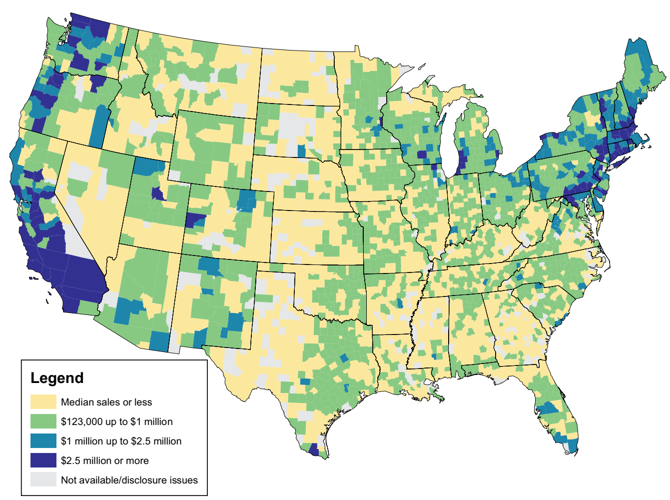


Source: Nutrition Business Journal.

Local food systems. Locally marketed foods account for a small but growing share of total U.S. food sales. Direct-to-consumer sales by agricultural producers increased from $551 million in 1997 to $1.2 billion in 2007, according to the Census of Agriculture. The number of farmers' markets has nearly doubled over the last 10 years, and the number of other forms of local marketing, such as farm-to-school programs and community-supported agricultural organizations, has increased as well. Local food markets can increase the financial viability of farm operations located close to urban centers. Farmers near urbanized areas, particularly in the Northeast and on the West Coast, had the highest levels of direct-to-consumer sales in 2007 (fig. 2-9).

Figure 2-9.

Value of farmers' direct sales to consumers, by county



Source: USDA/NASS, 2007 Census of Agriculture.

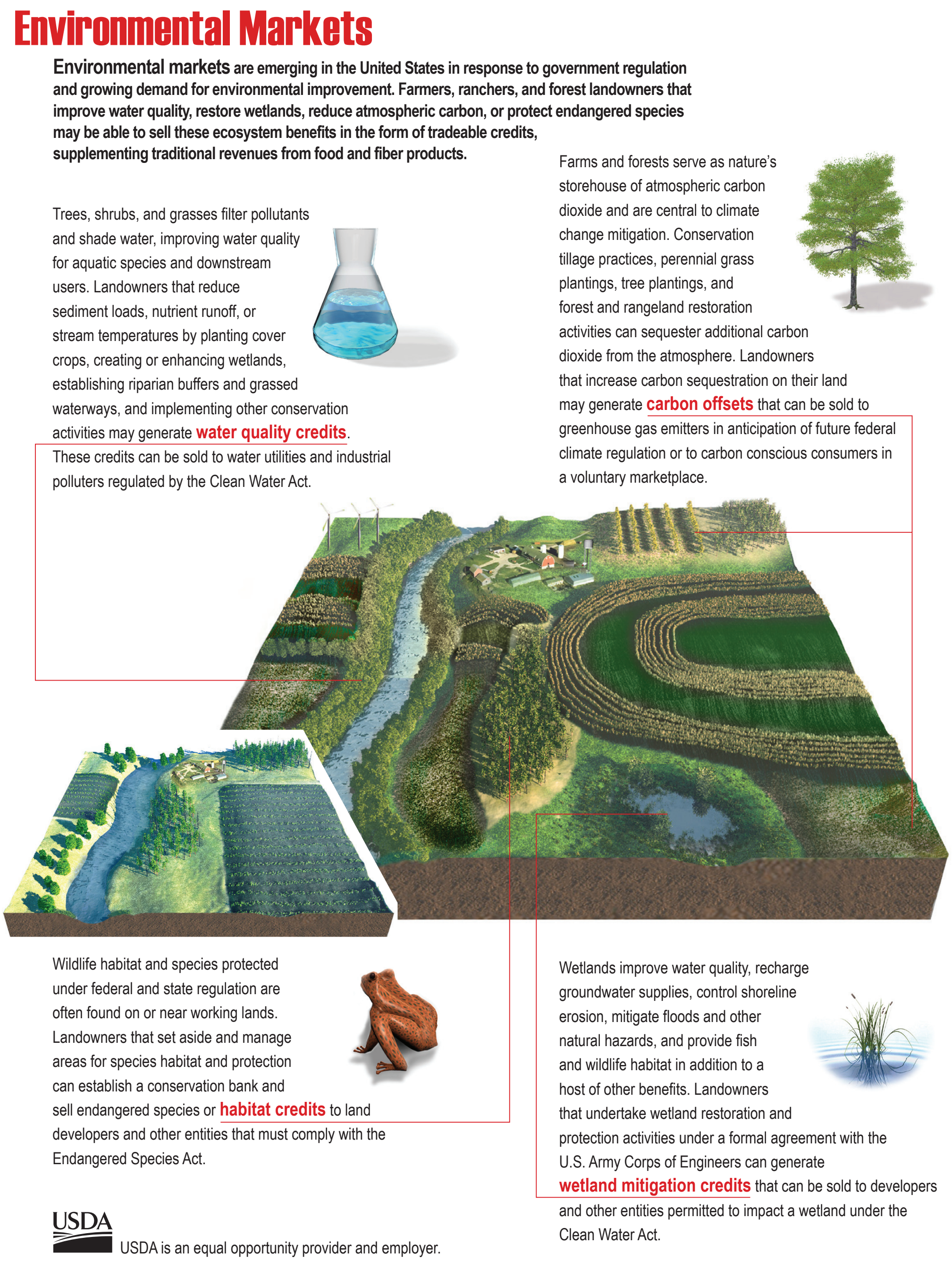
Recreational use of agricultural land. Much like changing consumer preferences for food, changing preferences for recreation can influence agricultural land-use decisions. Roughly 2.5 percent of farms reported income from farm-based recreation in 2004 —such as fees for hunting, fishing, petting zoos, and horseback riding (Brown and Reeder 2007). Farmers located in the South accounted for more than half of all U.S. farmers reporting recreational income in 2004, and farms located in areas with broad-based recreational economies were more likely to provide recreational opportunities.

Bioenergy markets. Ethanol grew from just over 1 percent of the U.S. gasoline supply in 2000 to 7 percent in 2008 (Westcott 2009). In the process, corn used to produce ethanol rose from 6 percent of the U.S. corn supply to roughly 25 percent over this 7-year period. Federal policy incentives have helped generate the market for biofuels (and increased the demand for corn production), most recently including the Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007. This trend has not only increased the amount of land planted to corn, including lands that were formerly used for grazing or were idle, but also reduced the acreage planted to other crops. Because corn typically receives higher inputs of nutrients and pesticides than other major crops, the increase in biofuels feedstock production also increases the likelihood of soil erosion and runoff of nutrients and chemicals (Malcolm et al. 2009). It may also increase water withdrawals if accompanied by increased installation or use of irrigation systems.

Environmental markets. There are potential opportunities for farmers to market ecosystem services (fig. 2-10). For example, water quality credit trading programs allow farmers

Figure 2-10.

New markets for agricultural lands



to sell credits for nutrient and sediment reductions. These credits can then be sold to industries that are subject to pollution abatement regulations. Similar markets exist for the preservation of wetlands and are being considered for greenhouse gas mitigation. When coupled with voluntary markets for ecosystem services and with labeling standards, such as USDA's organic label, these markets could compensate landowners for undertaking environmentally friendly farming practices (Ribaudo et al 2008).

Institutional and policy developments

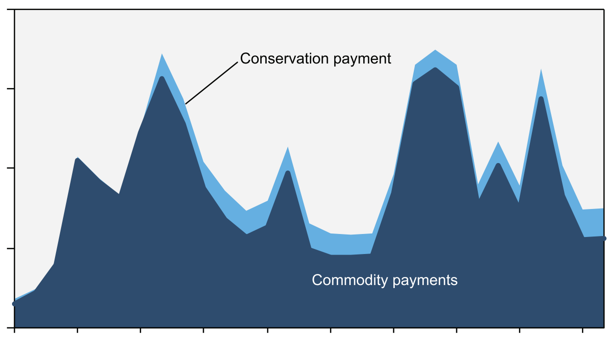
Government policies and programs at all levels can have a significant impact on agricultural land use decisions, either directly through property rights legislation and land-use regulations, or indirectly through government programs that affect input and output markets and, consequently, land-use decisions. Historically, the Federal Government's farm program payments were geared toward supporting farm prices and income for key agricultural commodities. Payments tied to program crop production had the effect of locking cropland in specific uses. Coupled with rising productivity, the result was surpluses of many program crops, which required supply controls to keep farm prices and incomes from falling (Dimitri et al. 2005). As a result, millions of acres of agricultural land were left fallow to satisfy acreage reduction requirements through the early 1980s.

Until passage of the Food Security Act of 1985, few payments were made to farm operators to encourage conservation. That Act's creation of the Conservation Reserve Program (CRP) changed the agri-economic landscape by providing payments to landowners to retire some 30 million acres of environmentally sensitive cropland from production. This helped reduce crop surpluses, and supply controls were subsequently phased out in the 1990s. Annual conservation program payments to farm operators began routinely exceeding $2 billion. With passage of the Farm Security and Rural Investment Act of 2002, additional conservation funds were targeted at working lands, principally through the Environmental Quality Incentives Program (EQIP), further increasing inflation-adjusted annual conservation program payments to farm operators to about $3 billion. Even so, conservation payments typically account for 25 percent or less of the total amount of farm program payments reported by farm operators (fig. 2-11).

In 2008, about 17 percent of farms received conservation payments, with an average value of over $2,900 per operation, and 29 percent received commodity-related payments with an average value of over $6,300 (table 2-2). Of the smaller 1.8 million farms, 15 percent received conservation payments, compared to about 26 percent of the larger farms (table 2-2 and fig. 2-12). While these data do not reflect the number of farmers receiving technical assistance in the absence of financial assistance, they do indicate that considerable outreach opportunities exist to attract more producers to conservation programs.

Figure 2-11.

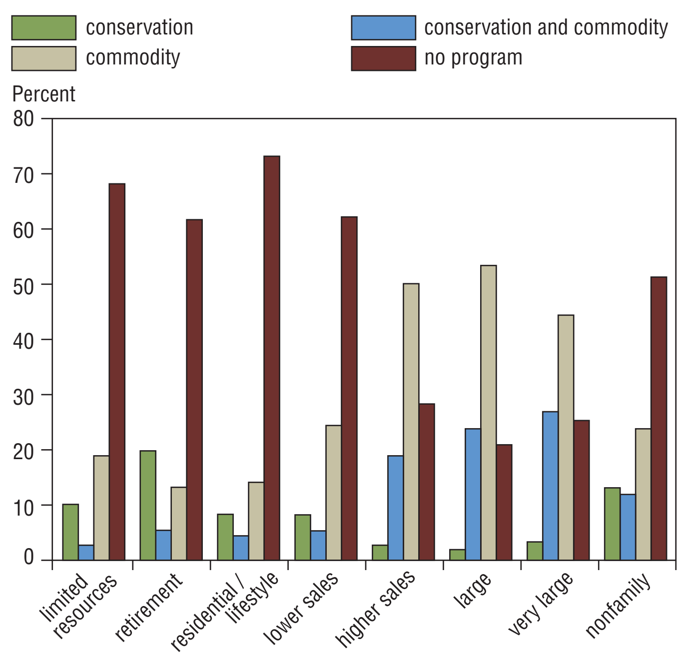
Agricultural commodity and conservation program payments to farm operators



Source: Economic Research Service, USDA and National Economic Accounts, Bureau of Economic Analysis. Constant dollar figures are based on the GDP chain-type price index with 2005 as the base year. Commodity payments include fixed payments, ad hoc emergency assistance, and transition payments in addition to payments tied to the production of specific commodities.

Figure 2-12.

Program participation by payment type and typology category, in percent, FY 2008



Source: 2008 USDA Agricultural Resource Management Survey (ARMS)

Table 2-2.

Government payments by farm typology, 2008

Category	Limited resources	Retirement	Residential/ lifestyle	Farming-occupation/ lower sales	Farming-occupation/ higher-sales	Large	Very large	Nonfamily	All
	Farm typology grouping[1]								
Farms, number	231,561	320,144	872,748	389,220	106,412	93,832	115,952	61,976	2,191,844
Farms receiving govt. payments	73,544	122,746	233,577	147,266	76,281	74,195	86,628	30,187	844,424
Farms receiving:	Percent								
No government payments	68.2	61.7	73.2	62.2	28.3	20.9	25.3	51.3	61.5
Conservation payments only[2]	10.1	19.8	8.3	8.2	2.7	1.9	3.3	13.1	9.4
Both conservation and commodity	2.7	5.4	4.4	5.3	18.9	23.8	26.9	11.9	7.5
Commodity payments only	18.9	13.2	14.1	24.4	50.1	53.4	44.4	23.8	21.6
Average government payments	Dollars								
Conservation	1,722	3,973	2,266	2,130	2,501	2,617	5,397	5,327	2,926
Commodity-related	939	857	1,221	1,878	7,101	13,452	31,420	11,735	6,338
	Percent of U.S. total								
Share of govt. payments	2.5	7.2	10.5	8.3	9.8	15.5	40.0	6.2	100.0
Conservation	5.1	19.7	21.4	12.7	7.7	7.9	18.9	6.5	100.0
Commodity-related	1.5	2.7	6.7	6.7	10.5	18.3	47.4	6.1	100.0

Source: 2008 USDA Agricultural Resource Management Survey (ARMS)

[1] See farm typology box on page 15 for definitions used in this table.

[2] Conservation payments are including for the following programs only: Conservation Reserve Program, Conservation Reserve Enhancement Program, Wetlands Reserve Program, Environmental Quality Incentives Program, and Conservation Security Program; the ARMS survey does not report data for participation in other conservation programs, including Conservation Technical Assistance.

There is evidence that even payments that have been "de-coupled" from production levels or commodity prices continue to influence the land-use decisions of individual farmers. By reducing the risk of income fluctuations, these payments, along with other commodity payments and federally subsidized crop insurance coverage, continue to encourage farmers to plant eligible crops (O'Donoghue and Whitaker 2010; Lubowski et al. 2006). On the other hand, because eligibility for commodity program payments on environmentally sensitive land has been tied to conservation compliance since 1985, these payments also limit, to some extent, planting decisions on highly erodible soil and wetlands. ERS estimates that up to 25 percent of the 1.2-billion-ton reduction in annual cropland soil erosion between 1982 and 1997 might be attributed to conservation compliance requirements (Claassen et al. 2004).

Environmental regulations

Regulatory policies that can affect agriculture include those promulgated under the Clean Water Act, the Clean Air Act, the Endangered Species Act, and the Federal Insecticide, Fungicide, and Rodenticide Act, among others. Under these Acts, agricultural producers may be required to obtain permission before undertaking regulated activities (such as draining wetlands) and the regulations may affect the availability of agricultural inputs. In addition, as livestock operations have grown in size, concentrated animal feeding operations (CAFOs) have come under closer scrutiny by the U.S. Environmental Protection Agency (EPA) as potential sources of water pollution. CAFOs meeting certain conditions must now implement nutrient management plans for animal manure applied to land. As of September 2010, EPA had issued 8,295 National Pollutant Discharge Elimination System (NPDES) permits, covering 43 percent of the estimated CAFOs

(Environmental Protection Agency 2011). This requirement can restrict farmers' options for using manure and in some areas can increase the cost of manure disposal. Under the Clean Water Act, EPA and States are required to establish total maximum daily loads (TMDLs) for water bodies that do not meet water quality standards. TMDLs establish pollutant loadings for listed water bodies in order to meet water quality standards. Along with other sources, agricultural nonpoint sources can be assigned a load allocation under a TMDL that establishes upper limits on allowable discharges. While TMDLs may identify sources of water pollution and help States and communities develop comprehensive plans for improving water bodies, they do not provide a direct enforcement mechanism for regulating agricultural nonpoint sources.

Conclusion

Through a range of production inputs and intensive physical use of soils, agriculture has many direct and indirect impacts on natural resources. With so much land in agricultural uses, it is important to understand the stewards of these lands and the factors affecting their land-use decisions. A number of gradual changes are occurring within the agricultural sector. The overall number of farms is stable, but there are fewer mid-sized farms, more large farms, and more small farms. These small farms, on average, derive almost all of their household income from off-farm sources. Full ownership of farms is trending down, and part owner and tenant operations are increasing. A growing share of production is occurring under agricultural contracts with processors and distributors. Conservation policy needs to be diverse to address the range of motivations within the landowner and land operator communities.

The factors driving land use and production decisions continue to evolve. Technology advances are affecting which crops can compete successfully in different regions. Climate change is expected to further alter the mix of crops and livestock in different regions (see chapter 5). Consumer preferences are shifting, and new markets are emerging within the agricultural sector. In particular, the growing demand for biofuels has already shifted the balance between livestock and crop production and strengthened the market for corn production. Finally, Federal conservation policies, such as the growth of land retirement and working lands programs, affect production and land-use decisions on vulnerable soils across the nation. This chapter discussed agricultural decisionmakers and the factors influencing their land management decisions. Chapter 3 focuses on assessing the current conditions of natural resources on non-Federal lands.

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CHAPTER 3

The State of the Land

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Agriculture has been described as a "leaky" system. That is, some tradeoffs are unavoidable among the competing demands that we place upon our farmers, ranchers, and forest landowners: To produce food, feed, fiber, and fuel for consumption in the United States and for export; to provide habitat for wildlife; to provide scenic vistas and recreational opportunities; and to do all of these things and more with minimal environmental impact.

More than two-thirds of the land in the conterminous 48 States is in private farms, ranches, and forests. The stewardship of these lands is closely linked to the quality of our environment. Farmers, ranchers, and forest landowners have made great strides in protecting the Nation's natural resource base, but maintaining these gains requires a continuing commitment to assessing and addressing important natural resource issues and concerns. This chapter provides an overview of the natural resource conditions and trends on U.S. agricultural and forest lands.

Soil health

Healthy land begins with healthy soils. Metrics for soil health include soil erosion, soil salinity, and soil carbon, which are affected by natural soil and site conditions, and by management. Healthy soils support—

- **Clean water** by transforming harmful substances and chemicals to nontoxic forms, cycling nutrients, and partitioning rainfall to keep sediment, nutrients, and pesticides out of lakes and streams;
- **Clean air** by keeping dust particles out of the air and storing carbon from the atmosphere; and
- **Healthy plant growth** by storing nutrients and water and providing structural support through a receptive rooting medium.

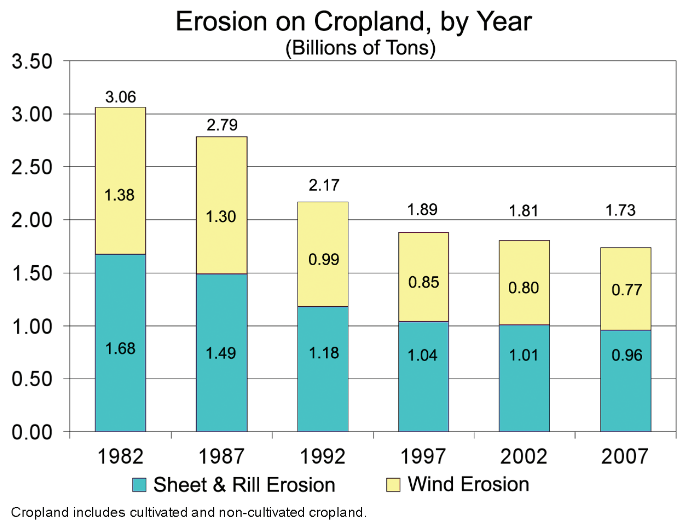
Soil erosion on cropland

Farmers reduced total cropland erosion by 43 percent between 1982 and 2007 (USDA-NRCS 2009) (fig. 3-1). Total sheet and rill erosion on cropland declined from 1.68 billion tons per year to 960 million tons per year, and erosion due to wind declined from 1.38 billion tons per year to 765 million tons per year.

On a per-acre basis over the 25-year period 1982 to 2007, average annual sheet and rill erosion rates on cropland declined more than 30 percent, from 4.0 tons per acre per year in 1982 to 2.7 tons per acre per year in 2007. Wind erosion rates dropped from 3.3 to 2.1 tons per acre per year during the same period. The bulk of the reductions occurred in the decade following implementation of the Conservation Reserve Program (CRP), conservation compliance, and other provisions of the Food Security Act of 1985. As a result of this Act, farmers retired much of the most highly erodible cropland and applied additional conservation practices on vulnerable cropland. Although the rate of decrease in soil erosion has slowed since 1997, the general downward trend in sheet and rill erosion and wind erosion continued through 2007.

Figure 3-1.

Trends in cropland erosion, conterminous 48 States, 1982–2007



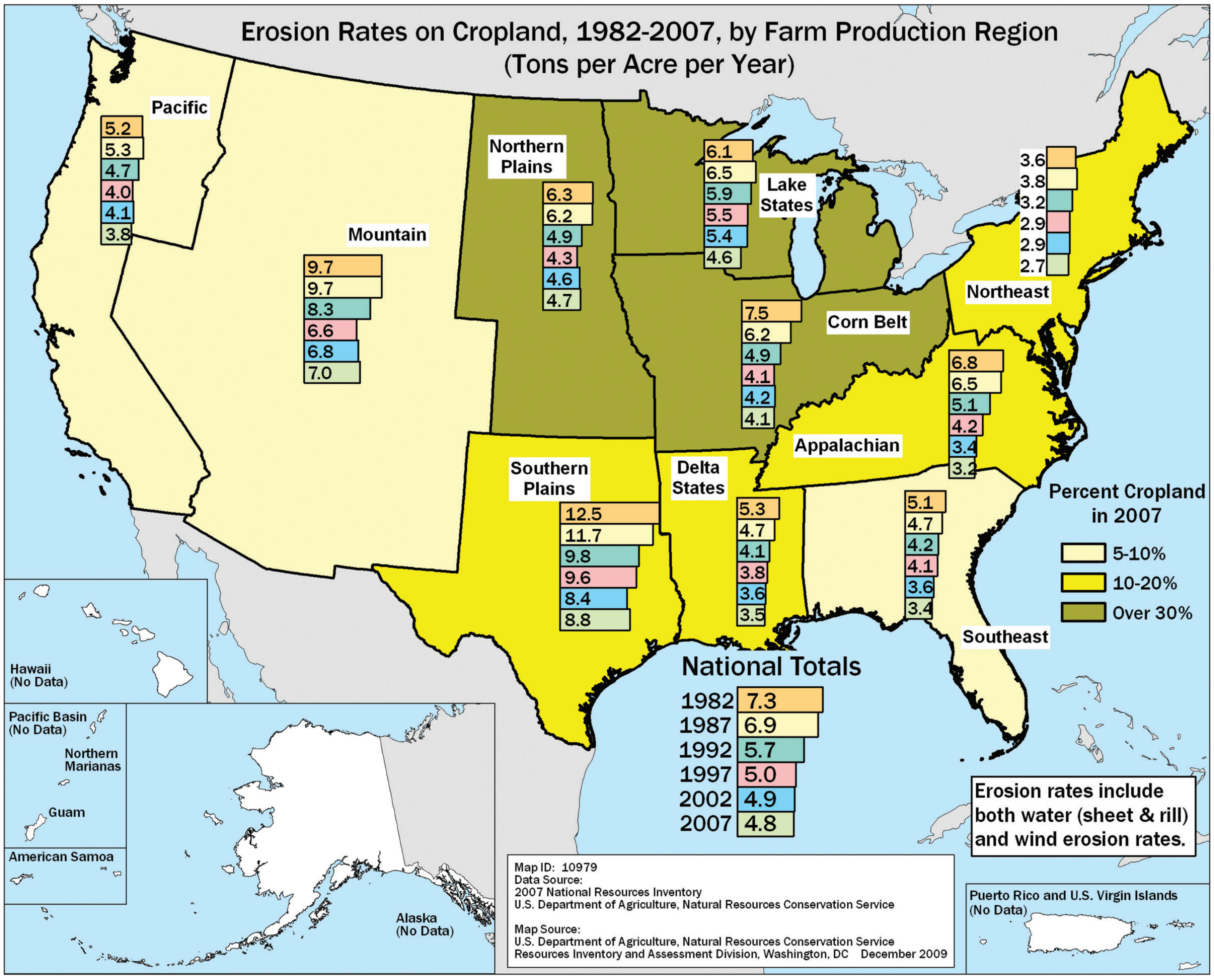
Source: 2007 National Resources Inventory, Natural Resources Conservation Service, USDA

Soil erosion on cropland is concentrated geographically because of the combined effects of climate, soil characteristics, landscape features, and cropping and land management practices (fig. 3-2). Fifty-four percent of total sheet and rill erosion occurs in two of the 10 farm production regions—the Corn Belt and the Northern Plains—where crop production is most intense. Most of the wind erosion occurs in regions where the soils are typically dry, vegetation is sparse, and winds are strong.

Natural soil formation processes replace a certain amount of soil lost through erosion. Excessive erosion is that share of erosion above the soil loss tolerance level (T), the maximum rate of annual soil erosion that will permit crop productivity to be sustained economically and indefinitely. Excessively eroding cropland soils are concentrated primarily

Figure 3-2.

Erosion rates on cropland, by farm production region, 1982–2007



Source: 2007 National Resources Inventory, Natural Resources Conservation Service, USDA

The many forms of soil erosion

Soil erosion is a natural geologic process that involves the breakdown, detachment, transport, and redistribution of soil particles by water, wind, or gravity. Water erosion occurs when the combined power of rainfall energy and overland flow overcome the resistance of soil particles to detachment. Although some soil erosion supports natural ecologic functions, excessive erosion can reduce the productive capacity of the land, impair the quality of water and air, and cause other onsite and offsite problems.

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, or rills, form as rainwater collects and flows over an unprotected soil surface.

Concentrated-flow erosion can follow sheet and rill erosion. Rills can 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 are not filled in with material from adjacent land, a condition known as **classic gully erosion** develops.

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 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 and in extreme cases can generate dust storms that cause significant health and property damage, reduce visibility, and close highways.

Water erosion data from the National Resources Inventory include only sheet and rill erosion and do not consider concentrated flow erosion or streambank erosion.

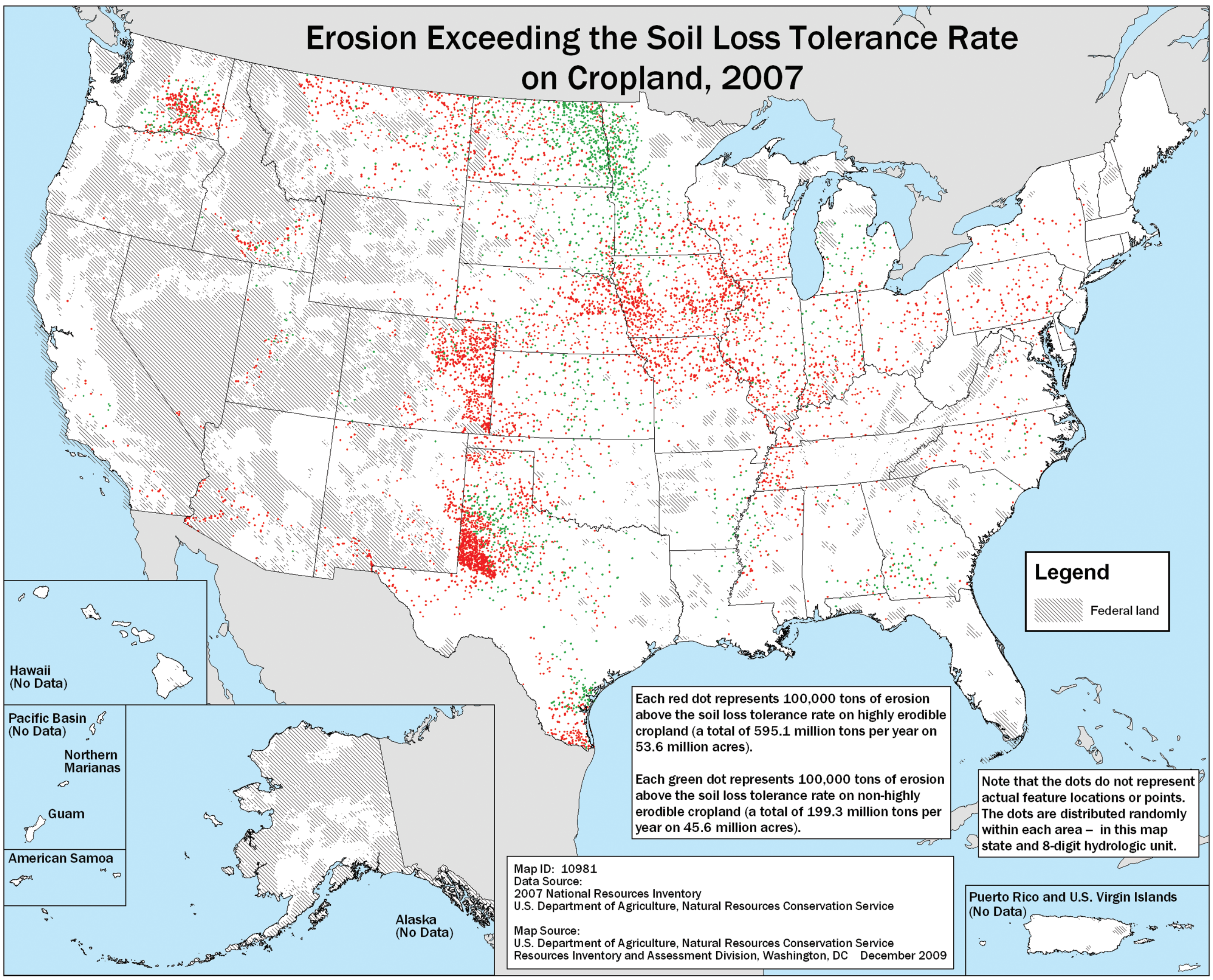
in the Great Plains, the Corn Belt, the Lake States, and the Palouse area of Washington State (fig. 3-3).

Figures 3-4, 3-5, and 3-6 show that throughout the period 1982 to 2007 most excessive cropland erosion occurred on highly erodible cropland.

- Figure 3-4 shows that the proportion of non-highly erodible cropland acres eroding above T decreased gradually from 29 percent in 1982 to 18 percent in 2007. There were about 294 million acres of non-highly erodible cropland in 1982, compared to 259 million acres in 2007—a decrease of 12 percent over the period.
- Figure 3-5 shows that the proportion of highly erodible cropland acres eroding above T also decreased, from 67 percent in 1982 to 55 percent in 2007. Additionally, the acreage of highly erodible cropland decreased by 22 percent, from 125 million acres in 1982 to 98 million acres in 2007, as these lands were enrolled in CRP or converted to other land uses.
- Figure 3-6 shows that although total erosion on highly erodible and non-highly erodible cropland had declined by 2007, the bulk of the erosion still occurred on the highly erodible cropland. Highly erodible cropland made up 30 percent of all U.S. cropland in 1982 but contributed 57 percent of total cropland erosion; 76 percent of total erosion on highly erodible cropland was above T. In 2007, highly erodible cropland contributed 52 percent of total cropland erosion on only 27 percent of the cropland; 66 percent of total erosion on highly erodible cropland was above T.

Figure 3-3.

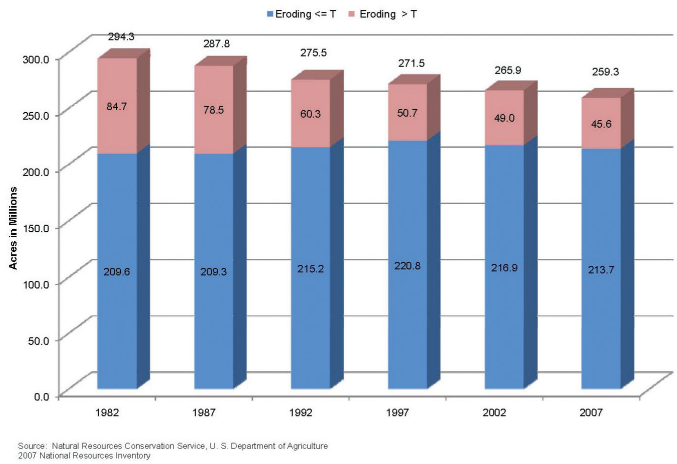
Erosion exceeding the soil loss tolerance rate on cropland, conterminous 48 States, 2007



Source: 2007 National Resources Inventory, Natural Resources Conservation Service, USDA

Figure 3-4.

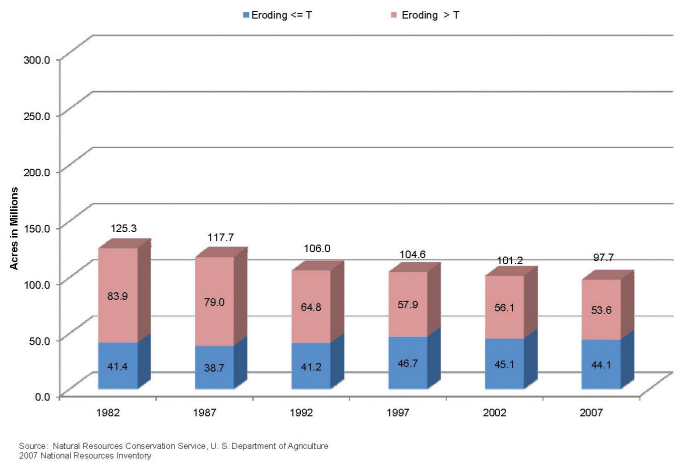
Non-highly erodible cropland & erosion relative to the tolerable erosion rate (T)



Source: 2007 National Resources Inventory, Natural Resources Conservation Service, USDA

Figure 3-5.

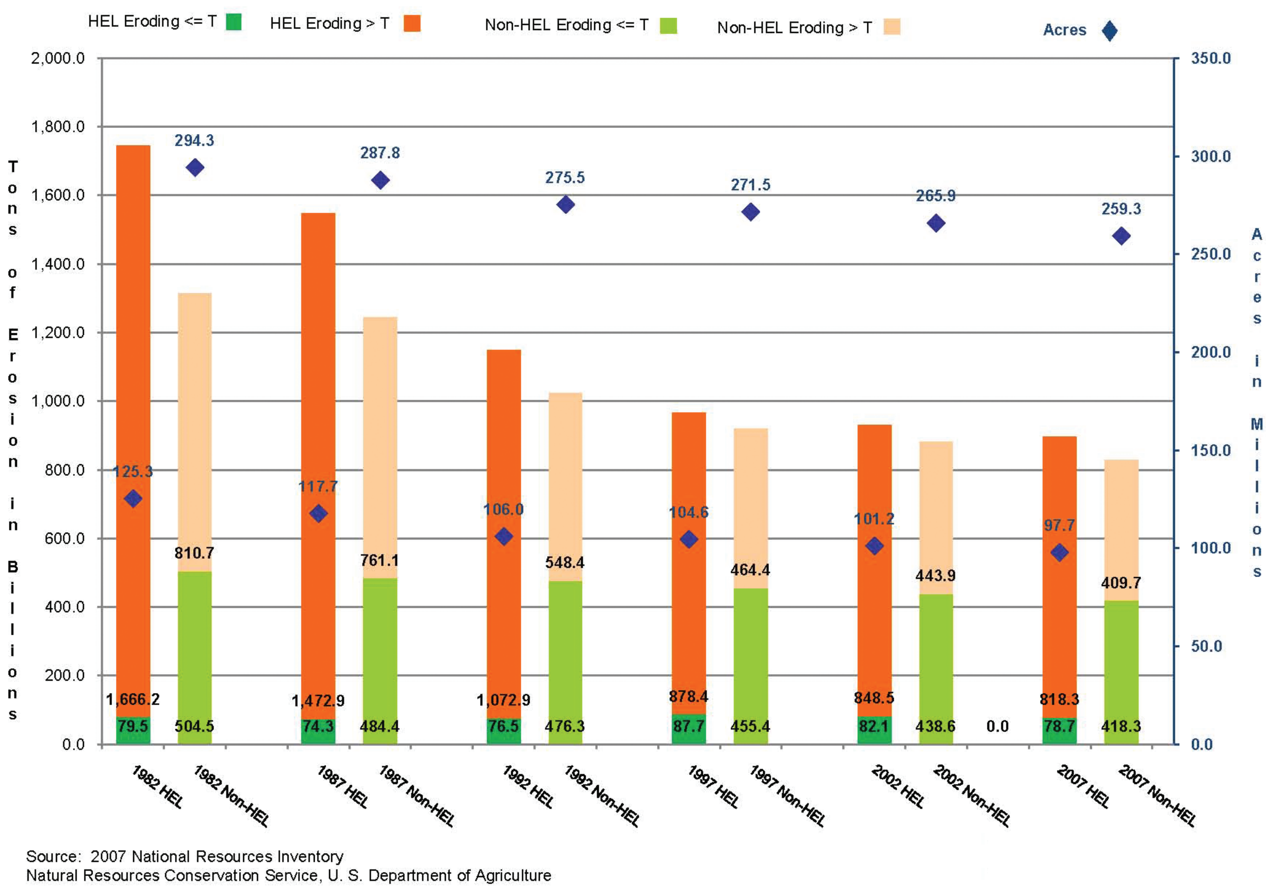
Highly erodible cropland & erosion relative to the tolerable erosion rate (T)



Source: 2007 National Resources Inventory, Natural Resources Conservation Service, USDA

Figure 3-6.

Total erosion on highly erodible and non-highly erodible cropland relative to the tolerable erosion rate (T)



Source: 2007 National Resources Inventory, Natural Resources Conservation Service, USDA

Soil carbon sequestration

The level of organic carbon in the soil is an important measure of soil health. Soil organic matter provides a receptive medium for plant roots, promotes the infiltration of water, and supplies nutrients to plants. Soil organic carbon also is the largest terrestrial carbon reservoir. Estimates of organic carbon content in the top 40 inches of soil range from—

- 16 to 67 tons per acre in cropland soils,
- 21 to 73 tons per acre in forested soils,
- 19 to 65 tons per acre in rangeland soils, and
- 14 to 182 tons per acre in soils in other land uses (fig. 3-7).

Through photosynthesis, plants combine carbon dioxide with water and with the aid of light energy form sugars that make up plant matter. Soil organic carbon content increases when plants leave carbon in the soil as decomposing organic matter. Although deep, undisturbed rangeland and forested soils have the highest levels of soil carbon near the soil surface, in many areas these soils are shallow or rocky and have less volume available for organic carbon storage than do the deep, rock-free soils typically used for crop production. In the United States, cropland soils have higher average levels of soil organic carbon stocks than do the other land uses.

The current soil organic carbon stocks for forest land and grasslands are likely lower than they were before European settlement because cropping, erosion, grazing, and other factors depleted those stocks to some extent. Although conventional tillage speeds up organic matter decomposition and lowers soil carbon stocks, most cropland soils today are farmed using some form of conservation tillage that involves less soil disturbance and leaves more surface residue. Conservation tillage can, over time, conserve or enhance soil organic carbon, and its continued use could increase current levels of soil carbon stocks by 15 percent.

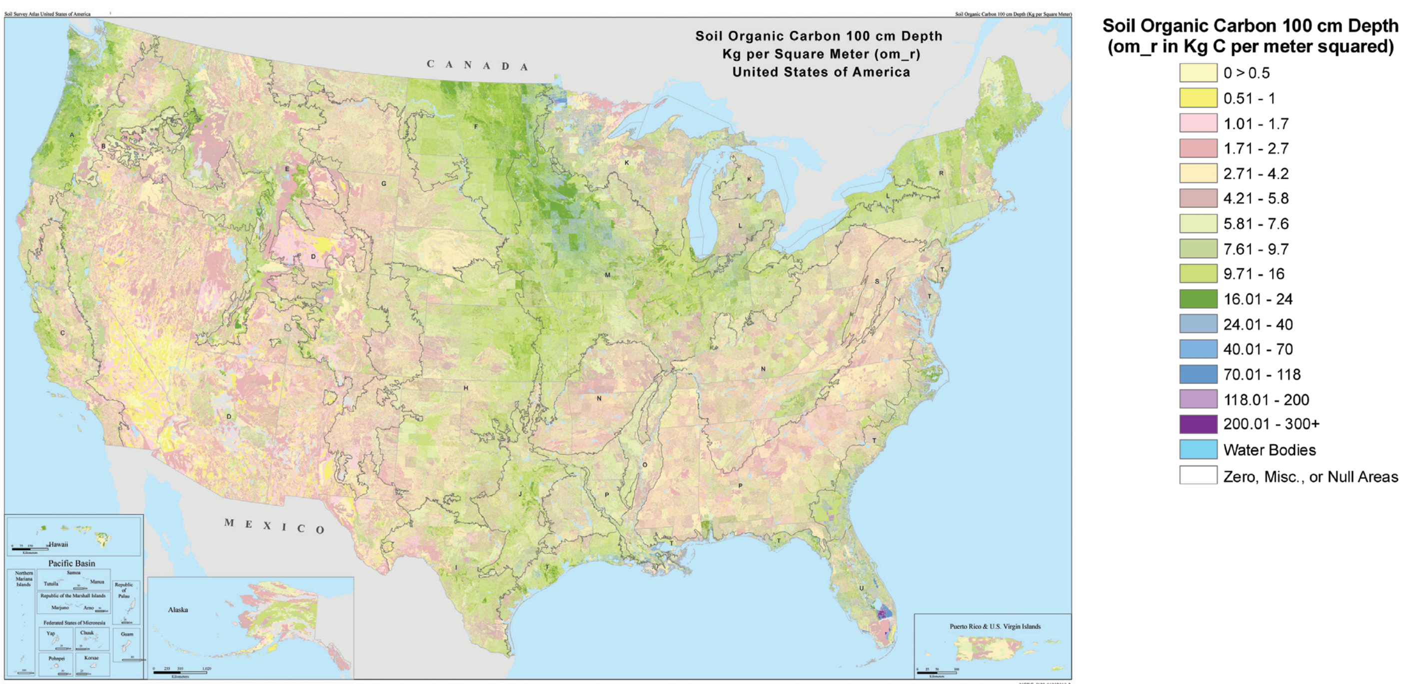
Determining soil organic carbon content

Soil organic carbon values are based on soil properties estimated from laboratory data from more than 25,000 sites analyzed for the National Cooperative Soil Survey. Although the data set is large, it represents a limited number of the soils in the United States, and land cover and agricultural management were not considered in site selection. Thus, estimates of soil organic carbon stocks for specific soil and land cover combinations have considerable uncertainty. The Rapid Assessment of U.S. Soil Carbon for Climate Change and Conservation Planning currently underway will help reduce this uncertainty. This one-time inventory, however, is addressing only broad soil and land cover groups and is not designed to address rates of change in soil organic carbon stocks.

Figure 3-7.

Soil organic carbon stocks

Soil organic carbon stocks are highest in the upper Midwest, an area dominated by cropland on deep soils, and in the heavily forested Pacific Northwest and Northeast.

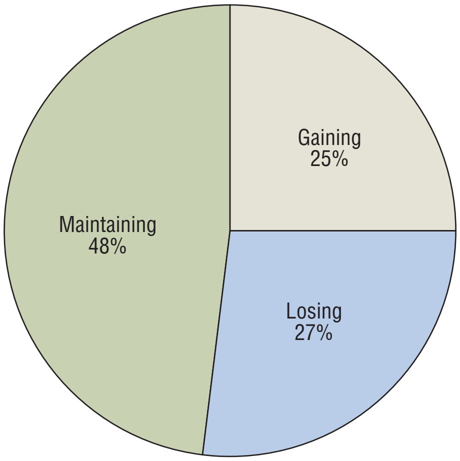


Source: USDA-NRCS

Figure 3-8 shows that nearly three-fourths of U.S. cropland is maintaining or increasing soil organic carbon levels. "Maintaining" means that a loss or gain in soil organic carbon over 20 years cannot be detected with routine soil sampling.

Figure 3-8.

Soil carbon trends on U.S. cropland, percent of acres by status



Source: Preliminary data, CEAP Cropland Assessment, conterminous 48 States

Soil salinity

Soil salinity reduces crop yields and leads producers to adopt more salt-tolerant crops. Where salinization is severe, crop production may be abandoned. Soil salinity can be attributed to—

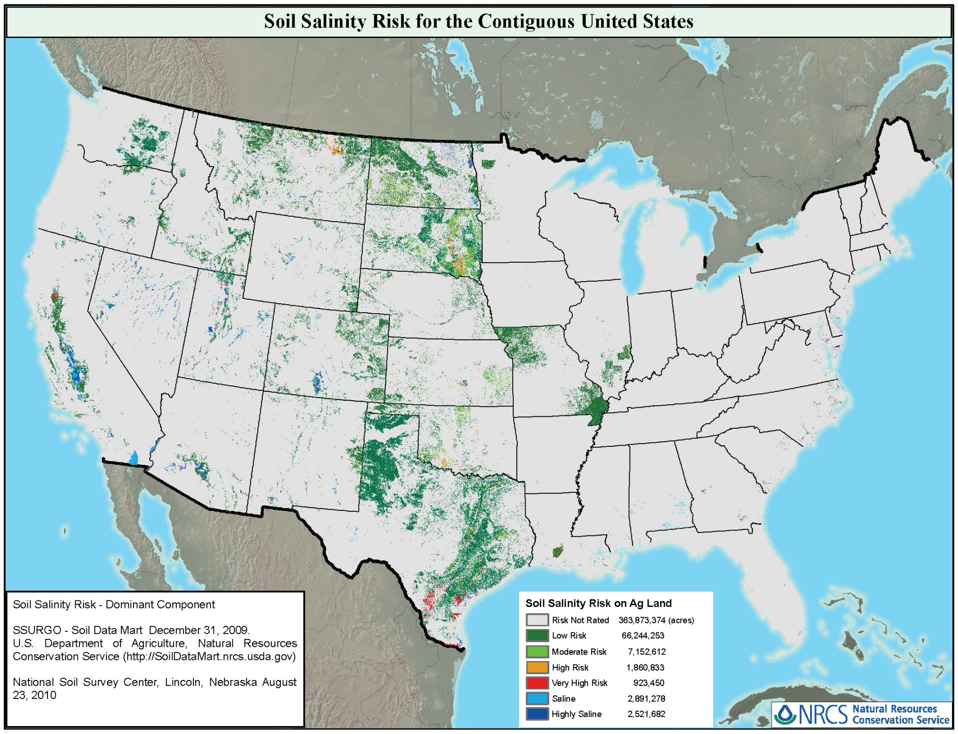
1. Salt accumulations in arid areas from past geologic and climatic conditions;
2. Salt enrichment from saline high water table wicking and saline irrigation water;
3. Salts weathering into the soil from soil minerals in semiarid and subhumid areas; and
4. Sea water influence in low-lying coastal areas.

In addition to these natural factors, inefficient irrigation and drainage can cause or accelerate soil salinization through leaching and evapotranspiration.

Saline soils occupy approximately 5.4 million acres of cropland in the conterminous 48 States. Another 76.2 million acres are at risk of becoming saline. The San Joaquin Valley, for example, which makes up the southern portion of California's Central Valley, is among the most productive farming areas in the United States. However, irrigation-induced salt buildup in the soils and groundwater is threatening continued productivity and sustainability (Schoups et al. 2005) (fig. 3-9). As climate changes, areas in the southwestern United States are at greatest risk of increasing salinity levels.

Figure 3-9.

Salinity-affected soils and soils at risk



Source: NRCS SSURGO

The soil salinity data used in this report are from various vintages of soil survey projects over several decades and represent less than optimal laboratory data and observations. The Soil Survey Program of USDA NRCS is updating information for soil surveys.

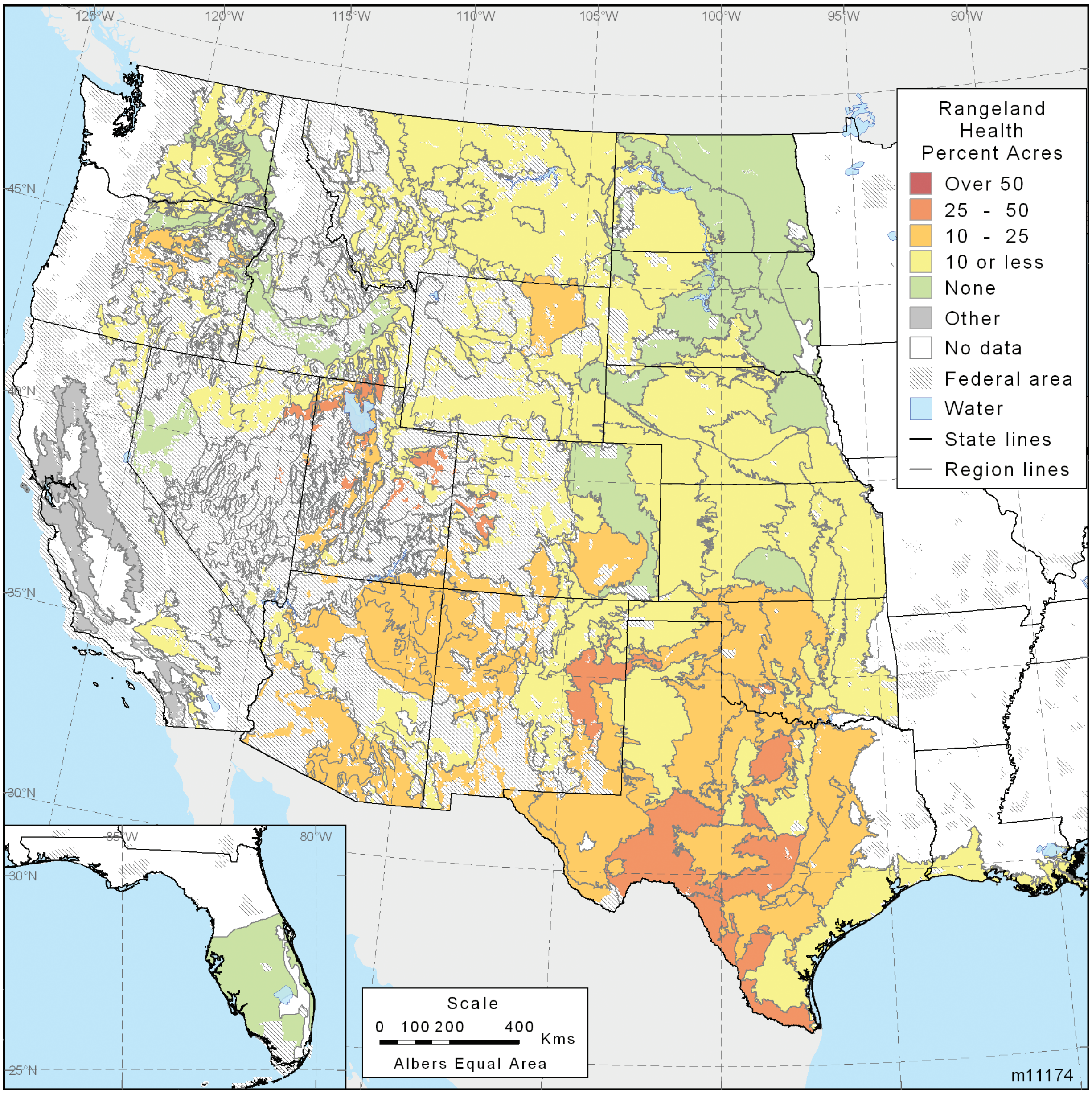
Rangeland health

A longstanding challenge for rangeland policy and management has been how to determine optimal conditions in the variety of types of ecosystems found in rangelands. A new rangeland health inventory system uses local knowledge to establish reference points, or reference conditions, for particular types of land, which allows assessment of site conditions at a specific time.

To determine range health at NRI sample locations, experts with knowledge of soil, hydrology, and plant relationships evaluated 17 different rangeland health indicators (Pyke et al. 2002) on the degree of departure (none-to-slight, slight-to-moderate, moderate, moderate-to-extreme, and extreme-to-total) from expected levels in the ecological site description (Pellant et al. 2005). Rangeland health at each location was determined by the median rating for soil and site stability, hydrologic function, and biotic integrity. Nearly 80 percent of the Nation's 409 million acres of non-Federal rangeland are relatively healthy. However, the remaining 20 percent (about 82 million acres) depart at least moderately from the reference condition for one or more of the three attributes of rangeland health described below (fig. 3-10).

Figure 3-10.

Rangeland showing departure from reference conditions for all three attributes of rangeland health: Soil and site stability, hydrologic function, and biotic integrity



Source: USDA-NRCS/NRI Rangeland Resource Assessment

At least 9 percent of rangeland acres have at least moderate departure from reference condition for all three attributes:

1. **Soil and site stability** is the capacity of a site to limit wind and water erosion. Less than 12 percent of U.S. rangeland has at least moderate departure from expected site conditions for soil and site stability.
2. **Hydrologic function** characterizes the capacity of the site to capture, store, and safely release water from rainfall, run-on, and snowmelt and to resist or recover from degradation. About 14 percent of U.S. rangeland has at least moderate departure from expected site conditions for hydrologic function.
3. **Biotic integrity** is the capacity of a site to support characteristic functional and structural plant communities in the context of normal variability, and to resist or recover from disturbances. About 18 percent of U.S. rangeland has at least moderate departure from expected site conditions for biotic integrity.

Soil erosion on rangeland

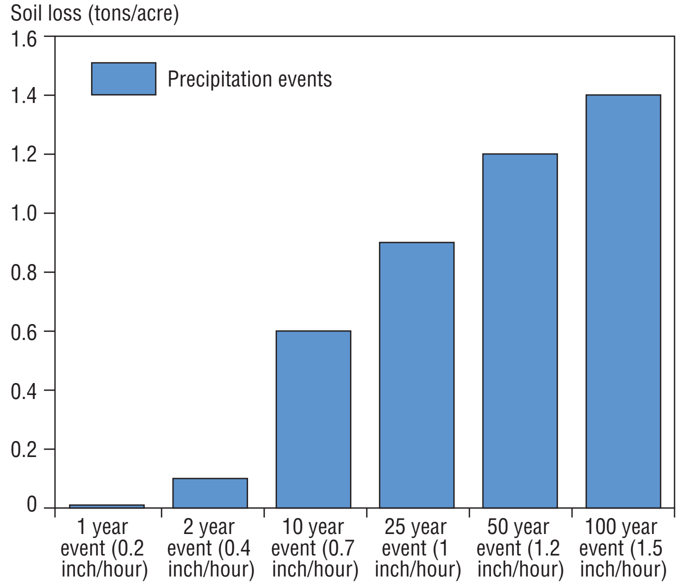
Tolerable soil loss rates on arid rangeland soils are typically lower than those on Midwestern cropland soils; many arid rangeland soils are shallower, have slower rates of soil formation in the dry climates typical of rangeland, and support vegetation that grows more slowly and provides less ground cover. Water erosion is less than 1 ton per acre per year on more than two-thirds of U.S. rangeland, between 1 and 2 tons on about one-sixth, and exceeds 2 tons on about one-sixth.

Average annual erosion rates on rangeland, however, do not tell the whole story. Most soil loss occurs during intense storms that generate large amounts of runoff, but such storms are rare. Consequently, while soil erosion is much less than average during most years, once-in-a-century storms can generate greater than 100 times average annual soil loss in less than a day. In Elko, NV, for example, historic data indicate that rainfall intensity has exceeded 1 inch per hour only four times per century (fig. 3-11).

Erosion is not distributed uniformly across non-Federal rangelands (fig. 3-12). Twenty percent of the area of non-Federal rangeland produces more than 65 percent of total soil erosion (USDA-NRCS 2010). More than 31 percent of U.S. non-Federal rangeland is vulnerable to unsustainable average annual soil loss; these most vulnerable acres are predominantly in the central and southern Great Plains (fig. 3-12) although vulnerable acres can be identified in each State. Soil disturbance and lack of vegetative and ground cover are the most important factors that contribute to erosion on rangeland (Wilcox et al. 2003, Pierson et al. 2009, Bartley et al. 2010a, Bartley et al. 2010b, Urgeghe et al. 2010). Areas with low to moderate soil erosion rates can be treated and erosion controlled through minor changes in management such as moving the locations of salt or supplemental feeding areas to redistribute livestock.

Figure 3-11.

Relationship of soil loss to precipitation for a sagebrush site on a loamy soil near Elko, NV



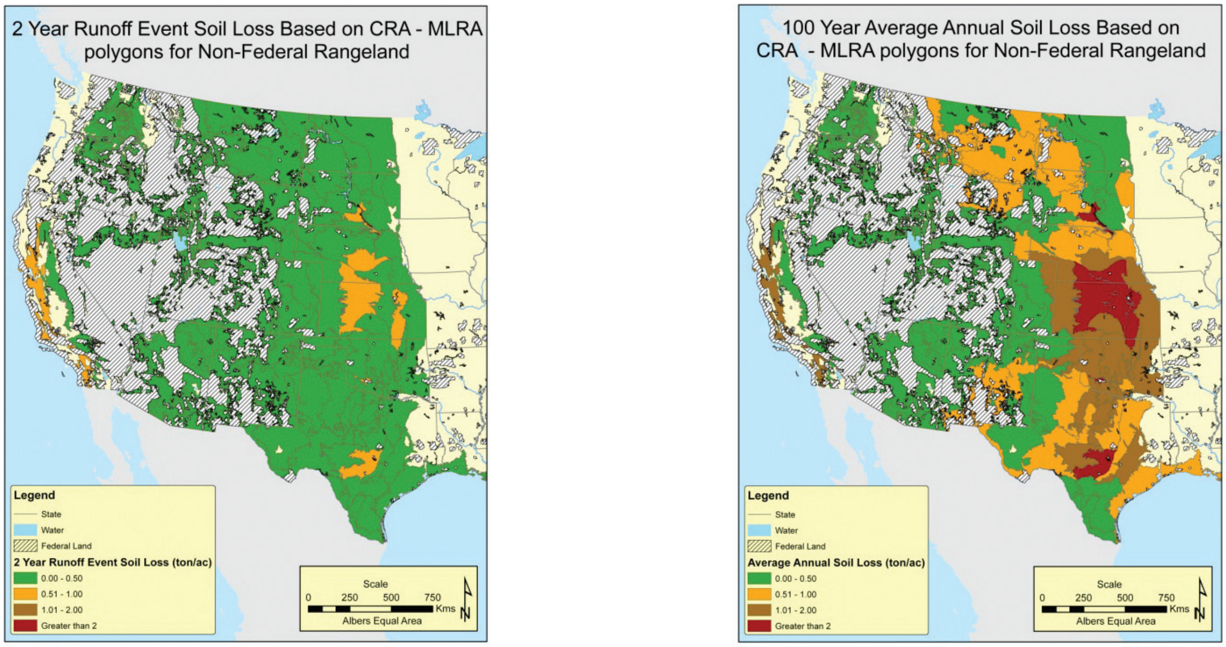
Source: USDA Agricultural Research Service

In the arid and semi-arid parts of the country where rangelands dominate, wind erosion can generate dust storms that cause significant health and property damage, and can even result in highway closures or accidents due to low visibility. Rangeland vegetation limits dust emission to extremely low levels. If rangelands, including much of the land currently protected by CRP in the Great Plains, are cultivated, the potential for wind erosion increases dramatically. Potential effects vary regionally (fig. 3-13).

Figure 3-12.

Average annual water erosion rates on western rangelands

Over the course of a century, the average annual water erosion rates are highest in the Central Plains from central Texas to South Dakota because the annual precipitation is higher there than in the intermountain States Arizona, Nevada, New Mexico, and Utah.

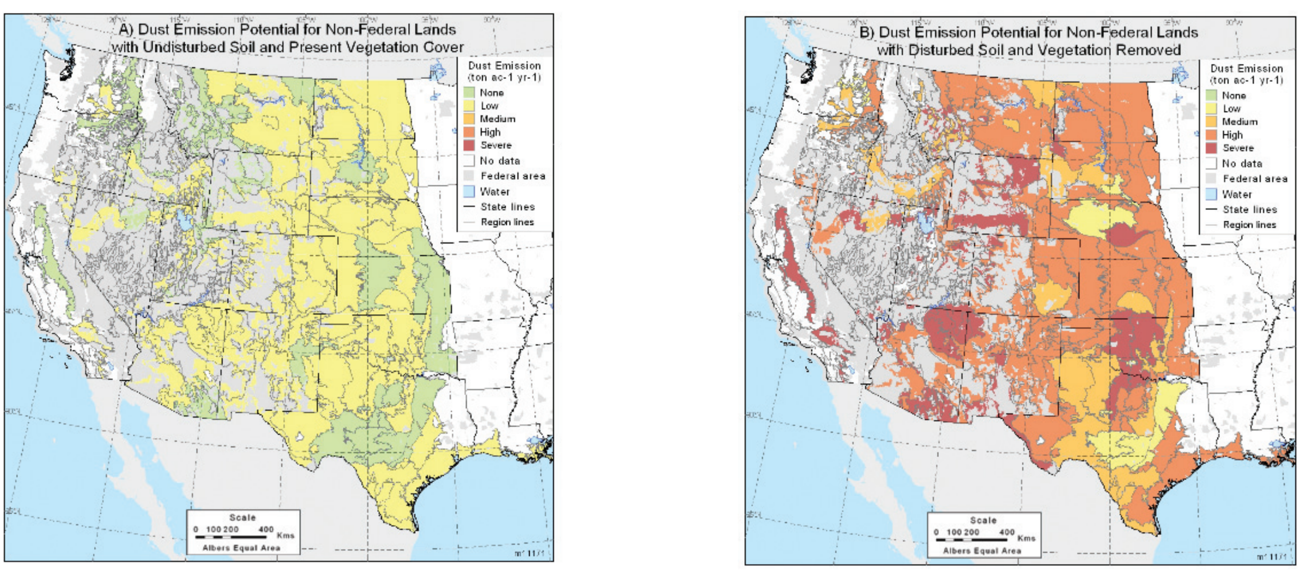


Source: USDA-Agricultural Research Service

Figure 3-13.

Potential effects of soil and vegetative disturbance on western rangelands

Dust production from rangelands is minimal when soils are vegetated and not intensively disturbed, which is typical for rangeland soils (left). Vegetation removal combined with intense disturbance, such as overgrazing, intensive off-highway vehicle use, or cultivation, dramatically increases potential wind erosion. Areas with soils more susceptible to wind erosion and soils having higher concentrations of fine particles (silt and clay) are at greater risk of high dust emission if intensively disturbed.

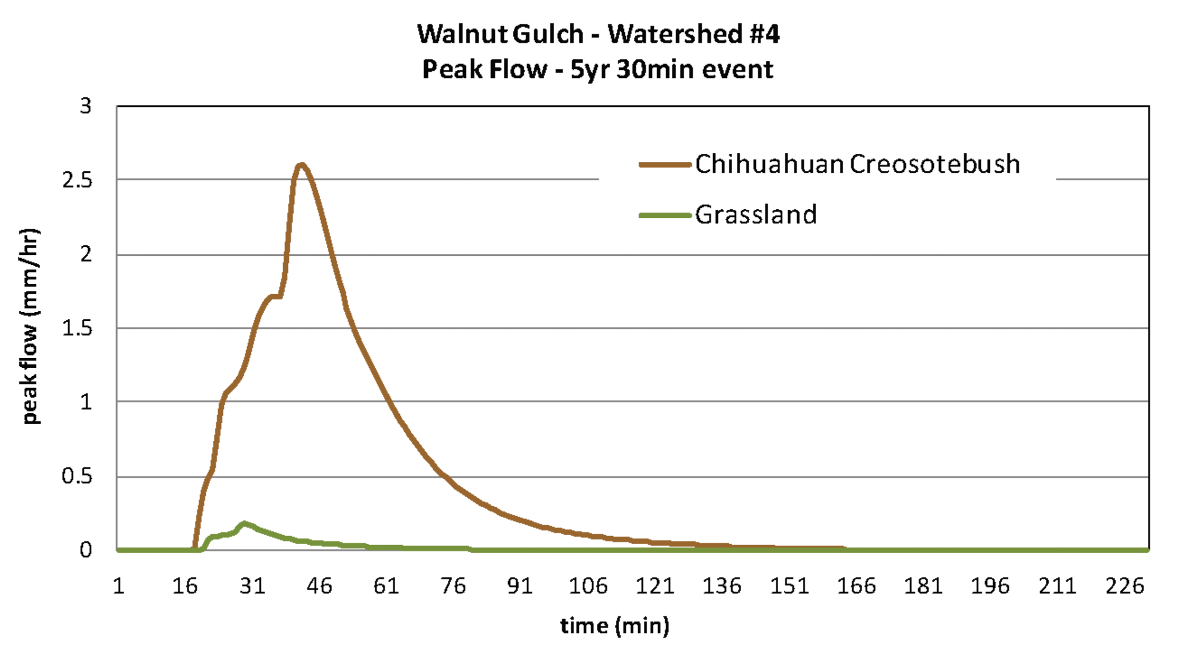


Source: USDA-Agricultural Research Service

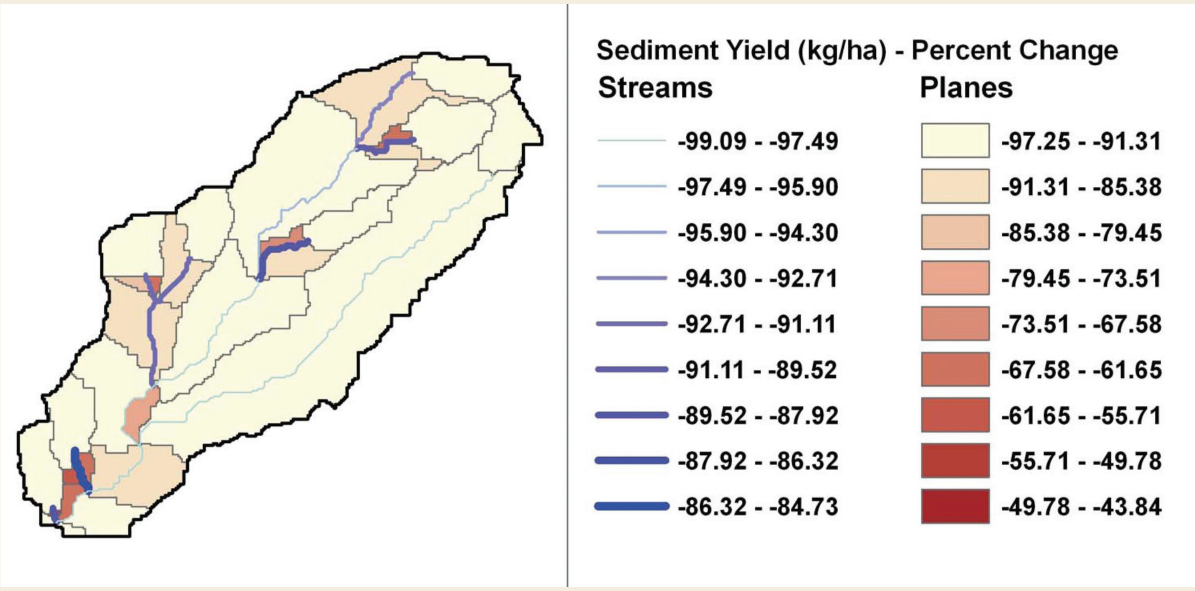
Brush Management on the ARS Walnut Gulch Experimental Watershed in southern Arizona

The Automated Geospatial Watershed Assessment tool was used to estimate the benefits of brush management to reduce the invasive species creosotebush and the benefits of reseeding practices to restore the watershed to native desert grassland. Benefits were found to be enhanced soil moisture and forage production, and significantly reduced surface runoff and soil erosion from water.

Change in peak flow (mm/hr) after removing the brush and restoring to desert grassland in southern Arizona



Change in sediment yield (kg/ha) after removing the brush and restoring to desert grassland in southern Arizona



Source: USDA Agricultural Research Service

Invasive plant species on rangeland

Non-native plant species occur on nearly 50 percent of non-Federal rangelands, and account for at least 50 percent of the land cover on more than 5 percent of these lands. Most non-native plant species cause no problems and in some cases are considered beneficial. Crested wheatgrass, for example, is an introduced species that is relatively easy to establish and commonly recommended for forage production and soil stabilization in arid regions (USDA-NRCS 2010). Under some conditions, however, some non-native species have become invasive. Once established, these species have been difficult to eradicate. Where they replace significant proportions of native plant communities, they can modify vegetation structure, the fire regime, soil erosion rates, and forage production. These changes in turn can have significant effects on wildlife populations.

Some non-native invasive herbaceous species can outcompete native species and reduce forage availability for wildlife and livestock. The annual bromes, which are the most widespread of the invasive plants, are highly invasive in many shrub communities including sagebrush and piñon and juniper savannas. Communities of annual bromes can be highly flammable from late spring through early fall. Other important non-native invasive plants include medusahead and *Centaurea* and *Cirsium* species (USDA-NRCS 2010).

Some native woody shrubs such as juniper and mesquite can invade areas replacing native grasses and forbs. Dense stands reduce habitat and forage for domestic animals and wildlife and can increase the potential for soil erosion. Deep root systems of woody species may reduce water availability to both plants and animals. Invasive juniper species, including eastern redcedar, are widespread, but are especially prevalent in the Great Plains from the Canadian border to the Gulf Coast. Juniper species often invade areas that have historically been disturbed, for example, in some areas where overgrazing was common during early settlement years (fig. 3-14).

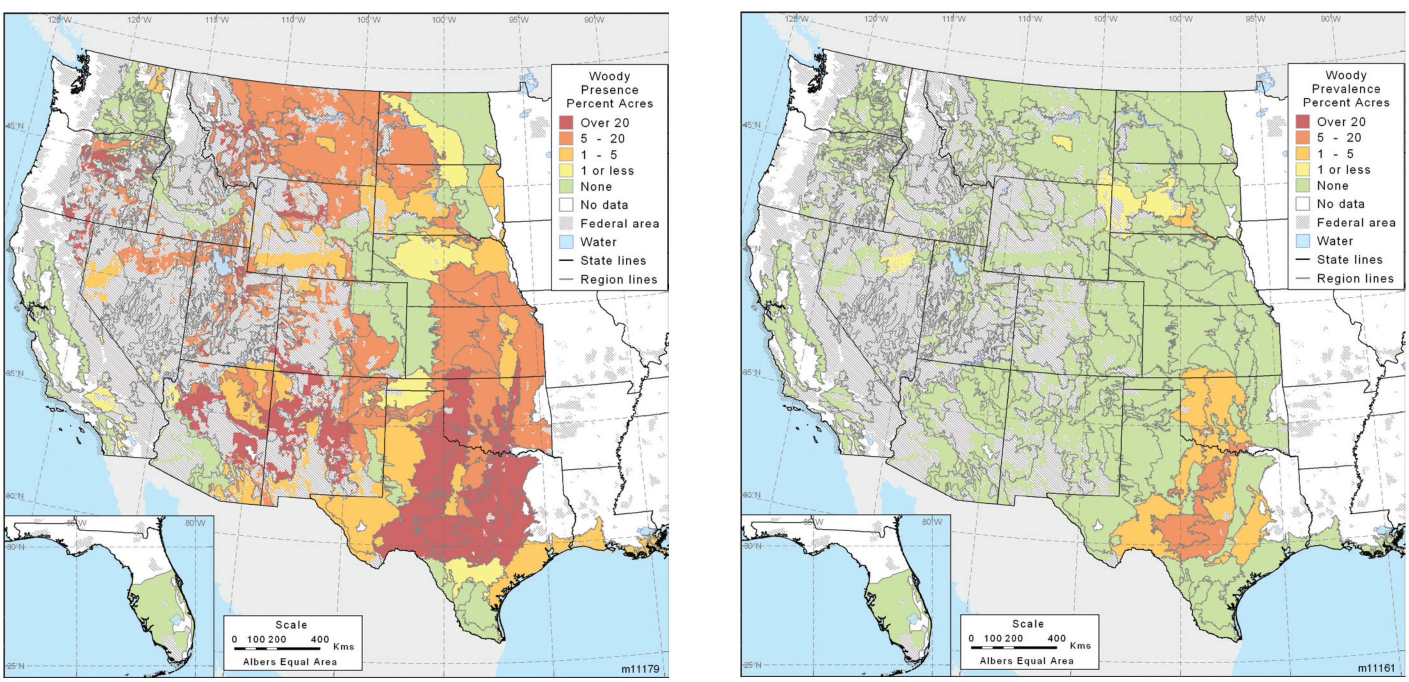
Forest health

Forests provide a vast array of public goods and services, such as clean water, timber, wildlife habitat, and recreational opportunities. Forest insect pests and diseases and forest fires are intrinsic components of naturally functioning forest ecosystems, but they also can have detrimental effects (USDA Forest Service 2009). Native and exotic pests have killed trees on millions of acres of U.S. forests. Similarly, wildfires have severely damaged forests and the waters and wildlife that depend upon them.

Figure 3-14.

Prevalence of invasive juniper species on rangelands in the 17 western States

Areas of rangeland where invasive juniper species are present (left), and areas where invasive juniper species make up at least 50 percent of the land cover (right)



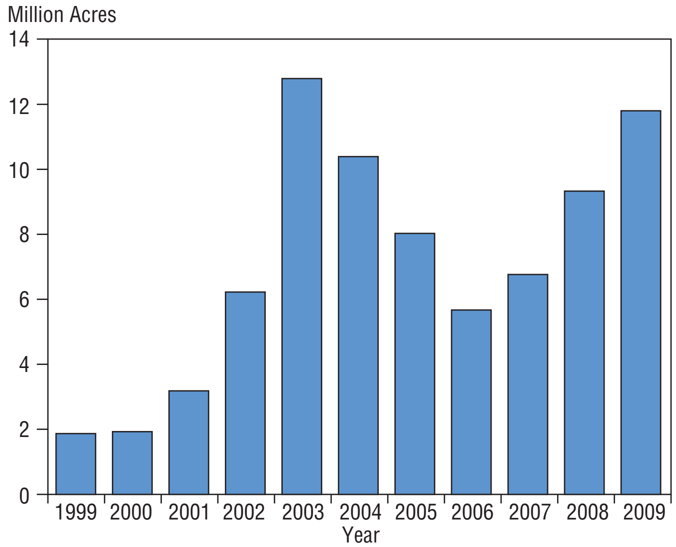
Source: USDA-NRCS/NRI Rangeland Resource Assessment

Forest insect pests and diseases can reach outbreak levels when susceptible forest conditions are combined with weather stress. Periods of below-normal precipitation and above-normal temperatures can stress trees and reduce their resistance to insects and pathogens. The Forest Service's Forest Health Monitoring (FHM) Program determined that a large increase in tree mortality from 2002 through 2009 was largely due to increased bark beetle activity in the West following severe regional drought (fig. 3-15).

A national risk assessment, completed in 2006 under the FHM program, identified areas where more than 25 percent of the trees greater than 1 inch in diameter are expected to die within 15 years due to insects and disease (Krist et al. 2007) (fig. 3-16). More than 27 million acres of non-Federal forest lands—an area about the size of Louisiana—were deemed to be at risk of mortality due to insect pests and diseases.

Figure 3-15.

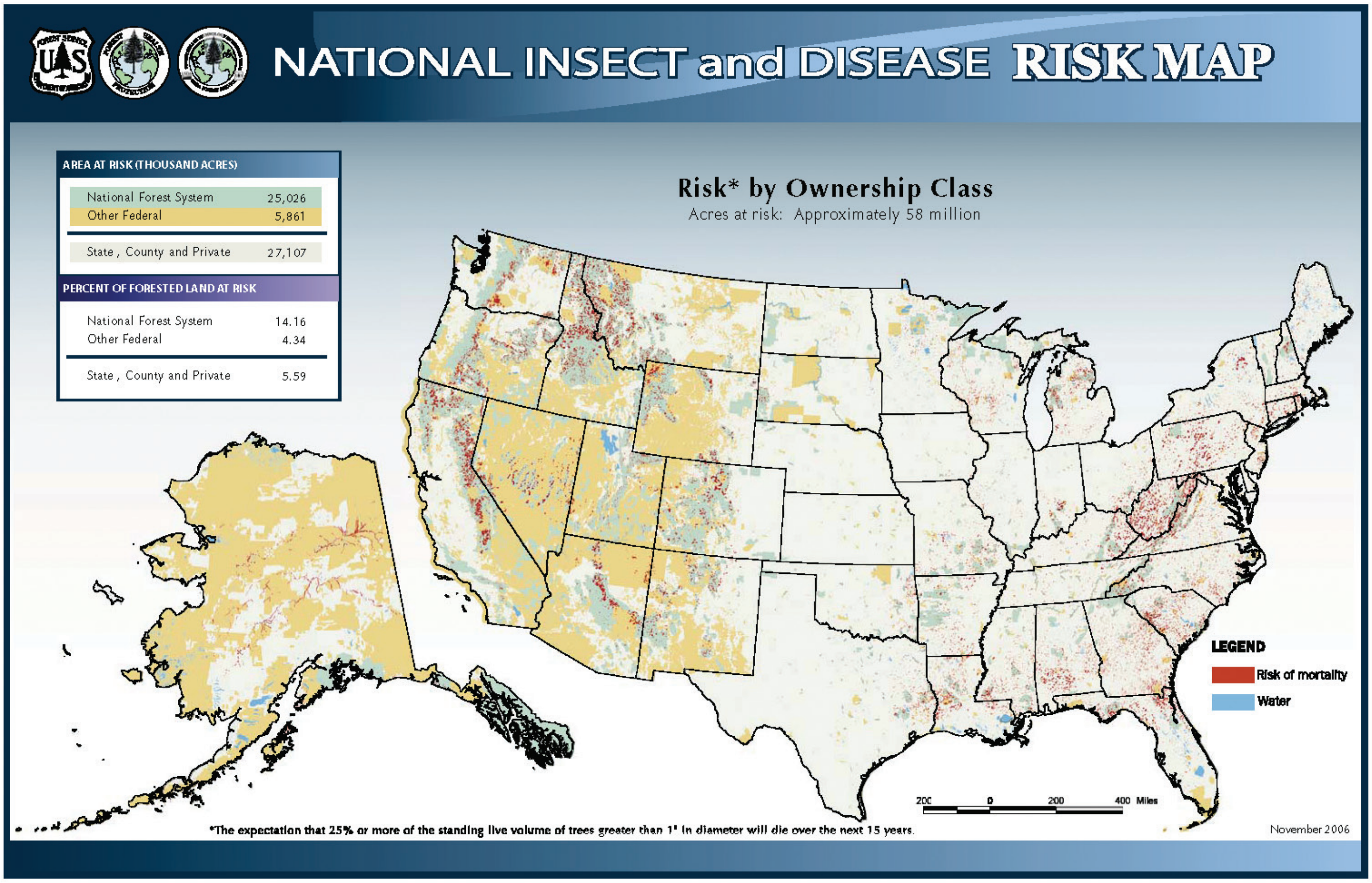
Acres with outbreak levels of tree mortality, 1999–2009



Source: USDA Forest Service

Figure 3-16.

Areas with potential risk of greater than 25 percent tree mortality due to insects and diseases

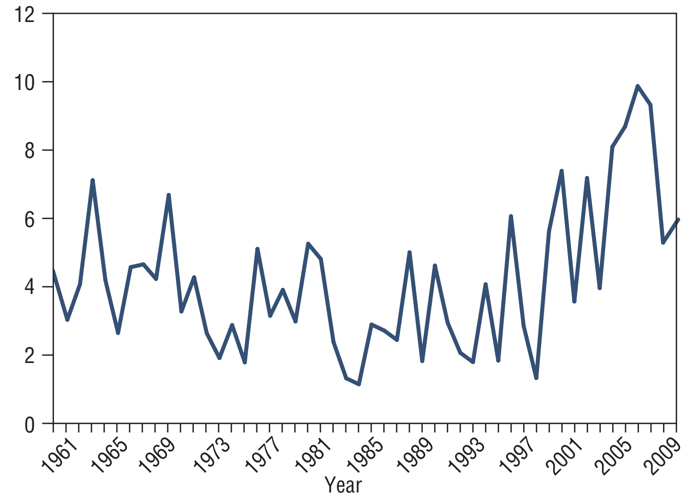


Source: USDA Forest Service

Fire is a major disturbance in many forests of the United States. The annual amount of area burned varies depending on weather conditions, fuel loading, and forest stand conditions. Much of the recent increase in area burned is due to increased fuel loads and recent changes in weather, especially in the western United States. The total forested area burned in 2006 was the largest fire-affected acreage during the period 1960 to 2009 (fig. 3-17). The Forest Service's Fire Modeling Institute has developed the Wildland Fire Potential Model to identify areas across the country with the greatest risk of forest damage due to wildfire under extreme conditions (Menakis 2008). Watersheds where private forests have the highest wildland fire potential are concentrated heavily in the Western and Southeastern United States (Stein et al. 2009) (fig. 3-18).

Figure 3-17.

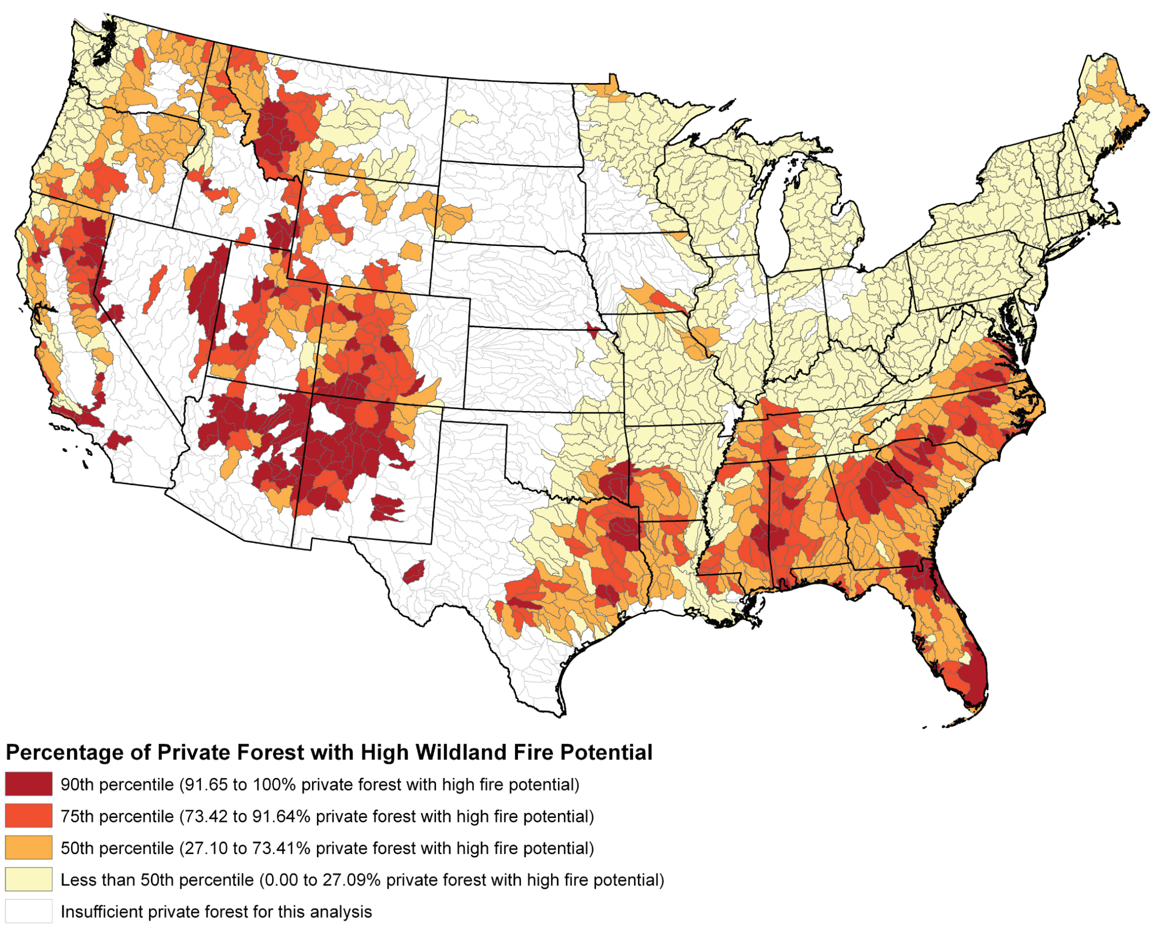
Total area of wildfires, 1961–2009



Source: USDA Forest Service

Figure 3-18.

Percentage of private forest with high wildfire potential



Source: USDA Forest Service

Invasive plant and animal species

An estimated 50,000 non-native plant and animal species have been introduced into what is now the United States since European settlement. Many of these plants and animals are beneficial; introduced plants such as rice, corn, and wheat and introduced cattle and poultry species are the underpinning of the U.S. agricultural economy, providing more than 98 percent of U.S. food production valued at about $800 billion annually (Pimentel et al. 2005).

Some of the deliberate and unintentional introductions of plants, animals, and pathogens, however, are invasive. Biological invasions by non-native species impose an enormous cost on agriculture, forestry, fisheries, and human food security and health. Many introduced species compete with or prey upon native species, hybridize with them, and carry diseases to them. Invaders can change ecosystems by altering hydrology, nutrient cycling, water use, and other ecosystem processes. Invasive weeds cause agricultural production losses and degrade water catchments, estuarine systems, and fisheries and clog rivers and irrigation systems.

Current environmental, economic, and health costs of invasive species are estimated to exceed $138 billion per year—an estimate that some consider conservative (Pimentel et al. 2005). Examples of invasive species include—

- The West Nile virus, which kills or sickens mainly birds but also mammals;
- The whirling disease parasite, which kills wild as well as farm-raised fish;
- The sudden oak death fungus, which kills oaks and other trees and shrubs, and the white nose syndrome fungus, which is decimating bat populations;
- Plants such as kudzu, water hyacinth, leafy spurge, saltcedar, Russian olive, and knapweed, which displace native plants or choke waterways;
- Invertebrates such as fire ants, which kill poultry chicks and livestock, and invasive mollusks, which outcompete native species and damage municipal water facilities;
- Vertebrates such as introduced rat species, which destroy stored grains and spread diseases, and feral swine, which damage crops and wildlands and also transmit disease.

Invasive species are "plants, animals, and other organisms whose introduction causes, or is likely to cause, economic or environmental harm, or harm to human health" (Executive Order 13112, February 3, 1999). The invaders spread by way of several pathways, and since many of these species infest areas not also inhabited by their natural biological controls, their spread is unrestricted and their impacts often costly. Only a small fraction of introduced non-native species become established, and only about 10 percent become invasive and harmful.

Use of some invasive species as biofuel feedstocks, and potential hazards and concerns are presently being discussed. For example, under a Conservation Innovation Grant from NRCS, Montana State University is developing innovative ideas for managing invasive plants in the upper Missouri River watershed. More than 1 million acres within the watershed are infested with Russian olive and saltcedar, which are potential sources of biomass for energy production.

The challenge of feral swine

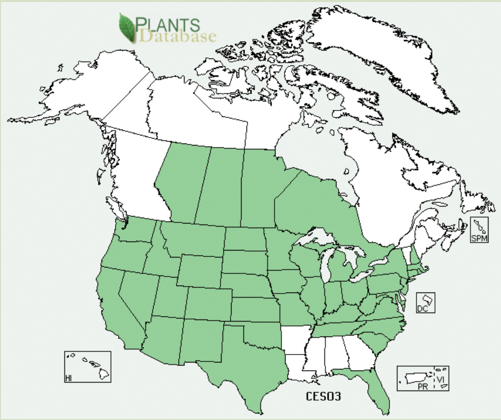
Pigs are thought to have been introduced into the United States by the early European explorers. Over time, many pigs were released or escaped into the wild, especially in the southeastern United States. Despite ongoing efforts to control their spread, wild pigs have increased both their range and population size (West et al. 2009). Estimates of the feral swine population range as high as 5 million (Pimentel 2007) in as many as 39 U.S. States (West et al. 2009).

Feral pigs are considered pests because they feed by rooting and grazing, which destroys crops and causes ecological damage in the form of reduced water quality, increased soil erosion, damage to trees and other native plants, and transmission of disease. Damage and control costs have been estimated to be around $1.5 billion annually (Pimentel 2007).

These animals have few natural predators in the United States, although in some locations alligators, bears, and large cats prey on them. Wild pigs are hunted in many areas, but hunting alone is unlikely to control them especially where habitat conditions are favorable. Because the pigs quickly learn to avoid single-control techniques, the best control mechanism appears to be a combination of techniques.

PLANTS Database

The USDA PLANTS Database (http://plants.usda.gov/index.html) provides standardized information about the vascular plants, mosses, liverworts, hornworts, and lichens of the United States and its territories, including invasive species. The map below shows the U.S. States and Canadian provinces where the yellow starthistle has spread. This invasive plant was introduced to the United States in contaminated seed from its native Eurasia in the 1800s. It crowds out native species and is toxic to horses.



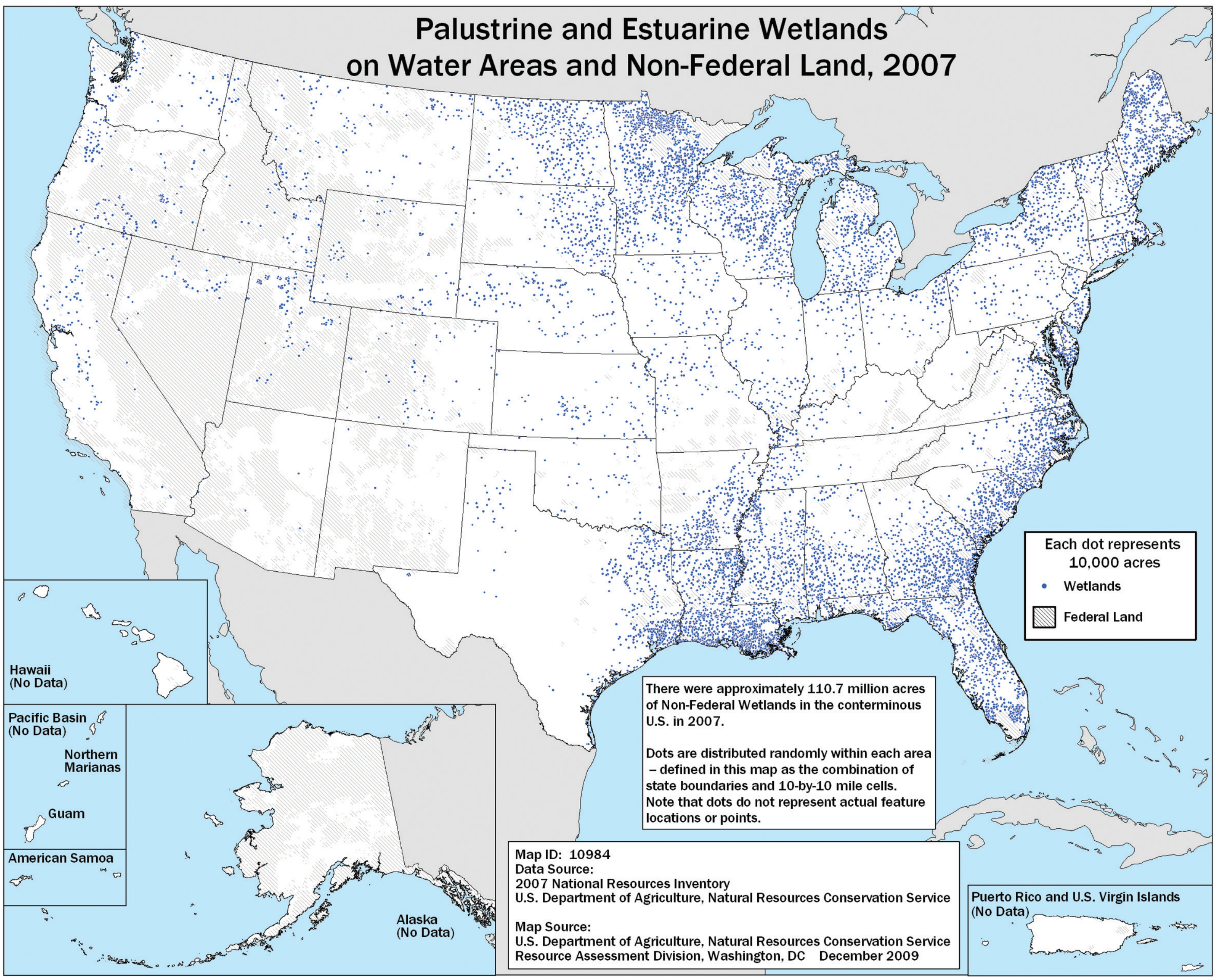
Wetlands

Wetlands are a condition of the land found across land uses. They are protected at the Federal, State, and local levels because of the valuable ecological services they provide. Wetlands filter nutrients, trap sediments and associated pollutants, improve water quality, provide fish and wildlife habitat, reduce floodwater runoff peaks, recharge aquifers, buffer shorelines from storm impacts, and produce food and fiber for human consumption and use. Wetlands conservation is supported by a growing awareness of their values by Federal, State, and local programs and the efforts of private organizations.

Wetlands cover about 111 million acres of non-Federal land and water in the conterminous United States (fig. 3-19), which is about half the acreage of wetlands that existed at the time of European settlement. The two principal wetland types are Estuarine and Palustrine. Estuarine wetlands occur in the tidal zones of coastal states where freshwater streams enter the ocean or where wetland emergent vegetation occurs in tidal waters partially diluted by fresh water. About 57 percent of U.S. wetlands occur in the Lake States, Southeast, and Delta States; wetlands are least abundant in the Pacific, Corn Belt, and Mountain States (fig. 3-20).

Figure 3-19.

Location of wetlands, conterminous 48 States, 2007

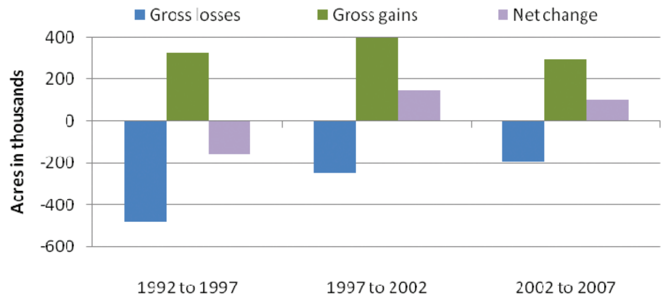


Source: 2007 National Resources Inventory, Natural Resources Conservation Service, USDA

The decade 1997 to 2007 was the first in which wetland gains outpaced losses. During this period, there was a modest net gain in wetland area of about 250,000 acres—a gross gain of some 690,000 acres less a gross loss of 440,000 acres (fig. 3-21). Sixty percent of gross wetland losses during the period 1997 to 2007 were due to urban and industrial development and about 15 percent to agriculture. Conversion of wetlands to agricultural uses during this period averaged over 6,500 acres per year, or about one-fourth the rate of conversion during the early 1990s. Conversely, more than 59 percent of wetland gains occurred on agricultural lands. Net gains were recorded in the Corn Belt and Northern Plains, a net loss was reported in the Southeast, and total wetland acreage remained stable in the other regions.

Figure 3-21.

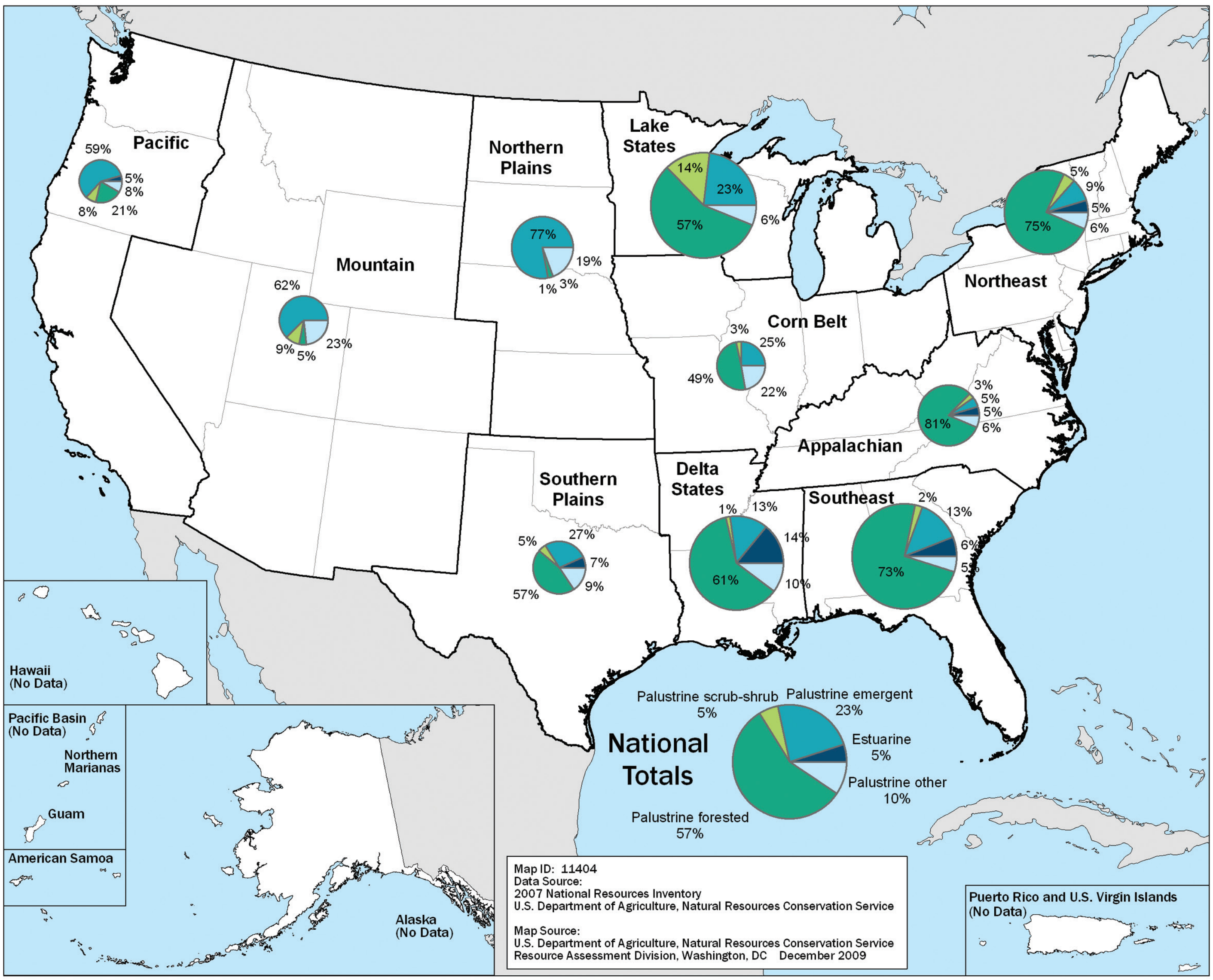
Losses and gains in Palustrine and Estuarine wetlands, conterminous 48 States, 1992–2007



Source: 2007 National Resources Inventory, Natural Resources Conservation Service, USDA

Figure 3-20.

Palustrine and estuarine wetlands by Farm Production Region, 2007



Source: 2007 National Resources Inventory, Natural Resources Conservation Service, USDA

Wetland conservation practices in the Prairie Pothole Region

As part of the Conservation Effects Assessment Project (CEAP), the U.S. Geological Survey (USGS) conducted a comprehensive, stratified survey of wetlands and catchments in the Prairie Pothole Region of the Upper Midwest and northern Great Plains—204 wetlands in 1997 and 270 catchments in 2004. These areas represented a subset of about 5 million acres of wetland and grassland systems established on Conservation Reserve Program (CRP) and Wetlands Reserve Program (WRP) lands. The purpose of the survey was to gather data for estimating a variety of ecosystem services provided by prairie pothole wetlands and catchments.

Principal findings include the following:

- Restoration practices improved the distribution and species richness of the native plant community, but not to the point of full site potential.
- Catchments with a history of cultivation had less soil organic carbon in the upper soil profile than did native prairie catchments.
- Wetlands on program lands have significant potential to intercept and store precipitation that otherwise might contribute to downstream flooding; conservatively estimated, wetland catchments on program lands could capture and store an average of 1.1 acre-feet of water per acre of cropland.
- Conversion of cultivated cropland to herbaceous perennial cover through CRP and WRP enrollments reduced total soil loss from uplands by an average of almost 2 million tons per year, potentially resulting in the delivery of less sediment and associated nutrients to sensitive offsite ecosystems such as lakes, streams, and rivers.
- Restored catchments provide at least some necessary resources for a diversity of bird species that cropland catchments do not; CRP and WRP enrollments led to increases in the number of grassland areas that exceeded published nesting area requirements for the five area-sensitive grassland bird species evaluated in the study.

Wildlife habitat

While a variety of productive wildlife habitat types are found in agroecosystems, much of the original grassland and wetlands in the Corn Belt, northern prairies, and California's Central Valley; the original bottomland hardwood forested wetlands of the Southeast; and the sagebrush habitats of western rangelands have been converted to agricultural use (Noss et al. 1995, Tewksbury et al. 2002). Although the United States harbors significant biodiversity, approximately one third of all species are at-risk or of conservation concern (Stein et al. 2000). The U.S. Fish and Wildlife Service lists 578 animal species as threatened or endangered in the United States under the Federal Endangered Species Act (fig. 3-22). Moreover, thousands of additional species are at risk of becoming threatened or endangered (fig. 3-23). Agriculture is listed as a source of endangerment for 45 percent of listed or proposed fishes and 64 percent of mussels; water pollution from all sources has been identified as a source of endangerment for 55 percent of fishes and 97 percent of mussels (Wilcove et al. 1998). Figure 3-24 shows the concentrations of plant and animal species considered at risk but not listed as threatened or endangered, largely in the mountainous areas in the East and the West, in Florida, parts of the Gulf Coast, and Hawaii.

More than one third of the listed animal species are fishes (140) or clams (70), highlighting the disproportionate number of aquatic listed species and the importance of aquatic habitats for their survival and recovery. Nearly 70 percent of the nation's freshwater mussels, more than half of the crayfish species, and more than one-third of freshwater fishes are at risk (Stein et al. 2000). Thirty-nine percent of all known North American freshwater fish and diadromous fish (those that migrate between salt and fresh water) are imperiled—more than double the proportion imperiled in 1989 (Jelks et al. 2008).

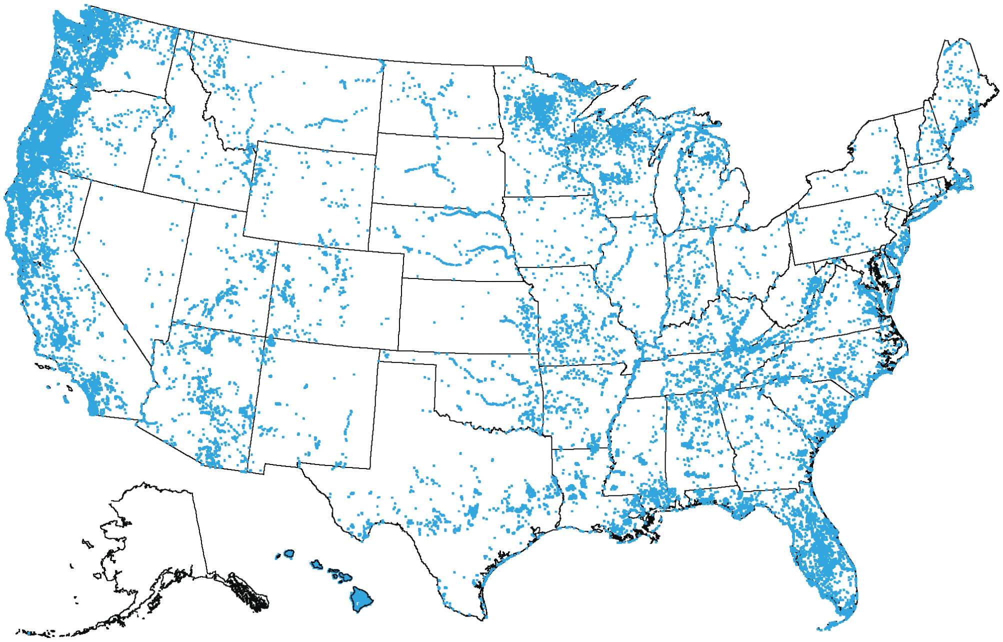
Bird populations are useful indicators of the status of other wildlife species that inhabit the same environments. There are more than 800 bird species in North America. Of bird groups in general, those experiencing the greatest population declines in recent decades include Hawaiian birds, seabirds and coastal shorebirds, grassland birds, and arid-land birds (North American Bird Conservation Initiative, U.S. Committee 2009). Threats to sagebrush habitats pose risks to greater sage-grouse and other sage-steppe dependent species (Knick et al. 2003).

Although the human footprint has caused significant changes to original ecosystems, productive fish and wildlife habitats do remain in agricultural landscapes, and USDA conservation programs are contributing significantly to collaborative efforts to conserve and restore important habitat functions (Haufler 2005). Grassland habitats can be restored or enhanced through conservation practices and programs on agricultural lands.

Figure 3-22.

Distribution of federally listed threatened and endangered species

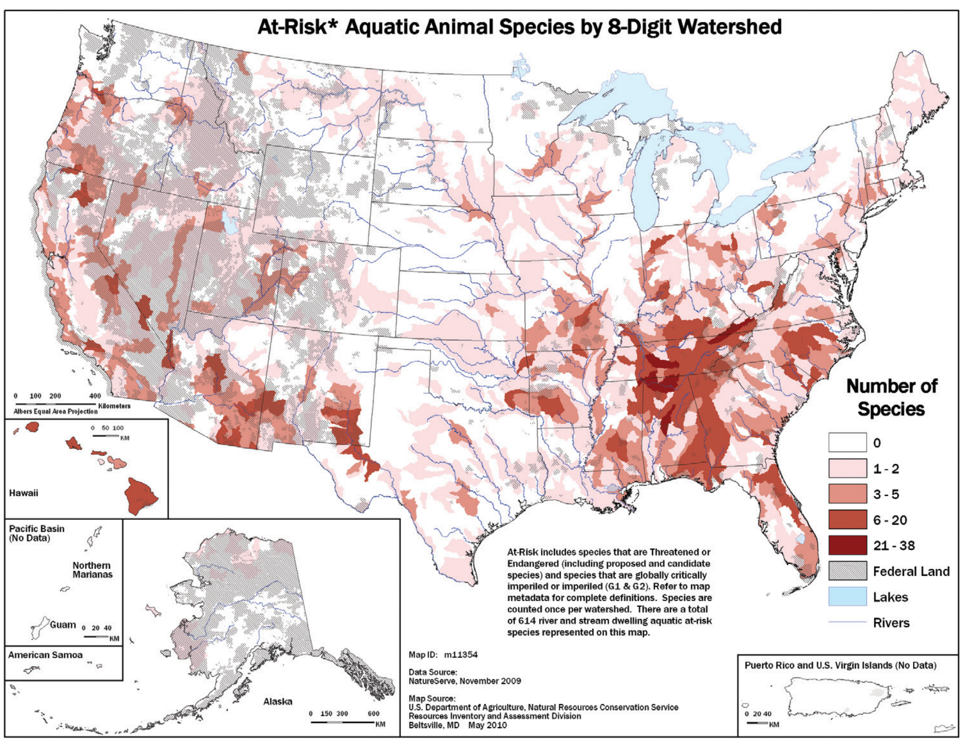
Each dot on the map represents a known occurrence of threat or endangerment. The patterns are most dense where water is present, reflecting the vulnerability of aquatic species.



Source: State Natural Heritage Data Centers (1996), cited in Stein et al. 2000.

Figure 3-23.

Areas of endangerment for aquatic animal species on non-Federal land and water



Source: NatureServe

For example, recent stabilization of long-term declines in Henslow's sparrow populations has been attributed to the presence of grassland habitats provided by Conservation Reserve Program (CRP) enrollments in Midwestern states (Herkert 2007). Likewise, CRP grasslands are contributing to meeting population goals of priority grassland birds in the Great Plains (McLachlan et al. 2007, McLachlan and Carter 2009).

In response to recent population declines, coordinated efforts have been made to set population goals, habitat objectives, and conservation strategies for northern bobwhites (Dimmick et al. 2002), greater sage-grouse (Connelly et al. 2004), prairie grouse (Vodehnal and Haufler 2007), and other priority birds through various bird habitat joint ventures.

USDA Sage-Grouse Initiative preserves vital habitat

The greater sage-grouse, a ground-dwelling bird inhabiting the sagebrush steppe ecosystem of the American West, has experienced a significant decline in population and habitat over several decades. The USDA Natural Resources Conservation Service (NRCS) Sage-Grouse Initiative (SGI) is accelerating implementation of conservation practices that would protect the birds and improve their habitat. NRCS and the Fish and Wildlife Service (FWS) of the United States Department of the Interior are collaborating to address potential Endangered Species Act (ESA) issues before they become intractable problems.

The SGI includes monitoring and evaluation to measure the biological response of sage-grouse populations to the initiative. Range-wide sage-grouse core areas have been mapped to gauge practice effectiveness, adaptively improve program delivery, and ensure that practices benefit the largest number of birds. Initiative-sponsored research is underway in Montana, Wyoming, and Oregon to assess benefits of grazing systems and encroached conifer removal. At least 525 ranches are participating in the initiative.

The Initiative employs the "conferencing" section of ESA to secure from FWS reasonable certainty for cooperators who voluntarily implement NRCS-sponsored conservation practices. NRCS cooperators will be in compliance regarding sage-grouse under ESA if the sage-grouse species is listed as threatened or endangered.

Establishment of field buffers promotes wildlife habitat

The Habitat Buffers for Upland Birds practice (Practice Code CP33) is the first Federal conservation practice to target species-specific population recovery goals of a national wildlife conservation initiative (the Northern Bobwhite Conservation Initiative). This practice offers incentives to landowners for establishment of a diverse native herbaceous community along crop field edges to provide habitat for northern bobwhite and other upland birds.

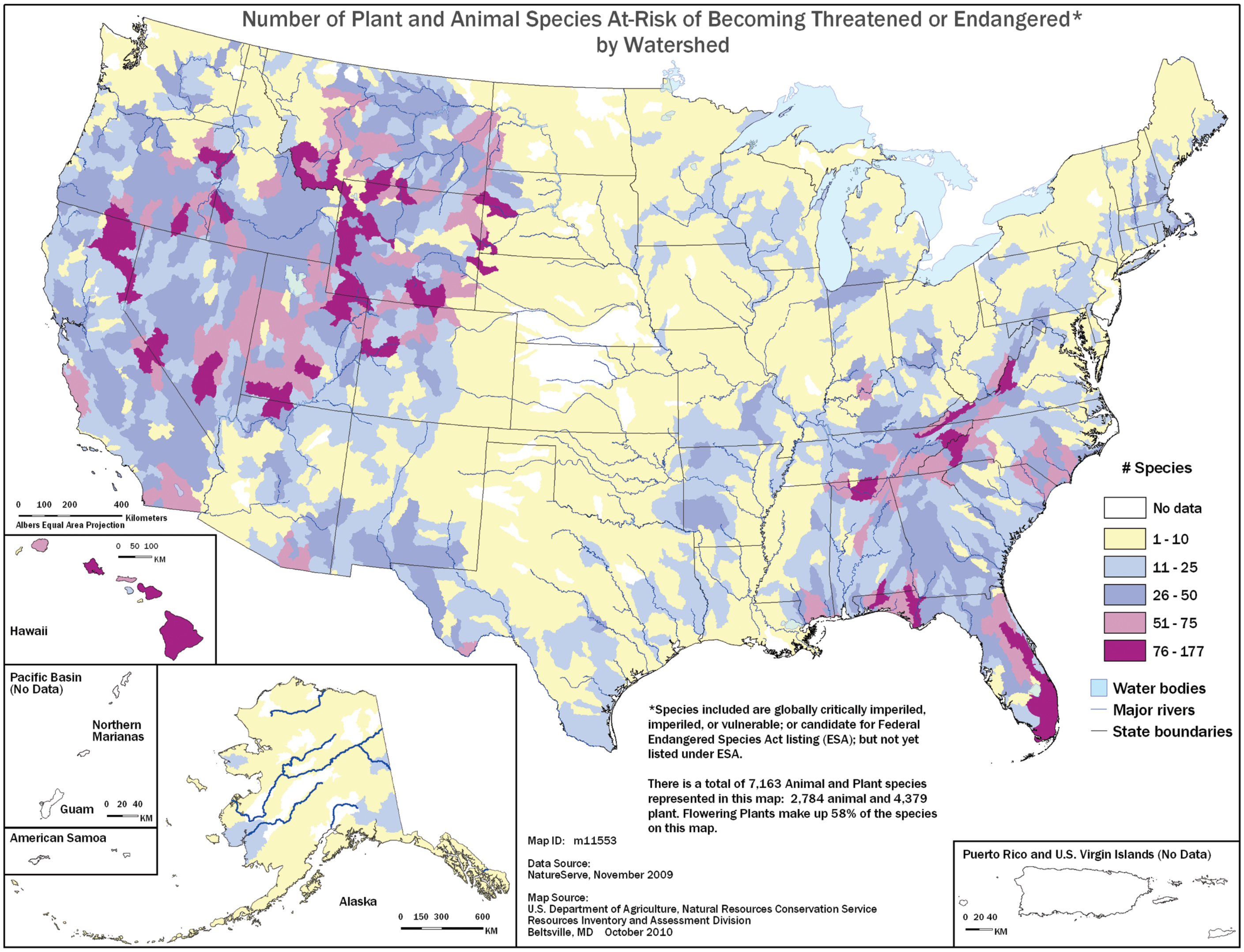
The USDA Farm Service Agency (FSA) administers the Continuous Conservation Reserve Program (CCRP), under which the CP33 practice is supported. FSA allocated 250,000 CP33 acres to 35 states within the bobwhite range for establishment of 30- to 120-foot upland habitat buffers under 10-year contracts. More than 209,000 CP33 acres were enrolled between 2004 and the end of 2009.

The results? A Conservation Effects Assessment Project (CEAP) wildlife study found that over a 14-State area, breeding bobwhite densities were 70 to 75 percent greater and fall bobwhite covey densities were 50 to 110 percent greater around CP33 fields than around unbuffered crop fields. This positive response to CP33 increased each subsequent year of the study. Several upland songbirds, such as dickcissel and field sparrow, also responded strongly to CP33 in the landscape. Area-sensitive grassland birds such as the grasshopper sparrow, however, exhibited little response.

These findings show that conservation buffers supported by CP33 and through conservation programs such as the Environmental Quality Incentives Program (EQIP) and Wildlife Habitat Incentive Program (WHIP) entail relatively small changes to primary land use yet can provide essential wildlife habitat in productive working agricultural landscapes. Broader application of this effective conservation practice can be used to accomplish regional recovery of bobwhite populations.

Figure 3-24.

Distribution of plant and animal species at risk of becoming threatened or endangered, by watershed



Source: NatureServe

Conclusion

Because farms, ranches, and forests make up more than 85 percent of the non-Federal area of the conterminous 48 States, the quality of the environment is linked with stewardship of those lands. Sound stewardship requires a continuing commitment to assessing and addressing important natural resource issues and concerns.

In general, natural resource trends on agricultural and forest lands are headed in the right direction. Soil erosion on cropland is down, and the bulk of the Nation's grasslands and non-Federal forest lands are in good condition. Soil carbon stocks are stable or increasing in most places. Although agriculture is a source of endangerment for many wildlife species, productive habitats remain in the Nation's farms, ranches, and forests. For the first time, wetland gains from agriculture are outpacing wetland losses to agriculture.

Despite these gains, many conservation issues remain to be addressed. Erosion will always be a concern where crops are grown and livestock are grazed. Non-native, invasive plants and animals are growing concerns on rangeland and cropland and in postharvest storage facilities. Expected changes in climate patterns will require adaptations in farm and forest management. Through the Conservation Effects Assessment Project (CEAP), USDA seeks to provide quantitative measurements of conservation benefits and more precisely identify conservation treatment needs.

USDA conservation programs strive to maintain a balance between food security and a healthy environment. Chapter 4 outlines USDA's current suite of conservation approaches.

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CHAPTER 4

Conservation Approaches

CHAPTER 4

Conservation Approaches

USDA's soil and water conservation mission uses a variety of approaches, from research to outreach, education, extension, and on-the-ground technical assistance. USDA carries out its conservation mission through nine agencies (see box on p. 51), working with a wide array of conservation partners, such as colleges and universities, conservation districts, Resource Conservation and Development councils, State and Federal agencies, State foresters, non-governmental organizations, and farmers, ranchers, and forest landowners.

In 1985, conservation efforts began to shift from focusing on supply controls and productivity to other environmental issues. From 1985 until the end of the 20th century, Federal conservation policy focused on agricultural land retirement. The environmental benefits of land retirement are significant, but less than 2 percent of the Nation's land area is now protected through land retirement programs. Working lands—those used most intensively and the foundation of the Nation's supply of food, feed, and fiber—account for about two-thirds of the Nation's land base.

This chapter describes the approaches USDA uses to carry out its conservation mission. It also provides data on the investment in USDA's soil and water resources conservation program.[1] Funding for USDA's conservation mission increased by about 25 percent between fiscal years (FY) 2002[2] and 2010, in constant 2009 dollars[3] (fig 4-1).

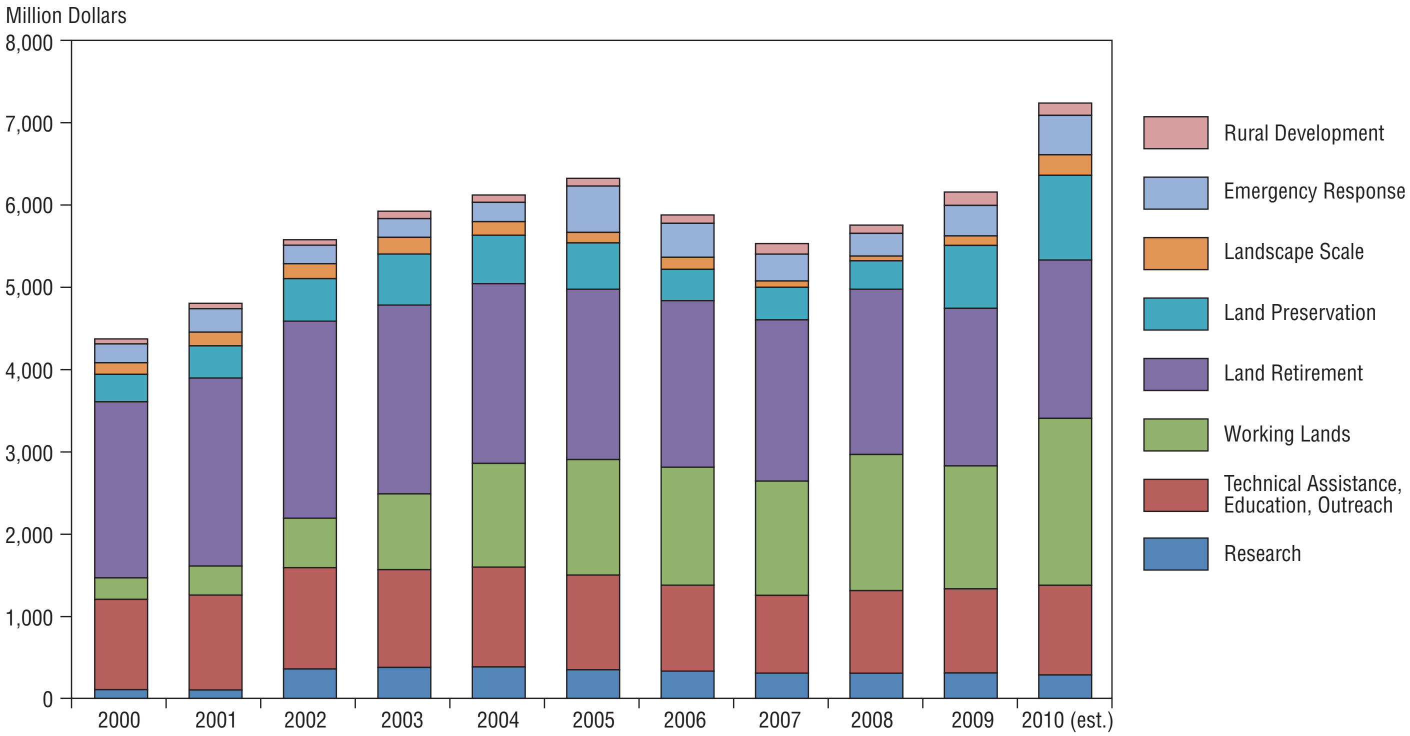
[1] Figures in excess of one million dollars are rounded to the nearest million in the investment tables in this chapter.

[2] Data were not available for 2000 and 2001 for some research efforts; therefore only data from FY 2002 through 2010 are used for the total funding comparison.

[3] Throughout this chapter, nominal dollars are converted to constant dollars using the Gross National Product Index as a deflator, with 2009 as the base year.

Figure 4-1.

USDA conservation investments by approach, million dollars (constant FY2009)



Source: USDA Budget crosscut

USDA Conservation-related Agencies

Agricultural Research Service (ARS) is the intramural research arm of USDA that works to ensure that Americans have reliable, adequate supplies of high-quality food and other agricultural products. ARS accomplishes its goals through scientific discoveries that help solve problems in crop and livestock production and protection, human nutrition, and the interaction of agriculture and the environment.

Animal and Plant Health Inspection Service (APHIS) protects the health of livestock, poultry, and crops from foreign diseases and pests, and helps defend the environment from invasive species, promote animal welfare, regulate the movement and environmental release of certain genetically engineered organisms, limit agricultural damage caused by wildlife, and protect natural resources while contributing to efforts to ensure public health and safety.

Economic Research Service (ERS) provides economic research and information to inform public and private decisionmaking on economic and policy issues related to agriculture, food, natural resources, and rural America. Through a broad range of products, ERS research provides data and expert economic analysis of many critical issues facing farmers, agribusiness, consumers, and policymakers.

Farm Service Agency (FSA) administers farm commodity, credit, conservation, and emergency assistance programs for farmers and ranchers. At the local level, FSA works with farmer and rancher county committees to help determine which programs are implemented countywide, and to make appropriate payments.

Forest Service (FS) administers programs for applying sound conservation and utilization practices to natural resources of the national forests and national grasslands, for promoting these practices on all forest lands through cooperation with States and private landowners, and for carrying out extensive forest and range research. The mission of the FS is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations.

National Institute of Food and Agriculture (NIFA)'s unique mission is to advance knowledge for agriculture, the environment, human health and well-being, and communities by supporting research, education, and extension programs in the Land-Grant University System and other partner organizations. NIFA provides grants to land-grant universities and competitive grants to researchers in land-grant and other universities, institutions, and to individuals, and helps States identify and meet research, extension, and education priorities affecting agricultural producers, small business owners, youth and families, and others.

Natural Resources Conservation Service (NRCS) works with private landowners to help them conserve, maintain, and improve their natural resources. The Agency emphasizes voluntary, science-based conservation; technical assistance; partnerships; incentive-based programs; and cooperative problem solving at the community level. NRCS works with landowners through conservation planning and financial assistance designed to benefit the soil, water, air, plants, and animals that result in productive lands and healthy ecosystems.

Risk Management Agency (RMA) administers the Federal crop insurance program, offering crop insurance products through a network of private insurance company partners; oversees the creation of new products and seeks enhancements in existing products; and offers risk management education and outreach programs to producers and communities.

Rural Development (RD)'s role is to increase rural residents' economic opportunities and improve their quality of life. RD forges partnerships with rural communities, funding projects that bring housing, community facilities, utilities, and other services. RD also provides technical assistance and financial backing for rural businesses and cooperatives to create quality jobs in rural areas. RD promotes the nation's energy security by engaging the entrepreneurial spirit of rural America in the development of renewable energy and energy efficiency improvements.

Conservation approaches

Research

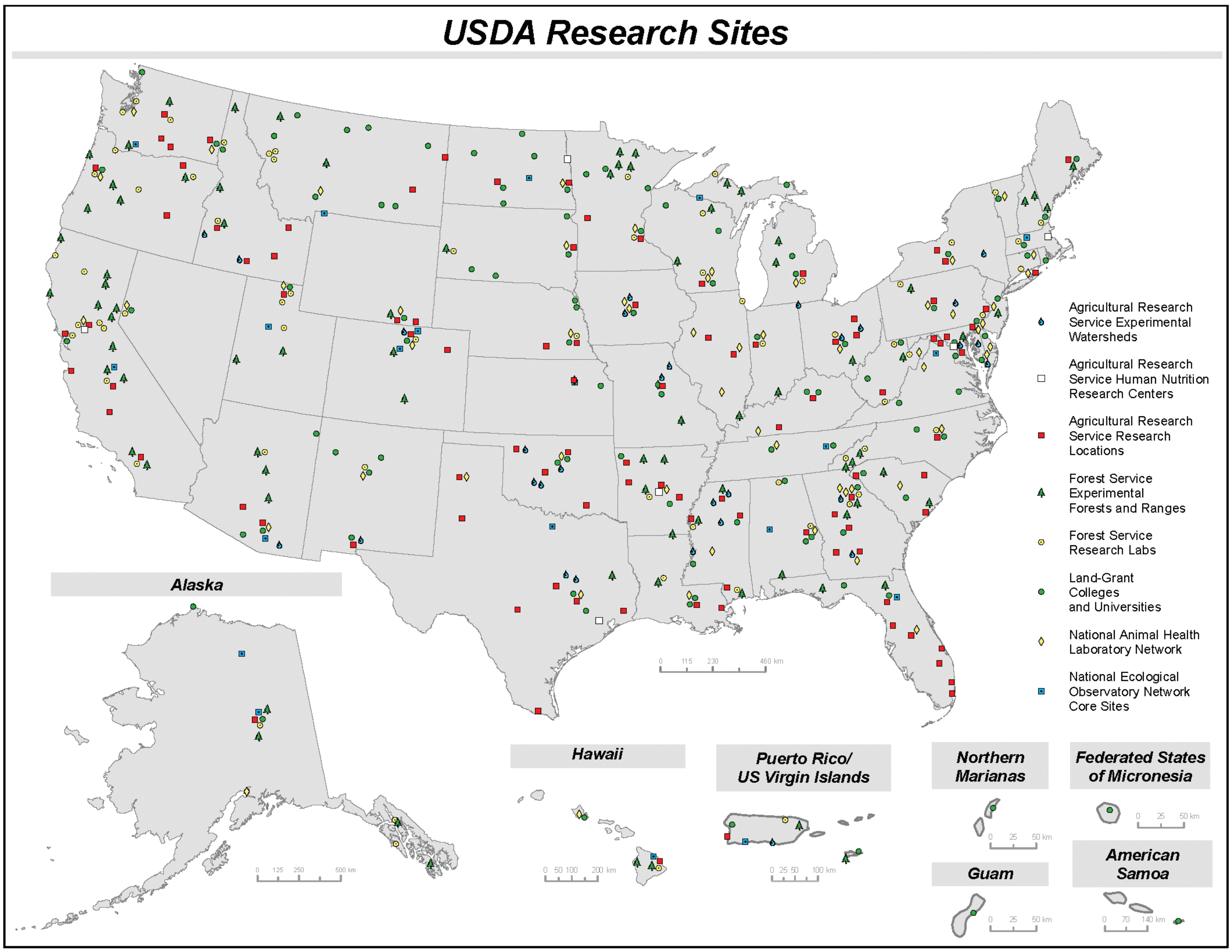
USDA research generates science, technology, and information that help producers and managers conserve and protect the Nation's soil, water and related natural resources. Intramural research is conducted by USDA scientists at over 100 research sites across the country (fig. 4-2), and additional research is funded through grants to institutions and the private sector. This work involves developing and improving technologies, and breeding or identifying new varieties of plants to address specific conservation problems, such as reducing erosion on particular soil types, improving the efficiency of inputs, enhancing adaptability to climate change and extreme environments, increasing carbon sequestration, and improving bioenergy feedstocks.

Science supports field-level decisionmaking

ARS collaborated with the Department of Energy and university partners to develop a user-friendly "Residue Management Tool" that can be used to assess the potential impact of corn stover removal on six environmental indicators – soil organic carbon, wind and water erosion, plant nutrient balance, soil water and temperature dynamics, soil compaction, and offsite environmental variables. The tool accounts for complex interactions between crop residues and the environmental indicators over time and was compared with results from field experiments at multiple locations across the country. It allows a producer considering corn stover harvest for sale as a bioenergy feedstock to evaluate how much residue should remain on the fields to maintain soil quality and productivity. These calculations should be part of an overall conservation plan.

Figure 4-2.

USDA research locations



Source: USDA

USDA conservation research investment rose slightly in nominal dollars between FY 2002 and 2010. However, when measured in constant 2009 dollars, USDA's investment in conservation-related research declined by about 20 percent from 2004 through 2007 (table 4-1). After leveling off for a few years, investment dropped another 10 percent as ARS research was reoriented to support USDA's new strategic goal of assisting rural communities to create prosperity so they are self-sustaining, repopulating, and economically thriving.

Technical assistance, education, and outreach

USDA staffs and partners located in approximately 3,300 field offices across the country provide science-based knowledge, technology, and tools to help producers, landowners, Tribes, State and local governments, and others to conserve, maintain, and improve the Nation's natural resources (fig. 4-3). Many of these offices include co-located staffs from multiple agencies, including NRCS, FSA, RD, RC&D

Table 4-1.

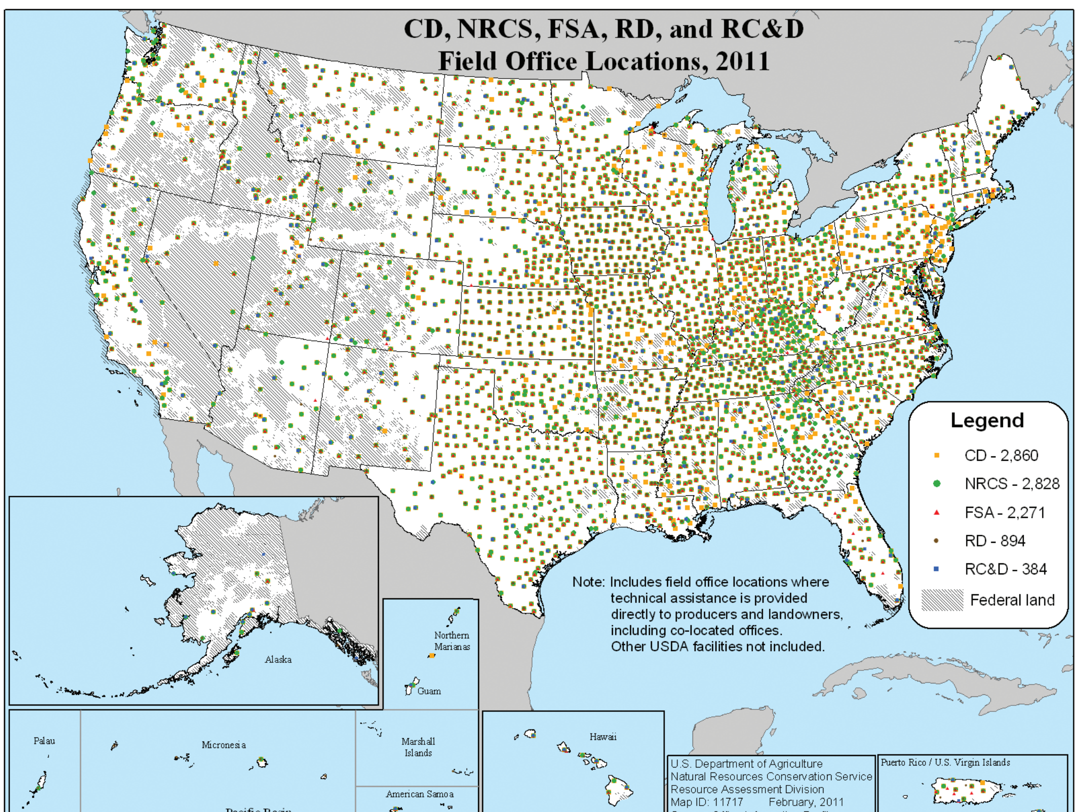
Conservation research investments

Fiscal year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agency	*Constant 2009 dollars, in millions*										
ARS	*	*	255	256	255	243	235	223	225	226	203
ERS	8	8	7	7	7	7	5	5	5	5	5
FS	0.9	0.9	0.9	0.9	0.7	0.9	0.7	0.8	0.8	0.9	0.9
NIFA	85	80	75	82	73	60	57	47	44	38	39
NRCS	13	13	20	30	46	37	33	31	30	31	29
Total	**106**	**103**	**358**	**376**	**382**	**348**	**331**	**307**	**305**	**301**	**278**

* Data were not available for these years.

Figure 4-3.

USDA and Conservation District field office locations



Source: USDA Office Information Profile, February 2011

Councils, and Conservation Districts. In all, there were an estimated 32,700 technical specialists available in 2011 to help producers and landowners solve conservation problems. Additionally, USDA has certified almost 1,500 technical service providers (individuals, private businesses, nonprofit organizations, or public agencies that help agricultural producers and owners of agricultural lands apply conservation practices) to complement this conservation workforce.

Outreach and education help landowners and operators to balance natural resource conservation with agricultural and forest production, and to learn about the USDA programs that are available to help them achieve their objectives. Technical assistance includes scientific expertise, tools, and data needed to develop conservation plans and implement conservation practices that conserve and enhance natural resources from field and operation to landscape and regional scales. Finally, through outreach and technical assistance planning, producers are eligible to enroll in a number of programs that provide financial assistance to offset a portion of the cost to install or maintain environmental improvements.

Technical assistance at the field level

Landowners annually apply conservation practices on almost 25 million acres of farm, ranch, and forest land with technical assistance provided through the Conservation Technical Assistance program. This accomplishment is possible because USDA technical specialists, partners, and landowners and managers utilize technical assistance tools, such as soil surveys; field-scale models (e.g., revised uniform soil loss equation); and assessments, handbooks, manuals, and technical guides that provide the foundation for assessing conservation needs and designing workable conservation systems. These conservation practices improve water quality, irrigation efficiency, soil condition, grazing land health and productivity, forest condition, and wildlife habitat.

USDA investments in technical assistance, education, and outreach rose in nominal dollars between FY 2000 and 2005 and then remained fairly steady through 2009, but have declined over the FY 2002 through 2010 time period when measured in constant dollars (table 4-2).

Table 4-2.

Technical assistance, education, and outreach investments[1]

Fiscal Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agency	*Constant 2009 dollars, in millions*										
APHIS	9	9	26	34	45	39	42	38	42	59	69
FSA	-	-	-	1	3	4	4	4	4	5	5
FS	157	155	147	146	147	168	127	130	116	116	121
NRCS	930	1,079	1,059	1,009	1,018	940	871	773	843	842	868
Total	**1,097**	**1,243**	**1,232**	**1,190**	**1,213**	**1,151**	**1,045**	**945**	**1,005**	**1,022**	**1,063**

[1] The investments presented here do not include technical assistance funding associated with Farm Bill conservation programs. Those resources are included under the applicable conservation approaches elsewhere in this chapter.

Natural Resources Conservation Service

The tables in this chapter provide data on USDA's investments in various conservation approaches, aggregated across the many agencies that contribute to USDA's comprehensive conservation program. For NRCS, these data include investments in both the technical assistance provided by NRCS personnel, and the financial assistance payments (cost-share payments, easement payments, rental payments, etc.) that help producers and landowners afford to implement new conservation measures. Some of these investments are made through discretionary programs, such as Conservation Operations and Watershed Operations, with resources provided through the congressional appropriations process. Additional investments are funded through mandatory programs (often referred to as Farm Bill programs), such as the Environmental Quality Incentives Program and the Wetlands Reserve Program, whose budget authorities are provided in laws other than appropriation acts. Table 4-3 shows NRCS technical assistance and financial assistance investments made through mandatory and discretionary conservation programs, in constant dollars. *(Note: these data are aggregated across the conservation approach tables provided throughout this chapter, and are not meant to represent additional investments. The investments described in those tables include both technical and financial assistance, and can be funded through both mandatory and discretionary programs.)*

Table 4-3.

NRCS mandatory and discretionary technical and financial assistance

Fiscal Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009[1]	2010[1]
Constant 2009 dollars, in millions											
Technical Assistance											
Mandatory	116	122	152	453	423	412	449	450	463	473	549
Discretionary	1,104	1,263	1,238	1,192	1,180	1,112	1,025	910	958	991	1,023
Total	1,220	1,385	1,390	1,645	1,603	1,524	1,474	1,360	1,421	1,464	1,572
Financial Assistance											
Mandatory	432	483	915	1,187	1,454	1,596	1,404	1,370	1,556	1,701	2,325
Discretionary	179	265	200	176	132	431	308	192	183	355	405
Total	611	748	1,115	1,363	1,586	2,027	1,712	1,562	1,739	2,056	2,730

[1] 2009 and 2010 include discretionary technical and financial assistance provided through the American Recovery and Reinvestment Act of 2009.

The data reveal that while discretionary technical assistance declined over much of the last decade before rising the past 2 years, mandatory technical assistance increased significantly starting with the Farm Security and Rural Investment Act of 2002. By FY 2010, NRCS's combined technical assistance approached $1.6 billion, representing a 13-percent increase over FY 2002. Financial assistance investments have grown as well, rising by 145 percent over this same time period.

Working lands

USDA administers a variety of programs to address specific resource issues on agricultural and forest lands in active production. These programs are designed to keep working lands productive while limiting negative impacts such as soil erosion, sedimentation, and nutrient runoff. Program participants receive Federal financial payments to help defray their costs to install and maintain the vegetative, structural, and management practices that provide a variety of environmental benefits to the producer (e.g., improved soil quality) and to the wider public (e.g., improved water quality). Investments in working lands programs have risen substantially in nominal and constant dollar terms over the FY 2000-2010 time period (table 4-4).

Table 4-4.

Working lands investments[1]

Fiscal year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agency	*Constant 2009 dollars, in millions*										
NRCS	262	326	601	923	1,260	1,409	1,434	1,389	1,655	1,495	1,930
Total	**262**	**326**	**601**	**923**	**1,260**	**1,409**	**1,434**	**1,389**	**1,655**	**1,495**	**1,930**

[1] Data include both technical and financial assistance.

The Environmental Quality Incentives Program (EQIP), as established by the Federal Agriculture Improvement and Reform Act of 1996, promotes long-term stewardship of the Nation's private working lands and natural resources by providing financial and technical assistance to implement conservation practices and systems on working agricultural and forest lands. EQIP offers assistance on cropland, pastureland, rangeland, and forest land. At least 60 percent of EQIP funds must be directed to livestock production conservation practices or systems. Based on extensive public-input NRCS established five national priorities, each with energy conservation dimensions:

1. Reduction of nonpoint source pollution (nutrients, sediment, pesticides, or excess salinity) in impaired watersheds consistent with Total Maximum Daily Loads as well as the reduction of groundwater contamination and reduction of point sources such as contamination from confined animal feeding operations;
2. Conservation of ground and surface water resources;
3. Reduction in emissions of particulate matter, nitrogen oxides, volatile organic compounds, and ozone precursors and depleters that contribute to air quality impairment violations of National Ambient Air Quality Standards;
4. Reduction in soil erosion and sedimentation from unacceptable levels on agricultural land; and
5. Promotion of at-risk species habitat conservation.

In FY 2010, with EQIP technical and financial assistance, conservation plans were developed to assist producers in—

- Reducing sediment and nutrient loadings from 14.5 million acres of agricultural lands;
- Improving irrigation efficiency on almost 1 million acres of irrigated land;
- Improving soil quality on 4.8 million acres of cropland;
- Protecting and improving the resource base on 16.7 million acres of grazing land;
- Protecting and improving vegetative condition on 800,000 acres of forest land; and
- Improving fish and wildlife habitat quality on 1.9 million acres of non-Federal land.

Land retirement

Land retirement programs provide landowners with financial incentives to voluntarily remove environmentally sensitive land from agricultural production. The goal is to place the most environmentally vulnerable agricultural lands in resource-conserving vegetative covers, or to convert them back to their original condition, such as wetlands. This approach reduces soil erosion, sedimentation, and nutrient and pesticide runoff and creates valuable wildlife habitat and sequesters carbon. Land retirement investment peaked in FY 2002 and has since gradually lessened in constant dollar terms (table 4-5).

Table 4-5.

Land retirement investments[1]

Fiscal year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agency	*Constant 2009 dollars, in millions*										
FSA	2,094	2,254	2,364	2,226	2,113	1,994	1,944	1,881	1,949	1,860	1,810
NRCS	47	32	32	69	73	77	81	80	61	56	59
Total	**2,141**	**2,286**	**2,396**	**2,295**	**2,186**	**2,071**	**2,026**	**1,961**	**2,009**	**1,916**	**1,868**

[1] Data include both technical and financial assistance.

The Conservation Reserve Program (CRP) was established by the Food Security Act of 1985. CRP protects soil productivity, enhances water quality, creates wildlife habitat, and sequesters carbon. Participants remove environmentally sensitive land from agricultural production by entering into 10- to 15-year contracts to establish and maintain resource-conserving vegetative covers. In return, participants receive annual rental payments, 50-percent cost-share payments, and in some cases additional incentive payments. Under the CRP General Signup, landowners and operators with eligible land compete nationally during specified enrollment periods.

Since 1985, a number of changes have been made to provide greater environmental benefits, including–

- *Developing and using an environmental benefits index (EBI)* to encourage landowners to select beneficial vegetative covers and to target land more likely to provide benefits;
- *Instituting continuous signups* to increase adoption of highly beneficial conservation practices by accepting eligible land into the CRP without requiring participation in the competitive signup;
- *Providing additional incentives* to increase wetland restoration, buffer establishment, wildlife habitat, and other environmentally beneficial practices;
- *The Conservation Reserve Enhancement Program (CREP)*, which creates Federal-State partnerships to address specific state and national conservation concerns through targeted CRP enrollments. Signup is held on a continuous basis, and additional financial incentives are generally provided; and
- *Targeting lands and practices to enhance carbon sequestration* by providing increased EBI points for practices that increase sequestration.

These changes are reflected in CRP conservation practice data provided in the table below. As the program grew and evolved, wildlife habitat, wetland restoration, and conservation buffers became increasingly emphasized, accounting for a combined 22 percent of the enrolled acres in 2007. Grass plantings accounted for over 90 percent of enrolled acres in the early years of the program, but have steadily declined since. Total acreage peaked in 2007 at 36.9 million acres, but in response to the 32-million-acre cap established by the Food, Conservation and Energy Act of 2008, declined to 31.3 million acres by August 2010. Most of the land coming out of CRP was in grass plantings (down 20 percent from 2007 acreage), and to a lesser extent tree plantings (down 10 percent). Wetlands and wildlife mixes remained steady, while conservation buffers increased slightly.

Practice	1987	1997	2007	2010
	(million acres)			
Grass Plantings	13.9	28.6	25.8	20.7
Tree Plantings	0.9	2.3	2.3	2.0
Wildlife Mixes	0.5	1.3	4.1	3.9
Buffers	0.0	0.1	1.9	2.0
Wetland	0.0	0.4	2.1	2.0
Other	0.0	0.1	0.7	0.6
Total	15.3	32.8	36.8	31.3

Land preservation

Land preservation programs help leverage the purchase of development rights and keep productive farm, ranch, and forest lands from being converted to other uses. Landowners retain the rights to use the land for production agriculture and forestry. These programs have been used to protect prime soils, ranchlands, and non-Federal forests from conversion; to protect habitat for threatened and endangered species; to limit urban sprawl and landscape fragmentation; and to safeguard lives and property by protecting and restoring land in flood plains.

Preserving forests and benefitting wildlife

To combat development pressure and other threats, the Forest Service used Forest Legacy Program funds in partnership with State agencies and other organizations to protect nearly 8,000 acres in Montana's Swan Valley. Forest and land fragmentation threatened to cut off migration routes for bears and other animals, diminish habitat for endangered bull trout, and impede management to maintain healthy forests capable of supplying products and services.

Land preservation investments nearly doubled between FY 2000 and 2004 in constant dollars, declined almost as much by FY 2008, and then nearly tripled over the past 2 years (table 4-6).

Landscape-scale conservation

Landscape-scale programs work with multiple landowners and land managers across public and private ownership boundaries to address landscape-scale natural resource issues. USDA watershed programs partner with local sponsors (other Federal, State, and local agencies, Tribal governments, and non-governmental groups) to develop watershed conservation plans, and provide technical and financial resources to install structural and nonstructural conservation measures to protect and improve water quality, develop and maintain municipal water supplies, prevent flood damages, and provide recreational opportunities.

Landscape-scale efforts for watershed improvement

Through the Great Lakes Restoration Initiative (GLRI), NRCS is targeting $34 million in funding in priority watersheds to address nonpoint source pollution control, wildlife habitat restoration, terrestrial invasive species control, and conservation easements for floodplain protection and purchase of development rights. GLRI partners include soil and water conservation districts; Resource Conservation and Development councils; State associations of soil and water conservation districts; State, county, and city governments; universities and extension agencies; State wildlife conservancies; and environmental organizations. States will use common performance indicators, processes, tracking methods, and outcomes assessment tools for consistency and transparency.

Investment in landscape-scale conservation programs declined in both nominal and constant dollars over much of the FY 2000–08 time period, and then rose with the influx of American Recovery and Reinvestment Act of 2009 funds (table 4-7).

Table 4-6.

Land preservation conservation investments[1]

Fiscal year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agency	*Constant 2009 dollars, in millions*										
FS	42	83	87	86	76	64	63	61	60	57	75
NRCS	287	309	455	535	512	500	318	335	285	707	981
Total	**329**	**392**	**541**	**620**	**588**	**564**	**381**	**396**	**346**	**764**	**1,056**

[1] Data include both technical and financial assistance.

Table 4-7.

Landscape-scale conservation investments[1]

Fiscal year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agency	*Constant 2009 dollars, in millions*										
NRCS	142	170	181	203	166	128	147	77	58	116	207
Total	**142**	**170**	**181**	**203**	**166**	**128**	**147**	**77**	**58**	**116**	**207**

[1] Data include both technical and financial assistance.

Emergency response

Emergency response programs help repair damages caused by natural disasters, including floods, droughts, wildfires, hurricanes, and severe-weather events. These emergency programs provide technical and financial resources to local sponsors and individuals to implement emergency measures to stabilize streambanks and repair other flood damages; rehabilitate farmland and forest land damaged by natural disasters; and carry out emergency water conservation measures. These programs are funded on an as-needed basis. For example, funding spiked in 2005 in response to Hurricane Katrina (table 4-8).

Rural development

Rural development efforts accelerate the conservation, development, and use of natural resources; improve the general level of economic activity; and enhance the environment and standard of living in rural areas. Some programs are targeted to specific issues, providing grants for energy audits and renewable energy development assistance; funds to agricultural producers and rural small businesses to purchase and install renewable energy systems and make energy efficiency improvements; loans, grants, and loan guarantees for drinking water, sanitary sewer, solid waste, and storm drainage facilities; and grants to nonprofit organizations to provide technical assistance and training to assist rural communities with their water, wastewater, and solid waste problems. USDA rural development conservation investments have increased since FY 2003 with the increase in rural renewable energy and energy efficiency projects (table 4-9).

Measuring success

USDA conservation approaches are not independent of each other; all contribute to effective management of natural resources. For example, research and assessment help increase the benefits of investments in working lands, land retirement, and land preservation programs by identifying conservation treatment needs and helping technical specialists understand which conservation practices will be most effective in particular locations or situations. Outreach efforts can help USDA connect to underserved populations, as well as increase program participation in areas with the most critical conservation needs.

It is difficult to quantify the environmental benefits of any single conservation program or approach, but critical to understand how well conservation efforts are working and what further improvements are needed. USDA is conducting an interagency research project to scientifically measure the impacts of conservation practices—the Conservation Effects Assessment Project (CEAP).[4] CEAP assessments are being developed for cropland, grazing lands, wetlands, and wildlife. Preliminary CEAP results from the national cropland assessment show that conservation measures are having an impact. About 51 percent of cropland acres are under adequate conservation treatment. The practices put in place on these acres reduce potential losses of nitrogen, phosphorus, and sediment to water resources. However, the study also points to significant conservation needs and opportunities to improve conservation on cultivated cropland (see chapter 6).

[4] Information on research estimation methodology, other physical effects, and additional CEAP reports can be found in greater detail at http://www.nrcs.usda.gov/technical/NRI/ceap/index.html.

Table 4-8.

Emergency response investments[1]

Fiscal year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agency	*Constant 2009 dollars, in millions*										
FSA	92	52	43	59	27	63	93	72	28	71	75
FS	39	87	85	90	155	96	73	69	71	78	89
NRCS	98	145	97	79	52	405	247	185	177	222	179
Total	**229**	**285**	**225**	**228**	**234**	**564**	**413**	**327**	**276**	**371**	**343**

[1] Data include both technical and financial assistance.

Table 4-9.

Rural development conservation investments[1]

Fiscal year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Agency	*Constant 2009 dollars, in millions*										
NRCS	62	69	67	63	63	58	54	52	50	51	50
RD	-	-	-	27	27	36	48	76	50	112	94
Total	**62**	**69**	**67**	**90**	**89**	**94**	**102**	**128**	**101**	**163**	**144**

[1] Data include both technical and financial assistance.

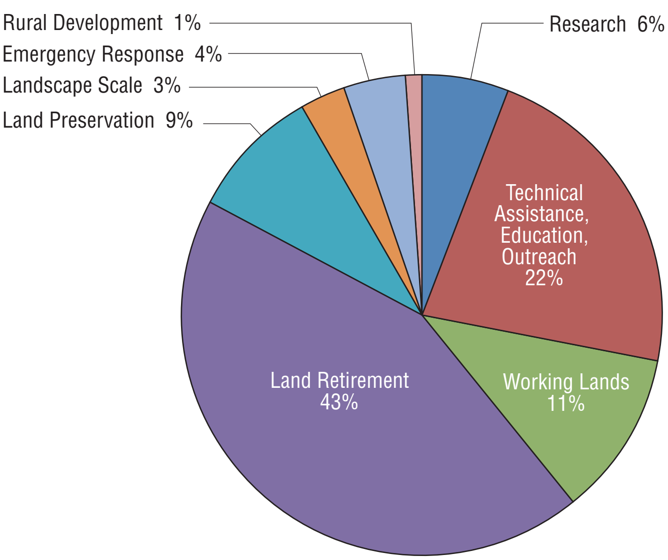
Conclusion

This Nation has invested billions of dollars in an evolving soil and water conservation program. Since passage of the 2002 Farm Security and Rural Investment Act, USDA's conservation investment increased by 25 percent through FY 2010. Much of that increase occurred in the last 2 years, reflecting the impacts of the Food, Conservation and Energy Act of 2008 and the American Recovery and Reinvestment Act of 2009. Working lands programs, for which funding more than tripled from FY 2002 to FY 2010, have grown from 11 percent of the conservation budget in FY 2002 to 28 percent in FY 2010. Land preservation program investments have grown from 9 percent to 15 percent. Over this same time period, land retirement programs declined from 43 percent of the conservation budget to 28 percent, and research investments fell from 6.5 percent to 4 percent (figs. 4-4 and 4-5). While technical assistance and financial assistance have both increased since FY 2000, the ratio of technical to financial assistance has declined.

These investments and the strong partnerships with State and local governments, private land owners and managers, and many other organizations and groups have made major contributions to the condition of the Nation's natural resource base (see chapter 3). Research and analysis efforts are not only assessing current resource conditions and conservation achievements but also identifying where future conservation investments may have the greatest impact. The challenge ahead is to find opportunities to tailor these programs and policies to support strong agricultural and forest sectors in rural economies while protecting and enhancing natural resources. As will be discussed in the next two chapters, this challenge is heightened by climate change and other emerging trends in the agricultural and forest sectors, such as biofuels production.

Figure 4-4.

USDA conservation investments in 2002, by program type

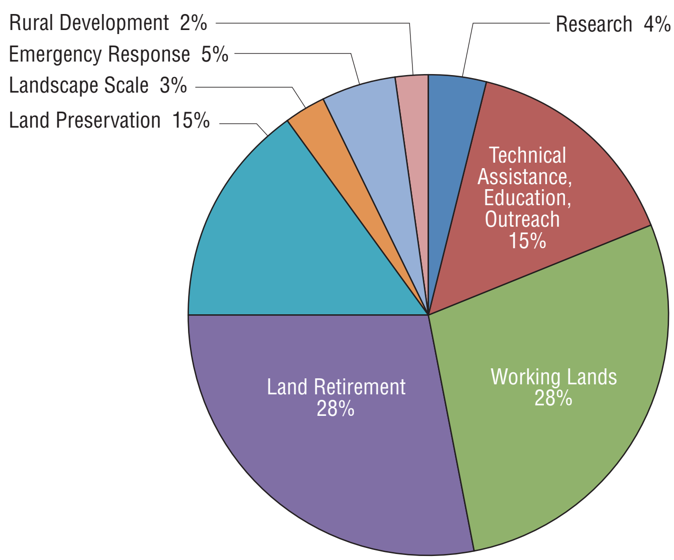


Total Funding = $5.6 billion

Source: USDA Budget crosscut

Figure 4-5.

USDA conservation investments in 2010, by program type



Total Funding = $6.9 billion

Source: USDA Budget crosscut

CHAPTER 5

Climate Change and Biofuels Development

CHAPTER 5

Climate Change and Biofuels Development

Many forces shape U.S. agriculture and forestry. Two of these forces, climate change and biofuels development, deserve special examination because of their growing influence on land-use patterns and natural resource conditions in the agriculture and forestry sectors.

The effects of climate change are already being felt across the United States and are projected to grow in the decades ahead (USGCRP 2009; ICCATF 2010). Increased heat, pests, water stress, diseases, and weather extremes will pose challenges for crop and livestock production (USGCRP 2009). Effects on forests are likely to include changes in forest health and productivity and changes in the geographic distribution of North American forests, including the range of regionally important tree species (IPCC 2007).[1] Although agriculture and forestry offer potential for mitigating climate change through carbon sequestration and emissions reduction, a pressing concern is their capacity to adapt to new climate-related conditions as they develop.

Renewable energy accounts for about 8 percent of the U.S. energy supply and is largely used in generating electricity and biopower. Biofuels account for 20 percent of the renewable supply but are expected to grow in response to policy levers emphasizing energy independence (EISA 2007). Agriculture and forestry will have a major role in the effort to expand the Nation's biofuel capacity through the production of conventional and alternative feedstocks. Large-scale production of new cellulosic feedstocks carries a considerable degree of uncertainty related to potential environmental, resource conservation, and invasive species impacts (GAO 2009).

The following pages examine the potential impacts of increasing climate variability and biofuels development on agriculture and forestry, and their implications for landscape changes and natural resource conservation.

[1] For more information on climate change and U.S. forests, see the U.S. Forest Service assessment conducted under the Forest and Rangeland Renewable Resources Planning Act (RPA). http://www.fs.fed.us/research/rpa/what.shtml#2010RPA

Climate change and U.S. agriculture and forestry

Agriculture and forestry in the United States are largely defined by climate. Nationally, regionally, and locally, small changes in average temperature or precipitation or increases in the frequency or intensity of extreme weather events such as droughts, floods, hail, and fire can alter both the mix and the distribution of commodity production. Changes in climate patterns can alter the geographic distribution of diseases and pests, increase the need for irrigation, and force farmers and forest landowners to adopt new technologies and production practices.

As climate variability increases, agriculture and forestry will need to incorporate adaptation measures and take mitigation actions. Operations will have to adapt to new temperature, precipitation, pest, extreme event, and related conditions. Agriculture and forestry are generally recognized as sectors that can sequester carbon and reduce greenhouse gas emissions at relatively low cost. To realize these mitigation opportunities, farmers, ranchers, and forest landowners will need to be able to convert emissions reductions and sequestered carbon into income.

Greenhouse gas emissions and opportunities for mitigation

Agriculture accounts for about 7 percent of gross U.S. greenhouse gas emissions. Three greenhouse gases associated with crop and livestock production are nitrous oxide, methane, and carbon dioxide. Nationally, agricultural sources account for 73 percent of all U.S. nitrous oxide emissions and 36 percent of all U.S. methane emissions (fig. 5-1).

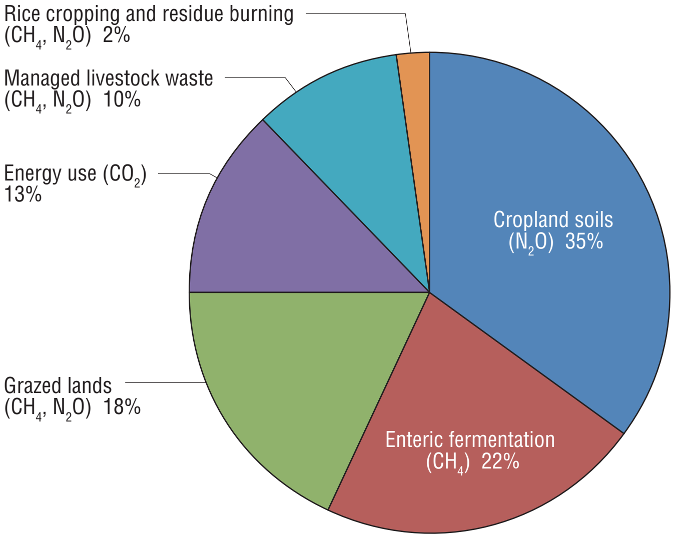
Agricultural greenhouse gas emissions, excluding those resulting from energy use, have been mostly stable since 1990. However, from 1990 to 2000, emissions from livestock production, crop production, and energy use grew, while those from grasslands shrank. From 2000 to 2005, energy use emissions continued to grow and grassland emissions increased back to 1990 levels; emissions from livestock and crop production shrank, although they were still above 1990 levels.

Agricultural and forestry practices also mitigate greenhouse gas emissions by removing carbon dioxide from the atmosphere and storing the carbon in soils and plant biomass. Total carbon sequestration in agriculture and forest sinks currently exceeds 800 million metric tons of carbon dioxide equivalent, which offsets about 11 percent of gross U.S. greenhouse gas emissions. In 2005, forests and harvested wood products sequestered 699 million tons of carbon dioxide equivalent, about 17 percent more than in 1990.

Overall carbon sequestration in agriculture and forestry remained level from 1990 to 2000, with carbon sequestration increasing in cropland soils, forests, and urban trees, but declining in harvested wood products. From 2000 to 2005, carbon sequestration increased in all four areas (fig. 5-2).

Figure 5-1.

Agricultural sources of greenhouse gas emissions in 2005 (Tg CO_2 eq.)

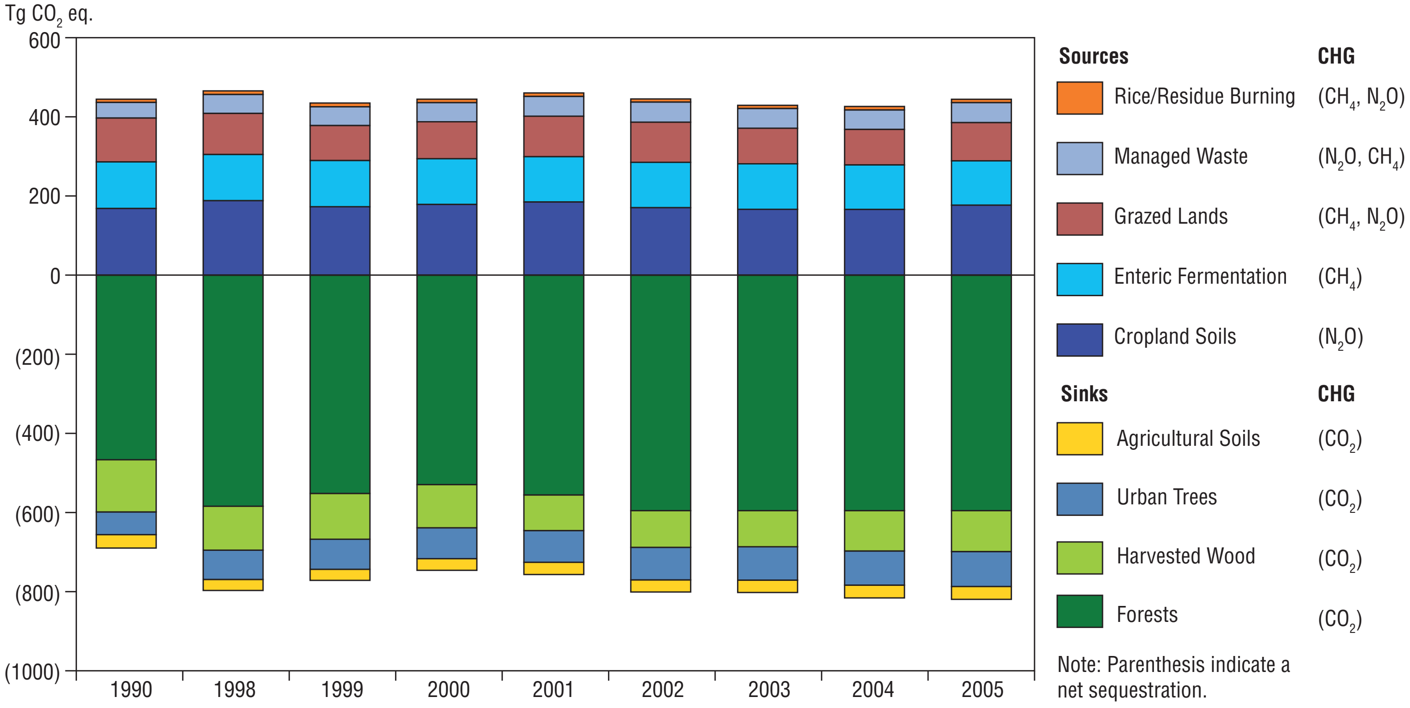


Greenhouse gas emissions from agriculture in order of magnitude, include: (1) nitrous oxide associated with managing cropland soils (primarily the use of nitrogen fertilizers), (2) methane related to enteric fermentation in livestock, (3) methane and nitrous oxide from managed grazing lands, (4) carbon dioxide from energy use, (5) methane and nitrous oxide from managed livestock waste, and (6) methane and nitrous oxide from rice cropping and residue burning.

Source: USDA 2008

Figure 5-2.

Annual agricultural and forestry emissions and offsets for 1990 and 1998–2005



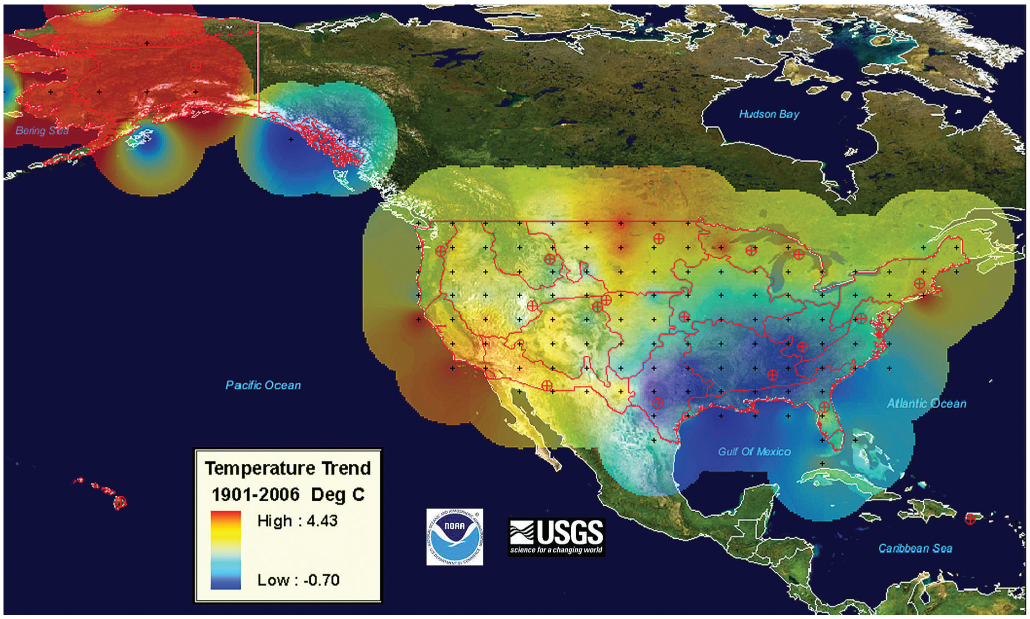
Source: USDA 2008

Climate change implications for agriculture and forestry

Historical data on U.S. temperature and precipitation levels show that the country has become, on average, warmer and wetter over the past 100 years (figs. 5-3 and 5-4). However, these changes have varied by region. Northern regions are generally warmer while parts of the South are cooler. Most areas in the East now receive more precipitation, while the Southwest receives less (USCCSP 2008). These trends are likely to continue for at least the next 20 years (USGCRP 2009).

Figure 5-3.

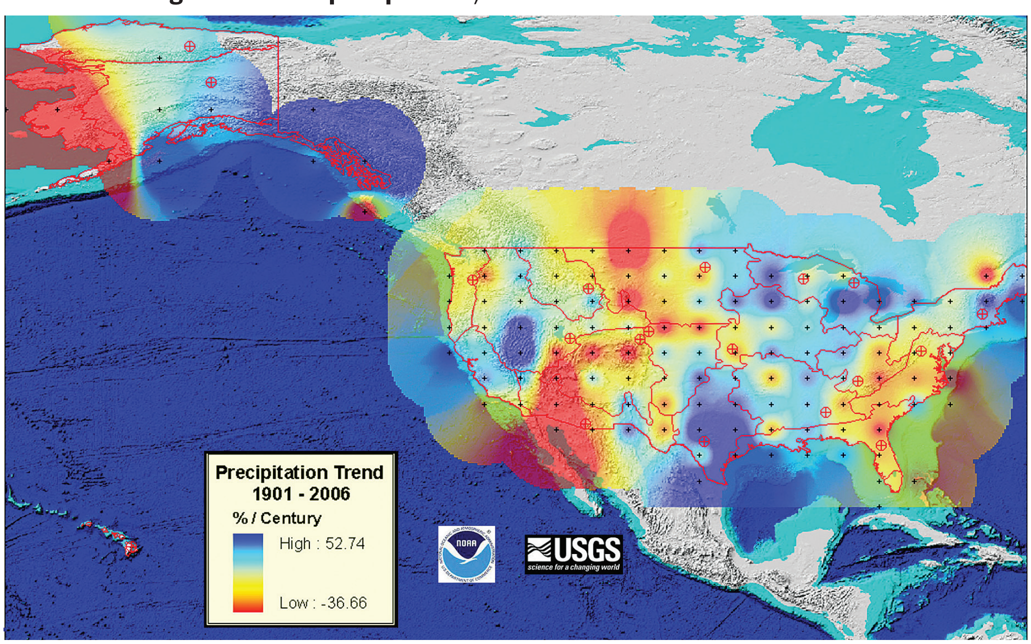
Observed changes in average temperature, 1901 - 2006



Source: Courtesy of NOAA'S National Climate Data Center and the U.S. Geological Survey, USCCSP 2008.

Figure 5-4.

Observed changes in annual precipitation, 1901 - 2006



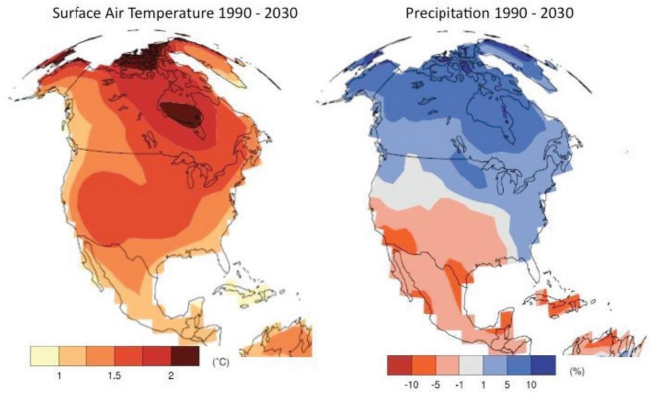
Source: Courtesy of NOAA'S National Climate Data Center and the U.S. Geological Survey, USCCSP 2008.

To illustrate potential effects of climate change on agricultural and forest landscapes, this appraisal uses the Intergovernmental Panel on Climate Change (IPCC) A1B emissions scenario, which assumes a future of technological change that is achieved across a balance of fossil- and non-fossil energy resources. This scenario is not an RCA projection of future conditions, but is being used to portray potential effects to which agriculture and forestry may need to respond in the coming decades. The following summarizes key projections:

- Changes in surface air temperatures and precipitation are projected across the western hemisphere (fig. 5-5). By 2030, average surface air temperatures could increase by 1.5 to 2 degrees Celsius (2.7 to 3.6 degrees Fahrenheit) over much of the United States. Precipitation in much of the western and southwestern United States could decline by 1 to 5 percent relative to 1990. In contrast, most of the northern and southeastern United States will see precipitation increase by 1 to 5 percent (IPCC 2007).

Figure 5-5.

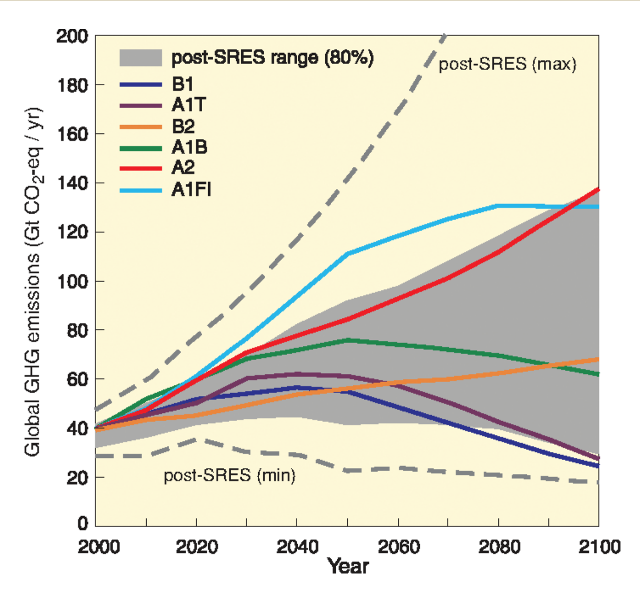
IPCC A1B Surface Air Temperature and Precipitation Projections



NCAR/DOE Climate Change Prediction Group: www.cgd.ucar.edu/ccr/ccp

Intergovernmental Panel on Climate Change (IPCC) Scenarios

The IPCC developed nine scenarios to illustrate how temperature and precipitation patterns may evolve over the next few decades under specific atmospheric greenhouse gas concentrations. The scenarios are grouped into four scenario families (A1, A2, B1, and B2) that explore alternative development paths. The A1 group assumes a world of very rapid economic growth, a global population that peaks in mid-century, and rapid introduction of new and more efficient technologies. A1 is divided into three subsets based on alternative directions of technological change: fossil energy intensive (A1FI), non-fossil energy resources (A1T), and a balance across all sources (A1B). Scenario A1B, which is being used in this RCA Appraisal for illustrative purposes, assumes that atmospheric concentrations of greenhouse gases will reach 700 parts per million by 2100, or about twice that of the pre-industrialization level. Major underlying themes are economic and cultural convergence and capacity building, with a substantial reduction in regional differences in per capita income.



This graph depicts six of the scenarios and their projected GHG emissions in the absence of additional climate policies. AIB is shown in green. The gray shading depicts the 80th percentile range of scenarios published since the special report on estimation scenarios (SRES).

Source: IPCC 2007

- Increases in mean temperature and precipitation levels will affect the length of the growing season and alter the geographic ranges where many plants and animals can live. By 2030, the number of frost days could decrease by 10 to 20 days across much of the United States, especially in the West, while growing seasons would be 10 to more than 20 days longer in much of the country (IPCC 2007).
- Increases in temperature will also increase the occurrence of extreme events. By 2030 much of the central and southwestern United States could experience 14 to more than 21 additional heat wave days[2] each year, and most of the Nation will have 10 or more additional warm nights[3] each year (fig. 5-6) (IPCC 2007).

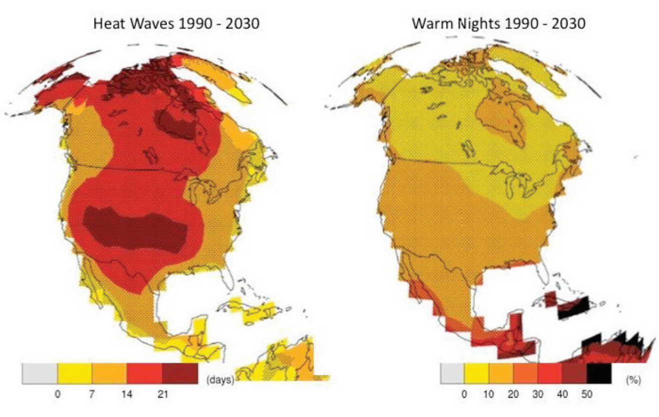
In some areas, changes in climate patterns may leave some plant and animal species vulnerable, especially those that cannot adapt to the new environmental conditions. Of particular concern is the potential for climate change to increase the spread of non-native and invasive plant species. Higher temperatures and lower precipitation can leave forests vulnerable to other stresses; for example, drought and high temperatures have led to serious insect infestations in piñon pines in the Southwest.

[2] Heat wave days exhibit maximum temperatures that are higher by at least 5°C (with respect to the climatological norm).

[3] Warm nights are when minimum temperature is above the 90th percentile of the climatological distribution for that day.

Figure 5-6.

IPCC A1B Heat Waves and Warm Nights Projections



NCAR/DOE Climate Change Prediction Group: www.cgd.ucar.edu/ccr/ccp

Livestock also can suffer; heat waves with a lack of nighttime relief led to losses of as many as 5,000 head of cattle in individual states in 1995 and 1999 (Hatfield et al. 2008).

Ecological changes

Extreme events. Climate change is expected to increase the magnitude and frequency of extreme weather events. Such change could threaten domestic and native plant and animal species that have relatively narrow climate tolerances. Extreme heat or cold, severe windstorms, greater amounts of rain or snow, and longer periods of extreme temperatures or precipitation could damage or destroy crops and livestock. Forest fires already have become much more prevalent throughout the western United States; the area burned in Alaska, for example, has doubled in recent decades as a result of higher air temperatures, reduced availability of moisture, and insect infestations (USGCRP 2009).

Weeds. Climate change may extend the range of many weeds farther north. Possible responses to increasing carbon dioxide levels include faster growth and reproduction rates and more resistance to control measures. In natural ecosystems, invasive weeds will likely threaten to crowd out many native plants. For example, the invasive weed kudzu infests more than 2.5 million acres in the southeastern United States and is currently spreading northward. This weed carries soybean rust, a fungal disease that has threatened soybean production (USGCRP 2009). Invasive and non-native species in forests can dramatically change species composition and increase vulnerability to fires.

Insects and plant pathogens. Changing climate conditions will alter agriculture's relationship with many insects (beneficial and harmful), invasive species, microbes, and other organisms. Higher temperatures and warmer winters will likely increase populations of insect species that now marginally overwinter at high latitudes, such as the flea beetle, which acts as a vector for Stewart's wilt, a significant corn pathogen. Insect pests also have stressed forests throughout the United States, for example, mountain pine beetle infestations on 1.5 million acres in Colorado, and spruce bark beetle infestations on 2.5 million acres in Alaska and western Canada. Plant pathogens also will respond to changes in humidity and rainfall. Diseases from leaf and root pathogens may increase where humidity and frequency of heavy rainfall events increase. On the other hand, increases in short- and medium-term drought will tend to decrease the duration of leaf wetness, thus reducing some forms of pathogen attacks on leaves.

Shifts in agricultural and forest land use

Crops. Warmer temperatures and increased humidity could lengthen the growing season for many crops. However, for crops that may be sensitive to extremes or that now grow in areas that may experience significantly higher temperatures or precipitation levels, the effects could be detrimental. Temperatures that consistently rise above the optimal levels for plant growth, seed production and pollination, fruit or grain production, and harvest point can cause the plants to grow more slowly or stop growing sooner; produce fewer or no seeds, grains, or fruit; or produce smaller yields. For example, studies suggest that an increase of 1.2 degrees Celsius (2.2 degrees Fahrenheit) in the South could lead to a 12-percent decrease in rice yield, a 5.7-percent decrease in cotton yield, and a 5.4-percent decrease in peanut yield. The same temperature increase in the Midwest could lead to a 2.5-percent increase in soybean yield. In addition to variation by crop and location, a non-linear relationship may exist between productivity changes and temperature. Productivity decreases more rapidly once the optimal temperature level is exceeded than it increases as temperatures approach the optimal level (Schlenker and Roberts 2008).

Water availability will play a key role in the success of crops under changing climatic conditions. During periods of higher temperatures, plants use more water to keep cool, so lower precipitation levels could exacerbate the effects of higher temperatures. Areas that grow warmer may experience fewer negative effects on crop production if precipitation increases or adequate irrigation water is available. In addition, rising carbon dioxide levels could benefit some crops, particularly soybeans in the Midwest and South and cotton in the South. Overall, however, corn, beans, and sorghum will likely suffer.

Livestock and grazing lands. Higher average temperatures and extreme weather events can stress livestock and reduce their growth rates, weight gains, and productivity (that is, meat, milk, or egg production). Additionally, increases in environmental stresses can limit animals' ability to cope with infection or illness. In confined operations, there are more management options to address impacts from climate change but implementing these options will likely increase production costs. Livestock on grazing lands will be more directly affected by climate variability because these animals are exposed to the elements.

Climate change will also affect livestock through its impact on grazing land ecosystems. Changes in temperature, precipitation, and atmospheric carbon dioxide conditions will alter the composition and range of plant species on grazing lands. Of particular concern is the possible crowding out of desirable grass species by less nutritious weeds. Another concern is the potential for rangeland fires to become larger or occur more frequently in areas that become hotter and drier. Where this occurs, the quality and quantity of forage could be significantly affected. These impacts will likely be positive and negative, and will largely depend on the availability of water and soil nitrogen. Table 5-1 lists some selected factors and management options that grazing land managers may consider to adapt to changing conditions.

Table 5-1.

CO_2 and climate change responses and management options for grazing land

Factor	Response	Management options
Primary production:	*Rising CO_2:* Increase or little change in primary productivity in most systems, especially water-limited rangelands. N may limit CO_2 response in some systems. *Rising temperature:* Increases in primary productivity in most temperate and wet systems. Decreases in primary productivity in arid and semi-arid systems that experience significantly enhanced evapotranspiration and drought. *Variable responses with precipitation:* Increases in production in regions where water is limiting, but tempered by increasing temperatures and more intense precipitation events.	Adjust forage harvesting (stocking rates; grazing systems). Use adapted forage species. Enterprise change (e.g., movement to more or less intensive management practices).
Forage quality	*Increasing CO_2* will alter forage quality. In N-limited native rangeland systems, CO_2-induced reduction in N and increased fiber may lower quality.	Interseed legumes where N is limiting and feasible. Alter supplemental feeding practices.
Animal performance	*Increased temperature, warm regions:* Reduced feed intake, feed efficiency, animal gain, milk production, and reproduction. Increased disease susceptibility and death. *Increased temperature, cold regions:* Enhanced animal performance, lowered energy costs.	Select animal breeds from adapted to new climate. Alter management (e.g., timing of breeding, calving, weaning). Enterprise change (above).

Source: Modified from USCCSP 2008, p.74

Forestry. Observed increases in precipitation in the Midwest and Lake States, nitrogen deposition, and temperature (which lengthens the growing season in the northern United States), as well as the changing age structure of forests and management practices, have contributed to increases in forest growth. Rising levels of atmospheric carbon dioxide can increase forest productivity and carbon storage if sufficient water and nutrients are available.

Climate variability also affects the frequency and intensity of forest disturbances such as fire, insect and disease outbreaks, ice storms, and windstorms, which can have important consequences for timber production, water yield, carbon storage, species composition, invasive species, and public perception of forest management. Forest management can help conserve carbon stocks gained through increased productivity by reducing plant debris that can fuel fires, reducing risks of insect and disease infestation, and moving wood into forest products and biobased energy and other products. Forest management can also maintain a flow of ecosystem services, including watershed protection, improved air and water quality, streamflow regulation, reduced erosion, carbon storage, biodiversity conservation, and recreational opportunities, and can provide raw material for paper and wood products and energy production.

USDA greenhouse gas mitigation and climate change research

Agriculture and forestry are generally recognized as sectors that can achieve relatively low-cost greenhouse gas mitigation by reducing greenhouse gas emissions and increasing carbon sequestration. Mitigation research has become more important as concerns about climate change have grown and the success of programs in reducing emissions and increasing carbon sequestration has been documented. In fiscal year 2009, USDA's climate change research investment was more than $52 million carried out through a variety of programs in the Agricultural Research Service (ARS), Economic Research Service (ERS), Forest Service (FS), National Institute of Food and Agriculture (NIFA), and Natural Resources Conservation Service (NRCS). This investment more than doubled in FY 2010 (table 5-2).

USDA research programs facilitate the development of new technologies, production and conservation practices, and varieties of crops, trees, and livestock suited to changing climate and related conditions. Highlights of current research foci include:

- The Greenhouse gas Reduction through Agricultural Carbon Enhancement network (GRACEnet) is a coordinated effort by ARS scientists to provide information on the soil carbon and greenhouse gas emissions of current and newly developed agricultural management practices.
- Forest Service research studies how climate change will impact forest, range, and urban ecosystems in order to develop tools for land managers and policymakers to aid in decisions to further ecosystem resilience. Forest Service carbon cycle research provides tools and information to support carbon sequestration management actions.
- ERS assesses economic, environmental, and land use implications of alternative climate and energy policies and scenarios that inform decisionmaking at multiple scales.
- The Agriculture and Food Research Initiative (AFRI) Climate Change Program administered by NIFA uses a systems approach to integrate social sciences and economics in investigating the impacts of climate change on agroecosystems, human interventions for adapting to and mitigating these impacts, and implementation of management strategies to maximize agricultural productivity and greenhouse gas mitigation under a changing climate.
- The Rapid Assessment of U.S. Soil Carbon and Conservation Planning, led by NRCS, is evaluating

Table 5-2.

USDA climate change research investment, fiscal years 2009 through 2011 (est.)

Agency	FY 2009	FY 2010	FY 2011 (est.)
		Millions of dollars	
Agricultural Research Service (ARS)	19.8	24.2	24.2
Economic Research Service (ERS)	0.7	2.6	2.6
Forest Service (FS)	26.9	31.9	31.3
National Agricultural Statistics Service (NASS)	0	0.8	0
National Institute of Food and Agriculture (NIFA)	4.6	56.0	56.0
Natural Resources Conservation Service (NRCS)	0.5	0.4	0.5
Office of the Chief Economist	0	2.9	2.4
Total	**52.5**	**118.7**	**116.9**

Source: President's Budget; data are rounded to the nearest $100,000.

differences in soil carbon associated with soil properties, agricultural management systems, ecosystems, and land uses. The results will be used to inform decision support tools, for example the Carbon Management Evaluation Tool – Voluntary Reporting of greenhouse gases (COMET-VR) and to develop a statistically valid baseline inventory of soil carbon stocks for the United States.

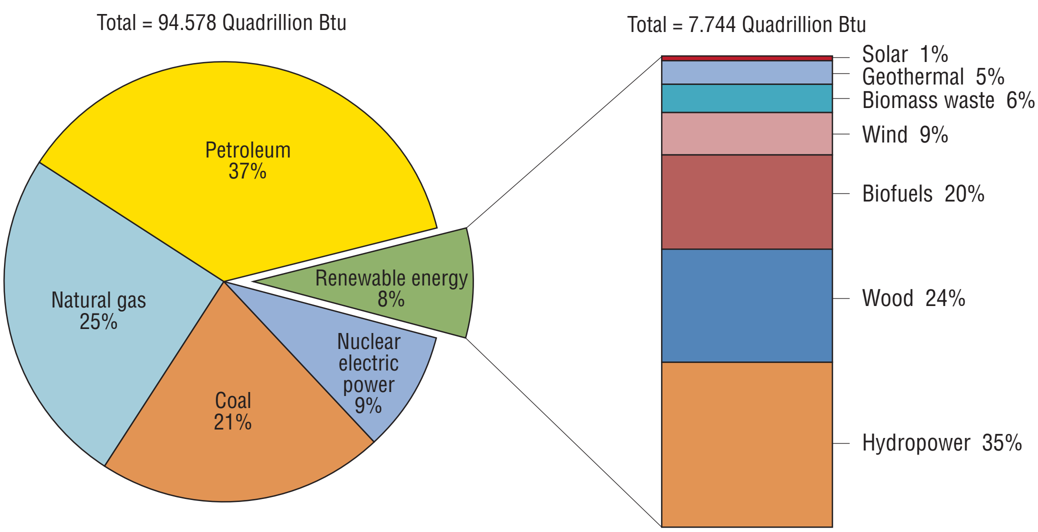
USDA research efforts help to improve the scientific understanding of climate change and the economic implications of alternative response strategies to enable farmers, ranchers, forest landowners, policymakers, and others to assess when, where, and how climate change will impact agriculture and forestry. USDA's extension, conservation, and renewable energy programs offer a vehicle for promoting the adoption of these new technologies and practices.

Biofuels and U.S. agriculture and forestry

Renewable energy has been a policy priority since the energy crises of the late 1970s. In the 1980s, States began to put in place policies requiring utilities to produce a portion of energy from renewable sources (Wiser et al. 2007). Renewable energy accounts for 8 percent of the Nation's energy supply; biomass, including agricultural and forestry residues, dedicated energy crops, municipal solid wastes, and industrial wastes, makes up about one-half of the renewable supply (fig. 5-7). In addition to generating electricity and power, biomass resources are used to produce liquid fuels, such as ethanol and biodiesel. Biofuels currently account for less than 2 percent of the total U.S. energy supply, but are expected to grow in response to new policy drivers emphasizing energy independence.

Figure 5-7.

Renewable energy in the Nation's energy supply, 2009



Renewable energy consumption increased by about 8 percent between 2008 and 2009, contributing about 8 percent of the Nation's total energy demand. (USEIA 2009b)

Note: Sum of components may not equal 100% due to independent rounding

Source: U.S. Energy Information Administration, Annual Energy Review, 2009, Table 1.3, Primary Energy Consumption by Energy Source, 1949 – 2009 (August 2010)

The Energy Independence and Security Act (EISA) of 2007 established a Renewable Fuels Standard (RFS2) that mandates that increasing volumes of renewable fuels be used in the United States, reaching 36 billion gallons per year by 2022 (fig. 5-8). This is roughly 26 percent of the projected annual U.S. motor gasoline consumption of about 140 billion gallons (USEIA 2009a). Beginning in 2015, EISA places a 15-billion-gallon limit on conventional biofuels' (ethanol derived from corn starch) annual contribution to the mandate and calls for increasing use of advanced biofuels to reach 21 billion gallons per year by 2022. Advanced biofuels include ethanol derived from cellulosic biomass, animal waste, and food and yard waste, or from non-corn sugar or starches; biodiesel; biogas (including landfill gas and sewage waste treatment gas); butanol or other alcohols from renewable biomass; or other fuels derived from cellulosic biomass. Materials from Federal land are excluded as a source of renewable biomass to meet EISA renewable fuels mandates.

Feedstocks

Ethanol from corn grain dominates the current U.S. biofuels market, accounting for 10.75 billion gallons in 2009, with production capacity up to 14.5 billion gallons[4] (RFA 2010). About 98 percent of domestic ethanol is made from corn grown in the Midwest.

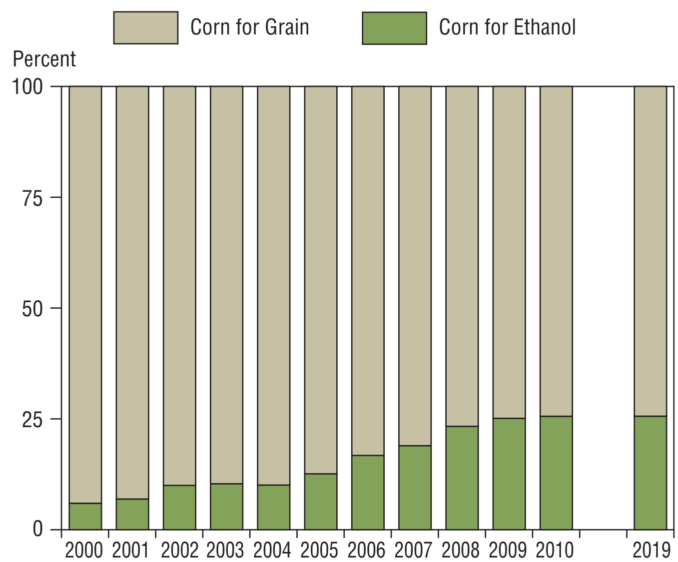
The share of U.S. corn production used for ethanol rose from 6 percent in 2000 to almost one-third in 2009. Increased ethanol production has raised demand for corn, contributed to higher corn prices, and increased acres planted to corn—rising from 79.5 million acres in 2000, peaking at 93.5 million in 2007, and fluctuating between 86 and 88 million acres over the past 3 years (USDA National Agricultural Statistics Service data in GAO 2009). Acreage planted to corn is expected to remain at about 89.5 million acres through 2019, with the share used for ethanol production increasing slightly (fig. 5-9) (WAOB 2010a). The increase in ethanol production also resulted in cultivation of some land that was formerly idled or in grazing uses and

[4] Includes under-construction capacity

Figure 5-9.

Harvested corn acreage, by end use

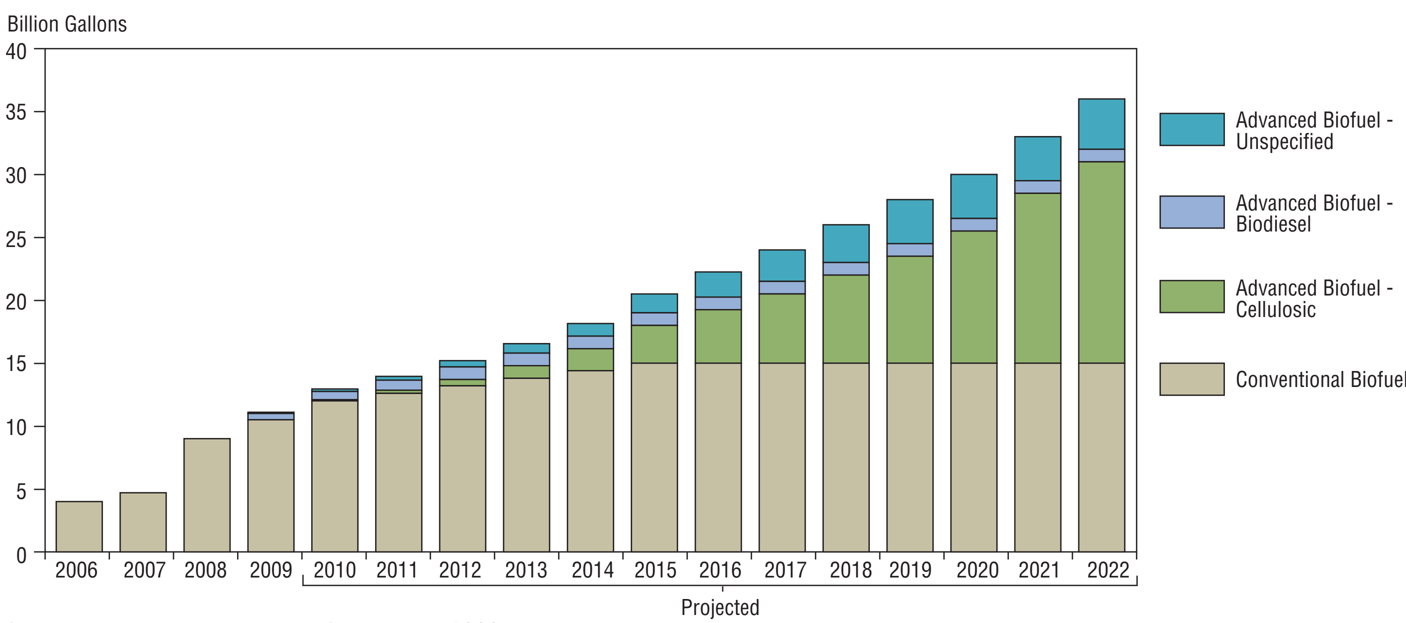
Status from 2000 – 2009 and Projection from 2010 - 2019



Source: WAOB 2010a

Figure 5-8.

RFS2-mandated levels for biofuels, by type



Source: Energy Independence and Security Act of 2007 reduced acres planted to other crops (GAO 2009). Cotton acres fell from 15.77 million in 2001 to 9.15 million in 2009. Wheat went down slightly, from 59.6 to 59.1 million acres (USDA National Agricultural Statistics Service data in WAOB 2010b).

Cellulosic feedstocks are expected to provide at least 16 billion gallons of advanced biofuels under the RFS2. The volumes of biomass necessary for cellulosic biofuels production will come from a variety of sources, including dedicated energy crops such as switchgrass, purpose-grown wood, crop residues such as corn stover or cereal straws, non-Federal timber and forest residues, and municipal solid waste. Assuming existing conversion technologies of 60 to 70 gallons of ethanol per dry ton of cellulosic biomass, the production of 16 billion gallons of ethanol would require approximately 230 to 265 million dry tons of cellulosic biomass. At a conversion rate of 70 gallons of ethanol per dry ton, USDA (2010) estimates that it is possible to meet the mandate for advanced biofuels using perennial grasses, energy cane, biomass sorghum, and oilseeds grown on 23 million acres of cropland and cropland used as pasture. This does not include the potential use of agricultural and forest residues that could account for up to 7 billion gallons of ethanol without requiring additional cultivated acreage.

Significant uncertainties associated with meeting the RFS2 mandates include feedstock production systems and practices, harvest and transport infrastructure, conversion technologies, and biofuels market development. Plants with high biomass productivity and yields such as fast-growing perennials (e.g., tall grasses and poplar trees) are likely to set the standard for alternate production systems for bioenergy feedstocks. Table 5.3 presents the cost and conversion rates for some feedstocks.

Potential impacts of biofuels production on natural resources

Increased domestic biofuels production will place new demands on forestry and agricultural production capacities and natural resource assets. While much is known about the natural resource requirements of current feedstocks such as corn and soybeans, substantial increases in bioenergy production are expected to come from other feedstocks such as wood, perennial grasses, and possibly algae. The effects will depend greatly on the feedstocks produced, and on where and how they are produced, harvested, and converted into fuels. These impacts will also vary by field, landscape, and watershed scales and the measures used to conserve soil, water, and related resources.

Table 5-3.

Cost and conversion characteristics of certain feedstocks (BRDI 2008)[5]

Feedstock	Total feedstock production costs (including harvest cost)	Yield	Total output	Harvesting and collection costs	Fuel yield
	$/acre	*Tons/ac/yr*	*Mil. tons/yr*	*$/planted acre*	*Gal/ac*
First-generation feedstocks					
Corn	417	4.2	355.2	101	388-418
Grain sorghum	261	1.8	12.4	89	168-181
Barley	272	1.5	5.7	78	138-161
Sugarcane	n/a	32.7	30.1	n/a	638
Sugarbeets	986	23.8	31.2	n/a	590
Soybeans	278	1.3	92	65	64
Second-generation feedstocks					
Corn stover	n/a	3	254	7-11	240-270
Wheat straw	n/a	1	58	17	80-90
Switchgrass	133-329	4.2-10.3	n/a	33-129	393

First-generation feedstocks *are those currently being used to produce biofuels for commercial sale.*

Second-generation feedstocks *are those with the potential to produce biofuels for commercial sale. The data shown for noncommercial feedstocks are from test plots, field studies, and research conducted by both the public and private sector. Production and harvest costs depend on fuel prices, which may have changed since those estimates were produced. Except for residues, feedstock production costs include land charges, which vary by region. Land charges represent an opportunity cost for landowners who manage their own land.*

Source: Biomass Research and Development Board (BRDI) 2008

[5] The values presented in this table are drawn from many different studies and sources. For a full description of the research and sources behind these values, see BRDI (2008), p. 14.

Because corn is a resource-intensive crop, increasing corn-ethanol levels to 15 billion gallons could have impacts on natural resources. Some projections estimate that U.S. corn production will increase by 3.3 to 3.7 million acres, in part through an increase in continuous corn production (BRDI 2008; Malcolm et al. 2009). Some of the largest corn acreage increases are projected for the Northern Plains (1.1 million acres), which relies heavily on irrigation from the Ogallala and adjacent aquifers. Irrigation water use varies significantly among the major corn-producing regions because of different climate zones and soil types. When averaged across all corn production in the region (rainfed and irrigated), about 7.1 gallons of irrigation water are consumed[6] per gallon of ethanol produced in the Corn Belt, reflecting that the majority of corn production is rain-fed. Comparatively, nearly 321 gallons of irrigation water are consumed per gallon of ethanol in the Northern Plains where most corn production is irrigated (table 5-4).[7] While these averages provide a general comparison of irrigation water needs, they mask actual water consumption on any given irrigated acre, which vary by year and location. For example, in 2008 irrigated corn production in Nebraska required over 500 gallons of irrigation water per gallon of ethanol produced (down from over 750 gallons in 2003) and Kansas required almost 800 gallons of water per gallon of ethanol.

With increased corn production there will likely be additional fertilizers and pesticide inputs that may have a risk of loss to adjacent water bodies (NAS 2008). Increased corn production modeled in one study resulted in a 2.8-percent increase in nitrogen losses to groundwater, with the largest increases occurring in the Great Lakes and Southeast states (Malcolm et al. 2009).

Cellulosic feedstocks, and perennials in particular, typically require fewer inputs such as irrigation water, tillage, nutrients, or pesticides, than do row crops (GAO 2009). Perennial energy crops, such as switchgrass or trees, require minimal tillage after planting and can help stabilize soils, reduce soil erosion potential (Nelson et al. 2006), and increase soil carbon (McLaughlin and Kszos 2005; Clifton-Brown et al. 2007; Blanco-Canqui et al. 2004). Nitrogen fertilizer requirements for switchgrass should be less than half that for corn (Mitchell et al. 2010). Delaying harvest of perennial grasses such as switchgrass until after the first frost may further reduce the need for fertilizer inputs by taking advantage of switchgrass' ability to translocate nitrogen post-frost into roots, rhizomes, and stem bases for remobilization the following spring (Simpson et al. 2008; Beale and Long 1997; Beaty et al. 1978). Perennial polycultures that are genetically diverse may be more resistant to disease and pests, further reducing the need for pesticides by supporting natural pest suppression (by beneficial birds and insects).

[6] Since liquid fuel industries typically use a volume-based product metric, results are expressed as gal of water consumed per gal of fuel produced (not total water use). Consumed water is that withdrawn from its source and has evaporated, transpired, been incorporated into products and crops, or otherwise removed from water resources and unavailable for use.

[7] The Corn Belt, Great Lakes, and Northern Plains constituted 89 percent of the corn production and 95 percent of ethanol production in the United States in 2007.

Table 5-4.

Water consumed in irrigated corn production

	Corn Belt (Iowa, Indiana, Illinois, Ohio, Missouri)	Great Lakes (Michigan, Minnesota, Wisconsin)	Northern Plains (North Dakota, South Dakota, Nebraska, Kansas)
		percent	
Share of US ethanol production capacity	51	17	27
Share of US corn production	53	17	19
		gallons	
Corn irrigation, groundwater	6.7	10.7	281.2
Corn irrigation, surface water	0.4	3.2	39.4
Total irrigation water use	**7.1**	**13.9**	**320.6**

Source: Wu et al. 2009, p.29

Water in ethanol conversion

The fermentation-based processes for producing corn-based fuel ethanol (or butanol) require approximately 3 gallons of water per gallon of ethanol produced. Due to water recycling efforts and cooling improvements, this is significantly less than the estimated 5.8 gallons required for conversion in 1998.

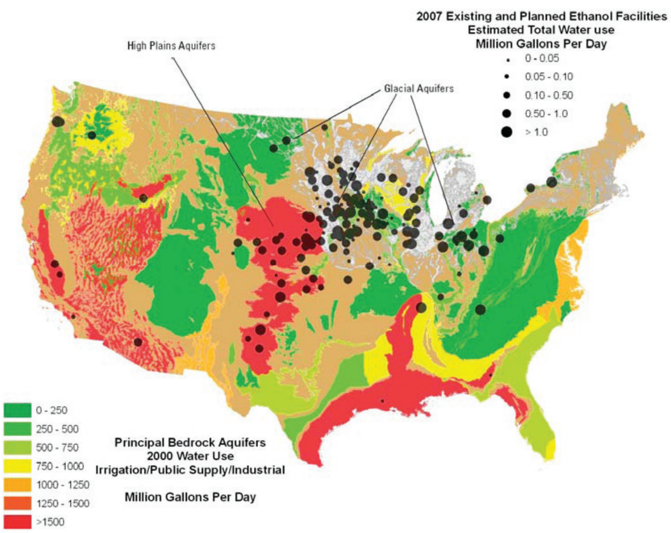
The potential in cellulosic feedstock conversion will depend on the process used and technological advancements achieved. Water consumed in the biochemical conversion process for cellulosic feedstock using advanced technology is estimated at 5.9 gallons of water per gallon of ethanol, while thermochemical gasification processes for cellulosic feedstock may only require 1.9 gallons of water per gallon of ethanol or other fuel (Wu et al. 2009).

Nevertheless, siting of some ethanol facilities is occurring where water resources are already under duress (NAS 2008). For example, many existing and planned ethanol facilities that require 0.1 to 1.0 million gallons of water per day are located on the High Plains aquifer, which is already suffering from significant water level decline (fig. 5-10).

Figure 5-10.

Ethanol facilities relative to major aquifers, 2007

Existing and planned ethanol facilities (2007) and their estimated total water use mapped with the principal bedrock aquifers of the United States and total water use in year 2000.



Source: USGS 2008

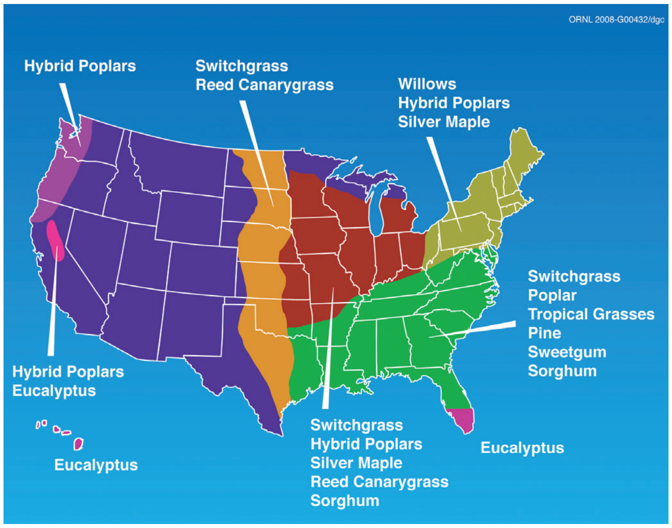
Many cellulosic feedstocks are likely to do well under rainfed conditions (fig. 5-11) and some, such as perennial grasses and many trees, are drought tolerant. However some feedstocks have greater water requirements, such as certain fast-growing woody biomass or algae. Algae cultivation can have particularly high water requirements, ranging from 333 to 2,000 gallons of water per gallon of fuel produced from relatively expensive closed systems to open-air ponds that experience substantial evaporation losses (USEPA 2009b). These energy crops may have potential to use saline or contaminated water sources, however. Algae-based energy farms may also provide some degree of "wastewater treatment" by removing nutrients, metals, and other contaminants and oxygenating the water (Rittman 2008).

Desirable traits in cellulosic energy crops (e.g., easily propagated, fast growing, high yield) also are exhibited by invasive plants. According to one study, monocultures of cellulosic feedstocks could be invasive and pose concerns for biodiversity, habitats, and other ecosystem services in certain regions (Barney and DiTomaso 2008). Potential may exist for genetically modified energy crops, such as algae grown in open-air ponds, to be spread to native systems.

While agricultural and forest residues are attractive as available by-products from existing enterprises, their overharvest could compromise soil stability and fertility and pose a potential water quality risk if soil erosion increases as a result of residue

Figure 5-11.

Potential rainfed feedstock crops in the United States



Source: Dale et al. 2010

removal (USEPA 2009a). Studies indicate that harvesting corn stover for bioenergy production can increase sediment loads to surface waters, but that the impact is highly variable, depending on the proportion of stover harvested and on soil type, slope, and field management (Kim and Dale 2005). The effects of residue removal on subsequent crop yields are highly variable, depending on soil type, climate, topography and tillage, and other factors (Blanco-Canqui and Lal 2009). While some studies have shown that the growth of woody plants and yields are decreased by soil compaction from residue collection equipment, results vary by site type (USEPA 2009b, Powers et al. 2005). Research evaluating sustainable residue removal rates is underway.

While the RFS2 limits the types of biomass and types of land from which the biomass can be harvested, [8] potential exists to drive land-use change as activities previously undertaken on lands converted to biomass production are abandoned or are shifted onto other lands. If marginal and highly erodible lands (much of which are currently enrolled in the Conservation Reserve Program [CRP]) are brought into production, previously achieved soil quality benefits from long-term conserving cover may be lost as a result of tillage, as well as challenge other ecosystem benefits. In the Midwest and Great Plains, CRP has helped certain bird species recover; converting CRP land to bioenergy feedstock production may reverse that trend. However, using these lands for perennial crop or wood production for bioenergy could mitigate losses, and concerns may be alleviated further if perennial grasses were harvested so as to avoid interfering with bird nesting and brood rearing seasons. Relative to monocultures, polycultures may do a better job of supporting biodiversity (Dale et al. 2010) and other ecosystem services. The maintenance of landscape-level biodiversity, including noncultivated areas nearby, will depend on the spatial arrangement of reserves promoting connectivity and population persistence, local management practices, and on the potential for biofuel crops and their pests to spread beyond managed boundaries.

[8] The RFS2 limits the types of biomass and types of land from which the biomass may be harvested to: (a) existing agricultural land (planted crops and crop residue from agricultural land cleared prior to December 19, 2007, and actively managed or fallow on that date), (b) planted trees and tree residue from tree plantations cleared prior to December 19, 2007, and actively managed on that date, (c) animal waste material and byproducts, (d) slash and pre-commercial thinning from non-Federal forest lands that are neither old-growth nor listed as critically imperiled or rare by a State Natural Heritage program, (e) biomass cleared from the vicinity of buildings and other areas at risk of wildfire, (f) algae, and (g) separated yard waste and food waste.

Lifecycle analysis of biofuels production

Lifecycle analysis of greenhouse gas emissions of biofuels is complicated by lack of agreement on standardized lifecycle assessment methods and information gaps (e.g., feedstock yields, domestic and international land-use data, and data on above-ground biomass and soil carbon for a variety of land cover crops worldwide) (GAO 2009). While biofuels may lower net greenhouse gas emissions by replacing fossil fuels, they also produce emissions in feedstock production and conversion, and may have direct and indirect effects on land use. Energy is used directly and indirectly in crop production. Increased nitrogen fertilizer use can increase nitrous oxide emissions, while precision application and conservation tillage can reduce energy consumption. Deep-rooted perennial cellulosic energy crops, including trees, can sequester carbon in the soil while cultivation of idle land releases stored carbon. Of the 12 studies evaluated by GAO (2009), net greenhouse gas emissions associated with corn ethanol ranged from a reduction of 59 percent to an increase of 93 percent; for cellulosic ethanol the range was from a reduction of 113 percent to an increase of 50 percent. The method used for accounting for indirect land-use changes had substantial impacts on the results, and many have questioned the assumptions used in these studies.

USDA investment in biofuels development

Biofuels development remains an important focus for the public and private sectors. Cost, which will be a critical factor in continuing progress, will be affected by advances in conversion technologies (particularly cellulosic), abundance of feedstock supplies (available and not dedicated to other uses), and capacity of infrastructure (for production and delivery).

USDA plays an important role in biofuel development and commercialization. In 2009, USDA investment in renewable energy was more than $282 million and more than doubled in 2010 (table 5-5). Advancement and commercialization of advanced biofuels is supported by the Biorefinery Assistance Program, the Bioenergy Program for Advanced Biofuels, and the Biomass Crop Assistance Program. All of these programs are geared toward the propagation of advanced biofuels that are expected to reduce pressures on natural resources. The Biorefinery Assistance Program, administered by Rural Development, provides loan guarantees for the materialization of commercial-scale biorefineries. Rural Development will also provide payments for the production of advanced biofuels through the Bioenergy Program for Advanced Biofuels. The Farm Service Agency's Biomass Crop Assistance Program provides support for the establishment of biomass crops and the delivery of the biomass to conversion facilities.

Research and development investment is essential for accelerating biofuels production in ways that do not deplete the natural resource base. The joint USDA and Department of Energy (DOE) Biomass Research and Development Initiative promotes development and demonstration of biofuels and biobased products (fig. 5-12).[9] USDA's Research, Education, and Economics mission area (including ARS, NASS, NIFA, and ERS), the Forest Service and Rural Development are also instrumental in research and development activities. Commercialization, another emphasis area, accounts for almost 57 percent of USDA's bioenergy and renewable energy investment. This is expected to increase with the implementation of the Biomass Crop Assistance Program in fiscal year 2010.

[9] BRDI provided up to $25, $33 and $30 million from 2009 to 2011 for research.

Table 5-5.

USDA bioenergy and renewable energy investment, fiscal years 2009 through 2011 (est.)

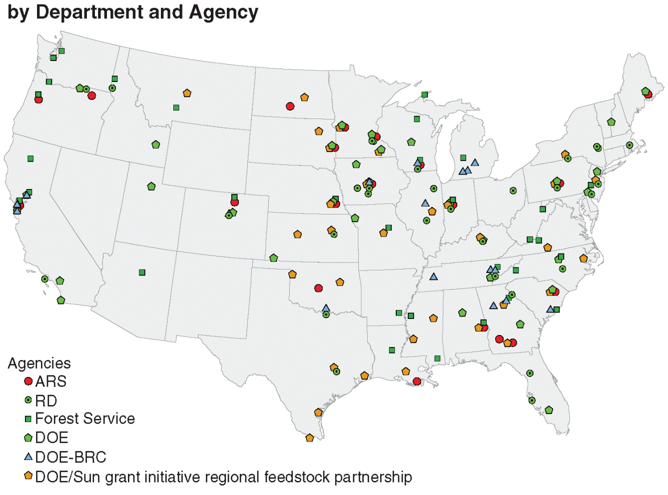
Agency	FY 2009	FY 2010	FY 2011 (est.)
		Millions of dollars	
Agricultural Research Service (ARS)	33.1	84.3	84.3
Departmental Management (DM)	3.0	3.0	3.0
Economic Research Service (ERS)	2.0	2.0	2.0
Farm Service Agency (FSA)	0	248.2	199.0
Forest Service (FS)	20.6	32.3	34.0
National Agricultural Statistics Service (NASS)	0	1.8	1.8
National Institute of Food and Agriculture (NIFA)	56.0	102.8	104.8
Natural Resources Conservation Service (NRCS)	6.2	9.5	9.9
Office of the Chief Economist (OCE)	2.0	2.5	2.5
Rural Development (RD)	159.5	158.6	219.1
Total	**282.3**	**644.9**	**660.4**

Source: President's Budget; data are rounded to the nearest $100,000.

Figure 5-12.

USDA, DOE research sites focusing on biofuel feedstocks, by agency and feedstock type

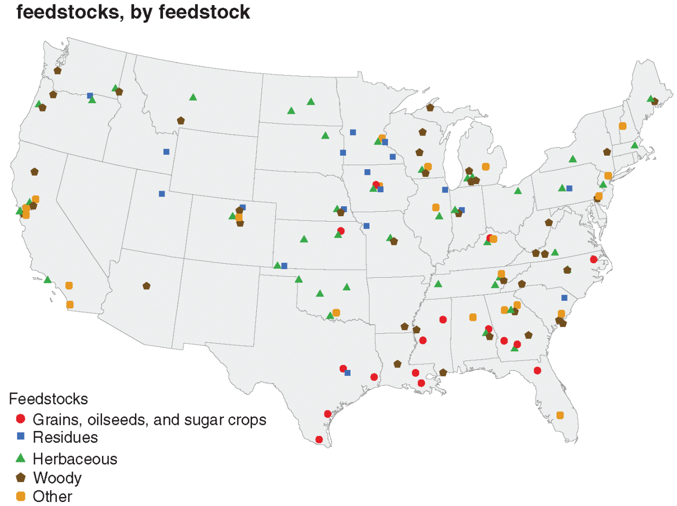
USDA and DOE research sites with a focus on biofuel feedstocks, by Department and Agency



Note: Common sites were offset slightly so they would be visible. In many cases, this reflects cooperative efforts in the same locations.

Source: USDA and DOE, 2008.

USDA and DOE research sites with a focus on biofuel feedstocks, by feedstock



Note: Common sites were offset slightly so they would be visible. In many cases, this reflects cooperative efforts in the same locations.

Source: USDA and DOE, 2008.

Conclusion

Climate change and biofuels development have important implications for the condition and distribution of agricultural and forest landscapes. New decision support tools, technologies, and conservation and management strategies will be critical in assisting agriculture and forest managers as they address the challenge of climate variability and maximize the potential opportunity of a growing biofuels market.

Climate change effects already are being observed across the United States. Average temperature has risen more than 2 degrees Fahrenheit in the past 50 years (USGCRP 2009). Over the past century, much of the United States has experienced higher precipitation and streamflow, while the West and Southwest have experienced increased drought conditions (Bates et al. 2008). While temperature and rainfall shifts may drive near-term productivity increases for some agricultural and forest systems, long-term projections suggest decreases in productivity and the need for significant management changes to adapt to new conditions (USCCSP 2008). Conservation and management measures can help operators adapt to increasing climate variability, for example, through improving irrigation efficiencies, increasing soil moisture storage, and incorporating more tolerant species (plants and animals) into their production mix. Many of these same conservation practices also serve to sequester carbon and reduce greenhouse gas emissions.

Biofuels currently account for 20 percent of the Nation's renewable energy supply and are expected to increase in response to incentives for energy independence. Achieving the 36 billion-gallon-per-year expectation of the Energy Independence and Security Act (EISA) would more than triple current production levels, with the greatest growth occurring in cellulosic, biodiesel, and other advanced biofuels. Overall, the effects of increased biofuels production on the landscape will depend greatly on what crops are produced; where and how they are produced, harvested, and converted into biofuels; and what measures are used to conserve soil, water, and related resources. Conservation practices such as conservation tillage, crop rotation, cover crops, riparian buffers, or biochar applications can increase carbon retention; reduce sediment, nutrient and pesticide runoff; and retain moisture and nutrients in the soil. Conservation tillage, where the crop residue is left on the soil surface, has been shown to reduce soil erosion by 75 percent relative to conventional tillage (Mitchell et al. 2010). Crop rotations and conservation buffers can help reduce disease, pests, and persistent weeds and support beneficial insects and wildlife that can help operators manage their input needs strategically.

Water supply limitations have the potential to be an issue in every region, although the nature of the impacts on ecosystems and existing uses of the land varies. Precipitation, generally, is likely to occur in heavier events that punctuate longer dry periods, and this variability will be very important for water management. Changing precipitation patterns (spatially and temporally) will pose challenges for agriculture and natural ecosystems. Where water is sufficient, some of the stresses that increased temperatures could have on crop growth could be minimized. In arid areas that are likely to experience declining precipitation trends, increased water stresses may be anticipated. Increasing biofuels production also may exacerbate water stresses in water-challenged environments.

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CHAPTER 6

Water Resources in the 21st Century – Conservation Opportunities

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Water Resources in the 21st Century – Conservation Opportunities

A stable, safe, and secure water supply is essential to our welfare. The public outreach conducted for this RCA Appraisal underscores that water is on the minds of farmers, ranchers, forest landowners, and other land managers, as well as their urban and suburban counterparts. Water quality and availability were the highest priority natural resource concerns identified by the over 2,200 individuals who participated in RCA listening sessions, focus groups, and surveys. Climate variability and expected shifts in the spatial and temporal availability of water increase the importance of managing these resources to meet current and future demands (see chapter 5).

This section discusses pressing water quantity and quality issues identified by stakeholders in the outreach process. It is followed by a discussion of conservation treatment needs for water quality and water conservation that presents preliminary data from USDA's Conservation Effects Assessment Project (CEAP) cropland assessment. These estimates will be refined in future years and followed with conservation treatment needs for other priority resource concerns.

Water resources

Liquid freshwater, which we depend on for drinking, food, habitat, and recreation, makes up less than 1 percent of all water on Earth (figs. 6-1 and 6-2). The United States has abundant supplies of freshwater, but sometimes that water is not where it is needed, available when it is needed, or sufficient for its intended use. The availability of plentiful water in one hydrologic basin rarely addresses the problem of water scarcity in another.

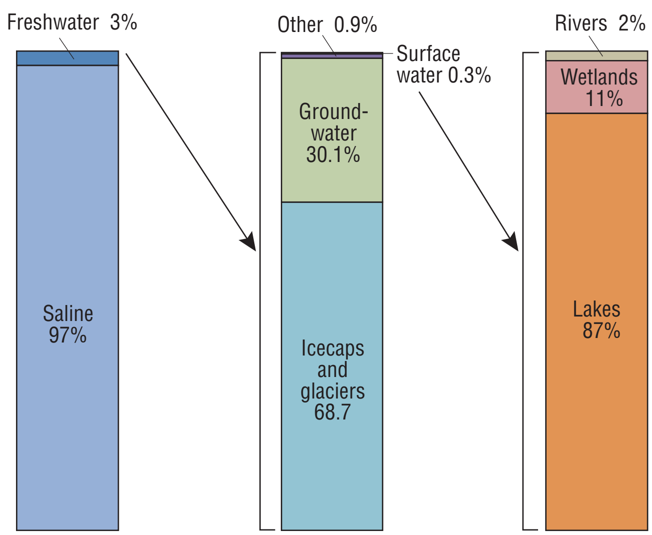
Water supply

The water we depend on is a renewable flow that moves through the phases of the hydrologic cycle and its reservoirs—snowpack, ice and glaciers, groundwater, atmospheric and soil moisture, and manmade reservoirs. The interaction between the flow resource (precipitation, runoff, and streamflow) and reservoirs is the focus of much of the discussion about water resources. The majority of food and fiber production is rainfed (flow resource), but irrigated agriculture and most other water uses depend on withdrawals from reservoirs, be they ground or surface, natural or manmade.

Agricultural uses dominated water withdrawals until the mid-1960s when thermoelectric power uses became the largest user (fig. 6-3). According to the U.S. Geological Survey, about 410 billion gallons of water were withdrawn per day for use in the United States during 2005 (Kenny et al. 2009). In 2005, agriculture accounted for about one-third of total withdrawals, and irrigation made up more than 90 percent of total agricultural withdrawals.

Figure 6-1.

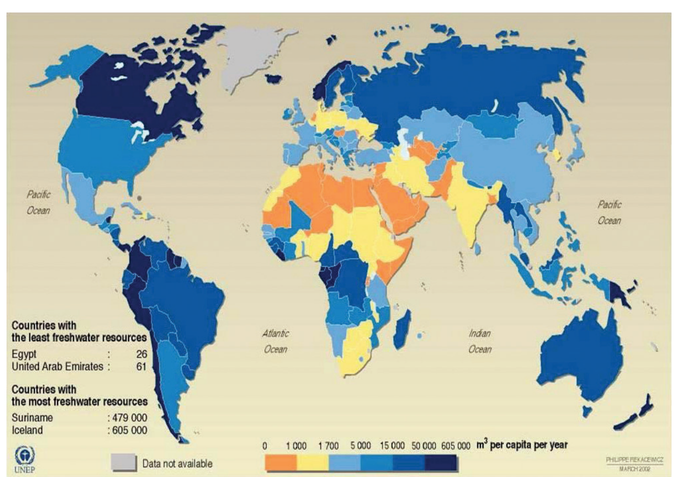
Distribution of Earth's water, by source



Source: adapted from USGS Water Science, http://ga.water.usgs.gov/edu/earthwherewater.html

Figure 6-2.

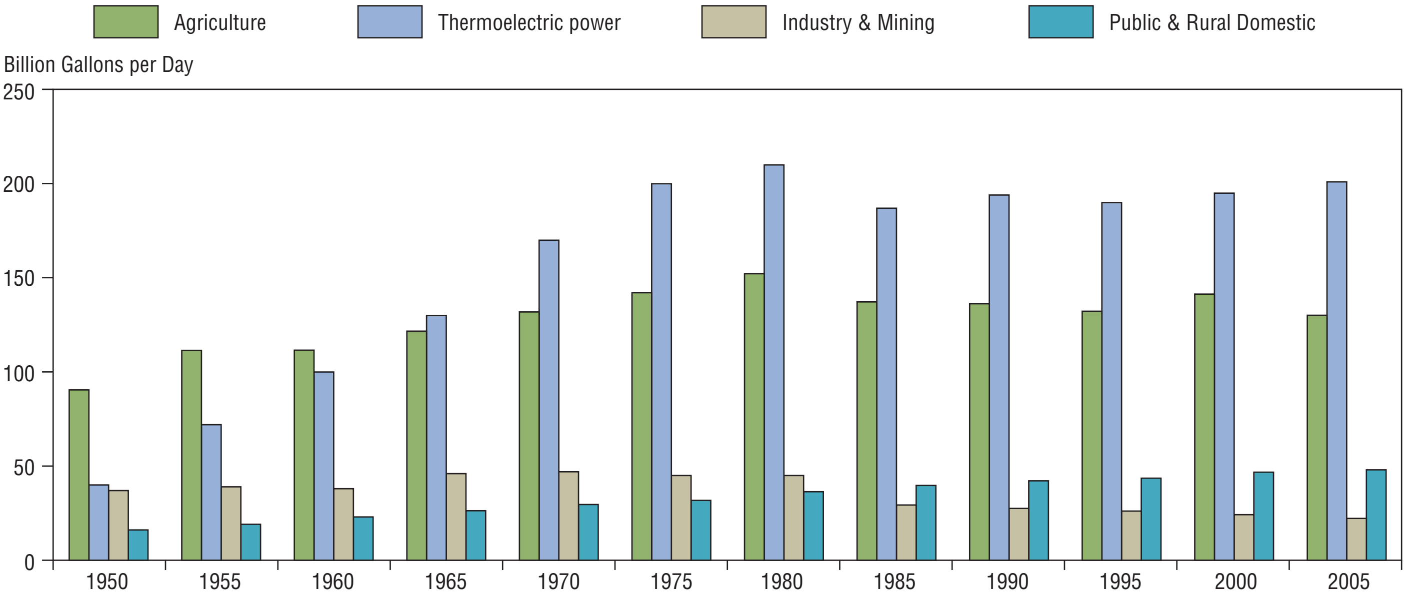
Distribution of Earth's water, by country



Source: United Nations Environment Programme 2002

Figure 6-3.

Trends in estimated water use in the United States, 1950–2005, by sector



Source: Kenny et al. 2009

States and other institutions regulate the quantity of water extracted from a water source by issuing withdrawal permits according to State laws. If permits for withdrawals exceed availability of water, unsatisfied demands result when water supplies decline. In addition to the extractive uses of water, instream or inplace water uses provide valuable benefits such as environmental flow, aquatic and riparian habitat, recreation, hydroelectric power generation, and navigation, among others. At times, and in many places, the competing extractive and in-place uses for water come into conflict.

Consumptive use, the portion of water withdrawals that is evaporated, transpired, or otherwise lost to the immediate basin, is an important hydrologic measure of water because it reduces the potential outflow of water from that basin. Estimates from 1995 and earlier indicate that irrigation *consumes* more than 80 percent of water withdrawn in the United States, which reflects the losses through evapotranspiration that are essential to crop growth.

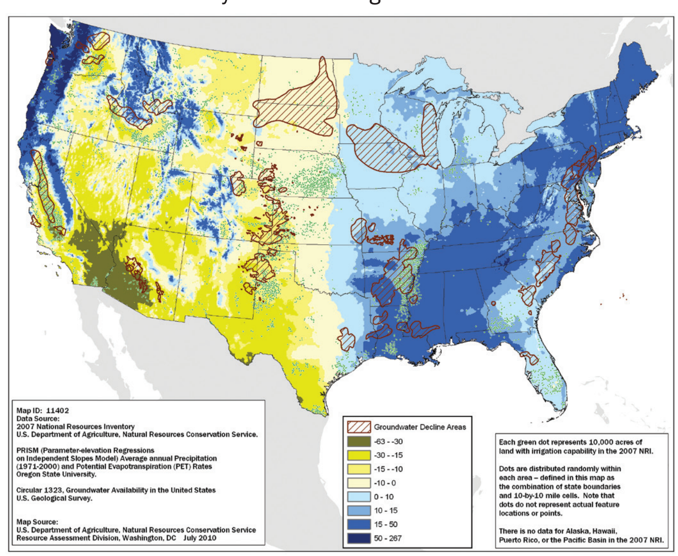
Irrigation. Irrigation in the United States expanded from 7.8 million acres in 1900 to 56.6 million acres in 2007.[1] About 42 million acres of irrigated land (75 percent of the Nation's total) are in the 17 western States, including almost 17 million acres (31 percent) in the semiarid Great Plains from North Dakota to Texas. The remaining 14 million acres of irrigated land (25 percent of the total) are in the humid East (fig. 6-4). While irrigation began in the

[1] While some 61 million acres have irrigation capacity in place, the number of acres irrigated in any given year is below that level.

Figure 6-4.

Indicators of water availability and the locations of irrigated land

Irrigated acreage is shown in green dots (1 dot equals 10,000 acres). The yellow color ramp indicates where potential evapotranspiration (PET) exceeds annual average precipitation. The blue color ramp indicates where annual average precipitation exceeds PET. Snowpack runoff from high elevations (blue areas in the intermountain region) is generally the source of surface-supplied irrigation water in western locations. Areas of aquifer decline are denoted by cross-hatching.



Source: U.S. Geological Survey; 2007 National Resources Inventory, Natural Resources Conservation Service, USDA; PRISM, Oregon State University arid parts of the country, the East is experiencing faster growth than any other region, increasing irrigated acreage by almost 190,000 acres annually from 1997 to 2007.

Surface water is used more intensively than groundwater for irrigation, accounting for 58 percent of water withdrawals in 2005 (fig. 6-5). On average, acres irrigated with groundwater receive less water per acre than do surface water-supplied acres. Most surface water irrigation occurs in the arid West, while groundwater irrigation occurs nationwide but is dominant in the humid East.

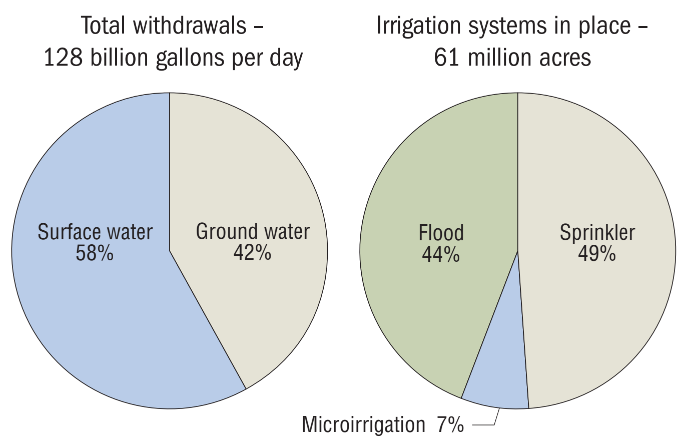
Irrigation is not needed for crop production in most of the United States, and only about 18 percent of the Nation's harvested cropland is irrigated. Irrigation water use is greatest and water scarcity is more common in the West (fig. 6-6). Across the West, there was a substantial shift from gravity irrigation to pressure irrigation systems between 1984 and 2008. By 2008, pressure irrigation systems—many designed to apply less water through drip, low-pressure sprinkler, or low-energy precision application systems—were in use on more than 40 percent of the irrigated acres in the West. The use of these technologies allows improved and more productive water management.

Agriculture often has senior[2] withdrawal rights in appropriative rights states (generally in the West) and controls land access to streams in riparian rights states (generally in the East). When other sectors are seeking additional water resources, many times they will buy water, land with associated water rights, or water rights alone from agricultural entities. Continued pressure on agricultural water supplies from competing demands is likely because of the volume of water controlled by agriculture.

[2] The use of water in many of the western states is based on the doctrine of prior appropriation and the maxim "first in time, first in right." The first person to use water is the "senior appropriator" who also acquires the right to its future use, while subsequent users are "junior appropriators."

Figure 6-5.

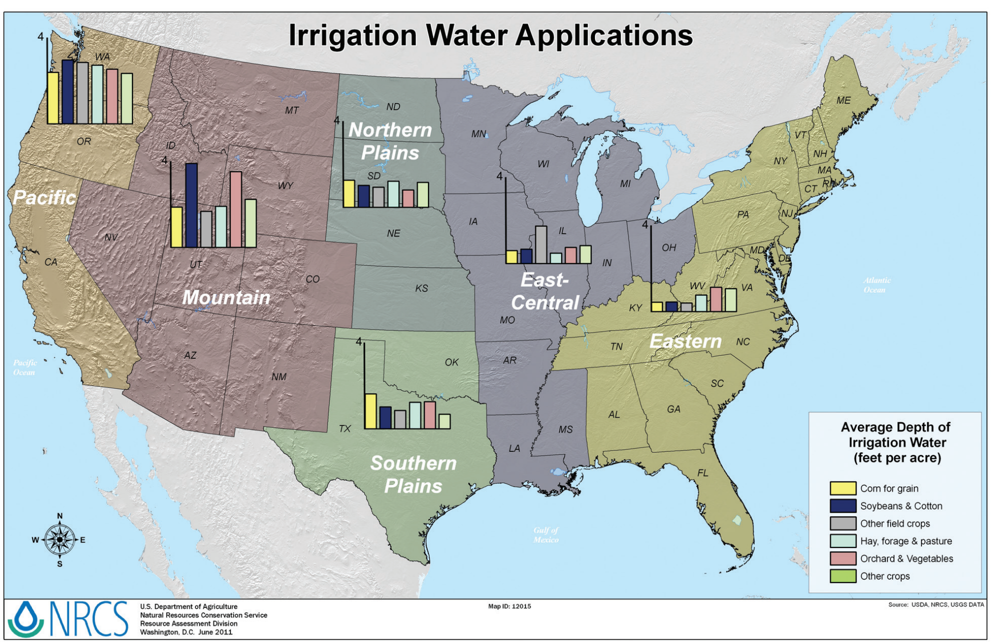
Irrigation water withdrawals, by source and irrigation systems, by type, 2005



Source: Kenny et al 2009

Figure 6-6.

Irrigation water applications, by region and by crop, 2003



Source: NRCS analysis of Census of Agriculture data.

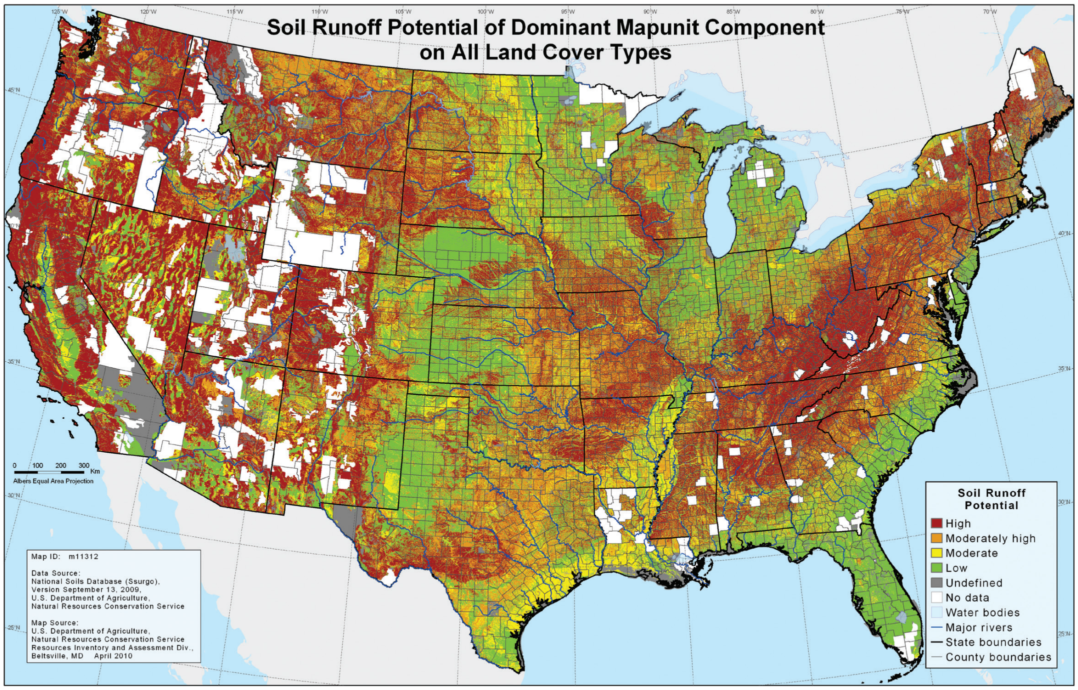
The average depth of irrigation water applied is shown by the bar height. Applications are generally higher in the more arid West, and vary by crop.

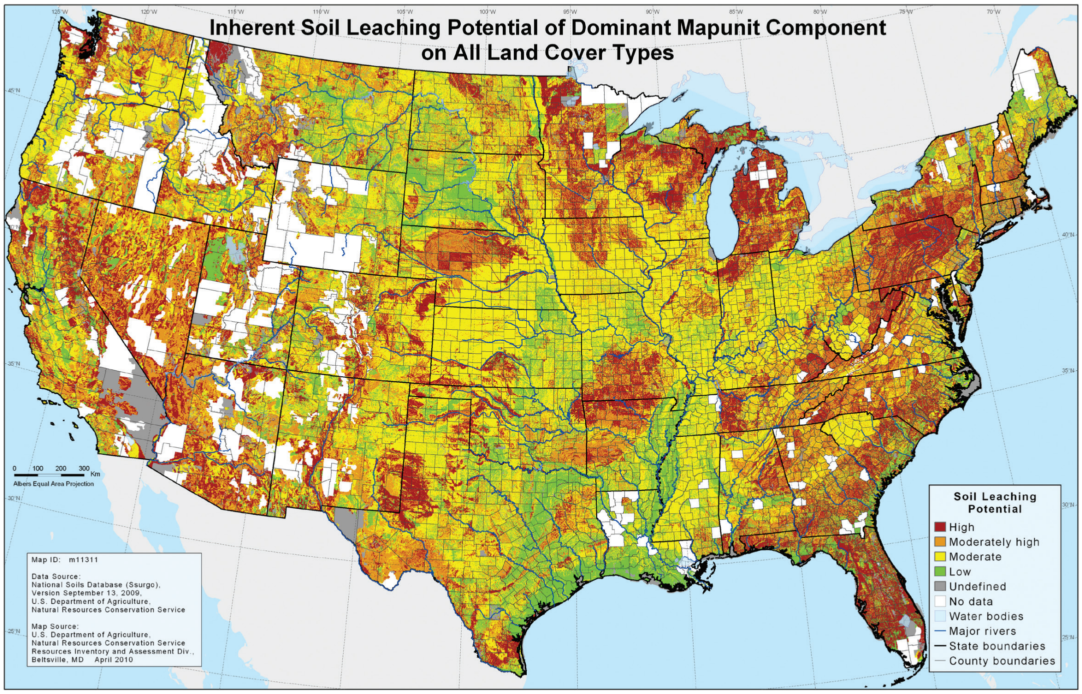
Water quality

Water quality is affected by many sources and activities, including agriculture. The quality of the Nation's water resources is a longstanding concern and despite evidence of progress in some areas, challenges remain. Public outreach conducted for this Appraisal identified nutrients and sediment as priority natural resource concerns. These materials can run off fields, leach into groundwater, or be deposited from the atmosphere. Controlling their movement depends strongly on management. Inherent soil and topographic factors such as soil type, organic matter content, and slope affect the potential for leaching and runoff (fig. 6-7).

Figure 6-7.

Soil leaching and soil runoff potential





The red and orange shades in these maps identify soils with high and moderately high vulnerabilities for runoff (top) or leaching (bottom) based on soil factors. Management measures, such as conservation buffers and nutrient management, can mitigate these inherent vulnerabilities and prevent movement of nutrients and pesticides to surface and subsurface water resources.

Source: USDA-NRCS

A recent assessment of the biological condition of the Nation's wadeable streams found that slightly over 50 percent were in fair or good condition (fig. 6-8) but also that nearly 42 percent were in poor condition. The assessment used benthic macro-invertebrates (e.g., aquatic larval stages of insects, crustaceans, worms, and mollusks) as the indicator for biological condition because of their capacity to integrate the effects of stressors, in combination and over time. The most common stressors were elevated levels of nitrogen and phosphorus, riparian disturbance, and streambed sediments (USEPA 2006).

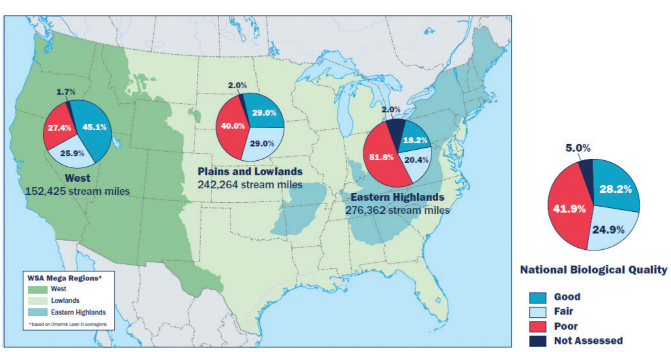
An assessment of the Nation's lakes generated similar results. Fifty-six percent of the Nation's lakes are in good biological condition, with natural lakes having a higher proportion in good condition than manmade lakes. The most pressing challenges identified were poor lakeshore habitat condition and excess nutrient levels that contribute to algae bloom, weed growth, reduced water clarity, among other problems (USEPA 2010).

In another study, USGS found elevated nutrient (nitrogen and phosphorus) levels in more than 90 percent of 190 streams draining urban and agricultural lands in the Northeast, Midwest, and Northwest. Concentrations of nitrogen were higher in the agricultural watersheds, while concentrations of phosphorus were similar for agricultural and urban-dominated watersheds (fig. 6-9). The level of nutrients reaching streams varies greatly depending on sources, amounts applied, agricultural production practices, conservation measures, soils, geology, and hydrology (fig. 6-10).

Water that moves below the root zone can carry water-soluble materials to the groundwater. USGS found median nitrate concentrations exceeding the background levels in 64 percent of the shallow aquifers (those less than 100 feet deep) studied. The median nitrate levels are higher in young groundwater (groundwater recharged in the last 10 years) than in old groundwater (fig. 6-11).

Figure 6-8.

Biological condition of the Nation's wadeable streams, 2010

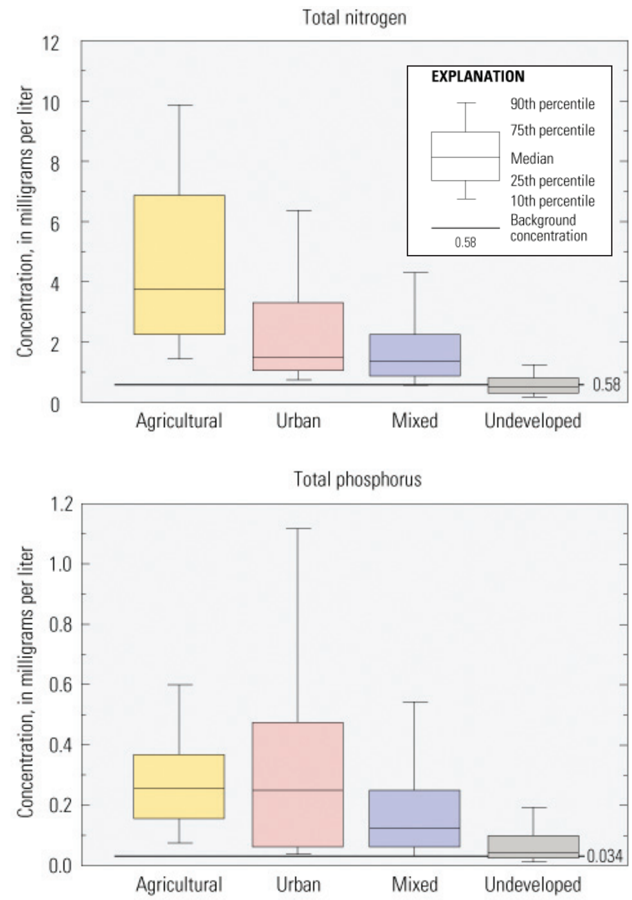


Source: USEPA 2006

Figure 6-9.

Nitrogen and phosphorus concentrations, by predominant land use

Concentrations of total nitrogen were highest in agricultural streams, with a median concentration of about 4 milligrams per liter (about six times greater than background levels), whereas concentrations of total phosphorus were similar in agricultural and urban streams, with a median concentration of about 0.25 milligram per liter (about six times greater than background levels).

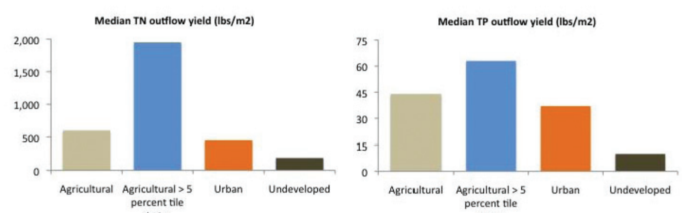


Source: Dubrovsky et al. 2010

Figure 6-10.

Effect of tile drainage on nitrogen and phosphorus losses

Tile drains installed to manage soils that hold too much water create a pathway for nutrient movement

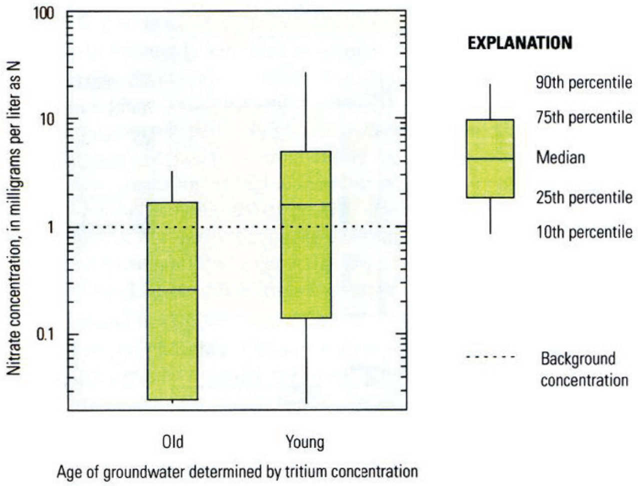


Source: Dubrovsky et al. 2010

Figure 6-11.

Nitrate concentrations in old and young groundwater

Nitrate concentrations were significantly higher in young groundwater than in old groundwater. Elevated concentrations of nitrate (greater than 10 milligrams per liter) rarely occurred in groundwater that entered the groundwater system prior to 1953.



Source: Dubrovsky et al. 2010

Almost all (98 percent) of the self-supplied domestic water serving 43 million people is drawn from shallow, young groundwater resources. USGS found that about 7 percent of all domestic wells and 20 percent of the wells in agricultural areas had concentrations above the EPA threshold for nitrate concentration levels (Dubrovsky et al. 2010). About one-third of larger water supply systems, those serving at least 25 people, also draw from groundwater, but generally from deeper aquifers with old groundwater.

Just as groundwater provides a reservoir for water supplies, it can also be a storage reservoir for nutrients that may discharge into surface water systems. The lag time between the application of conservation practices and detectable reductions in groundwater nitrate concentration generally makes it difficult to measure the effectiveness of practices in the short run, although lag time depends on hydrology and site-specific factors. For example, in areas of karst topography, shallow or perched aquifers, or sandy soils, response to conservation treatment may be observed more quickly than in settings where materials move more slowly. Groundwater discharge along with irrigation return flow and other stable flow sources accounted for more than 37 percent of the total annual nitrate load in about two-thirds of the streams studied by USGS (fig. 6-12).

Figure 6-12.

Percentage of total nitrate load contributed by baseflow

Source: Dubrovsky et al. 2010

Nutrient leaching: A critical conservation concern

Nitrogen and phosphorus are essential inputs to profitable crop production. Farmers apply these nutrients to the land as commercial fertilizers and in manure to promote plant growth and increase crop yields. Some of the nutrients applied to the land are lost to the environment and, when combined with naturally occurring levels of these elements, can create human health risks and other offsite environmental problems.

A recent CEAP study on the effects of conservation practices on cropland in the Upper Mississippi River Basin (UMRB) used computer modeling to quantify the movement of sediment and nutrients to water supplies. According to the draft report, farmers' use of conservation practices has reduced total losses of sediment from farm fields by 69 percent, total losses of phosphorus by 47 percent, and total losses of nitrogen by 18 percent, compared to losses that likely would have occurred if no conservation practices had been implemented.

A closer look, however, reveals that nitrogen loss is down by 46 percent in surface runoff but only by 5 percent in subsurface flow. Why is this? Some technologies that reduce surface runoff and erosion from cropland fields may not control the movement of soluble nitrogen into subsurface flow pathways. A comprehensive conservation plan designed to meet the site-specific characteristics of the operation and the field will combine erosion control practices (e.g., conservation tillage, buffers, cover crops) and nutrient management (e.g., form, rate, timing, and placement of nutrients) to address multiple loss pathways. Assistance to plan and implement the needed conservation practices is available through a variety of Federal, State, and local programs.

Implications for meeting current and future demand

Water resources are the foundation for meeting the demand for food, feed, and fiber today and in the future. Current challenges in water resource management are being amplified by new demands on agricultural and forest landscapes and the effects of climate change. For this RCA Appraisal, the most recent set of USDA World Agricultural Outlook Board (WAOB) projections formed the basis for identifying future demands on the resource base (WAOB 2010). Key assumptions included:

- **Population.** While population growth continues to slow worldwide, developing countries will account for 84 percent of global population by 2019.
- **Energy.** Expansion of the U.S. ethanol industry will slow from prior years, reflecting moderate growth in U.S. gas consumption and limited potential for further penetration in ethanol markets. Corn will remain the primary feedstock for U.S. ethanol, accounting for about 35 percent of corn use.
- **Economic growth.** U.S. and global economies will achieve moderate, steady growth supporting longer term gains in world food demand, global agricultural trade, and U.S. agricultural exports.
- **The dollar.** The U.S. dollar will depreciate slightly as part of the global adjustment of trade and financial markets, driving gains in U.S. agricultural exports, which in turn will increase farm cash receipts.
- **Crops.** Production will increase, mainly due to small but steady gains in productivity and increasing exports for most crops. Acreage planted to the eight major crops will decline slightly although cropland use will remain high.
- **Livestock.** Production will increase gradually as the global economy strengthens and the sector continues to adjust to higher prices for inputs.

These agricultural sector projections portray a near-term future that includes increasing crop and livestock production and expanding biofuels production, along with increasing population and economic growth, all of which are likely to increase the demand on water resources.

Soil and water conservation treatment needs

Understanding soil and water conservation treatment needs is essential for designing an efficient soil and water conservation program. Soil and Water Conservation Needs Inventories (CNIs) conducted by USDA in 1945, 1958, and 1967 helped to determine the locations and severity of natural resource problems and concerns on non-Federal lands. This information in turn shaped USDA's program of soil and water conservation. Since 1982, the National Resources Inventory (NRI), which followed the CNIs, has provided scientifically defensible trend data on natural resources on non-Federal lands. USDA's Conservation Effects Assessment Project (CEAP) builds on the strength of the NRI to develop nationally consistent information on the effects of conservation practices applied on U.S. agricultural lands.

The following discussion presents CEAP estimates of the effects of current cropland conservation on water conservation and the transport and fate of sediment, nitrogen, and phosphorus. Irrigation water applications as well as potential for sediment and nutrient losses vary according to a number of natural and management factors, such as soil, slope, rainfall intensity, and crops grown, among others. Across the nine basins presented here (fig. 6-13), there is substantial variation in the potential for irrigation water conservation and reductions in material losses.

Irrigation water conservation

Irrigation water conservation is complex because water used for irrigation is mobile, is supplied from alternative sources, includes return flow linkages, and is governed by alternative laws and institutions. "Water conservation" is a broad term that represents a range of actions to use less water—

- In absolute terms (water-use reduction);
- To achieve the goal (water efficiency); and
- Per unit of output (water productivity).

Reducing consumptive water use on irrigated agricultural land (water use reduction) usually involves a decline in irrigated area or production. In contrast, improving "water productivity" through better irrigation technology (irrigation water management, conveyance improvements, and application system improvements, singularly or in combination) increases output with the same or reduced levels of water application. Improving water productivity rarely increases downstream water availability. In fact, there may be a reduction in downstream flow because of increased consumptive use associated with higher yields. However, improving water productivity is a significant accomplishment, given the domestic and international demand for the products from irrigated agriculture.

Irrigated acres (2007 Census of Agriculture) and irrigation water applications (USDA 2008) are displayed in figure 6-14. Almost one fourth of the Nation's irrigated acreage is in the Missouri River Basin. Almost two-thirds of the irrigated land in the Nation is located in three major basins (Missouri, Western, and Arkansas-White-Red/Texas Gulf Basins). While irrigation occurs at some level in all major basins, it is concentrated where it is required or where supplemental water is profitable. The Lower Mississippi and Missouri had the greatest gain in irrigated acres over the period 2002 to 2007, continuing to increase the concentration of irrigated acres.

Water applied for irrigated crop production averaged less than 20 inches per acre in basins where irrigation is used

Figure 6-13.

Major river basins and water resource regions for the CEAP-Cropland assessment

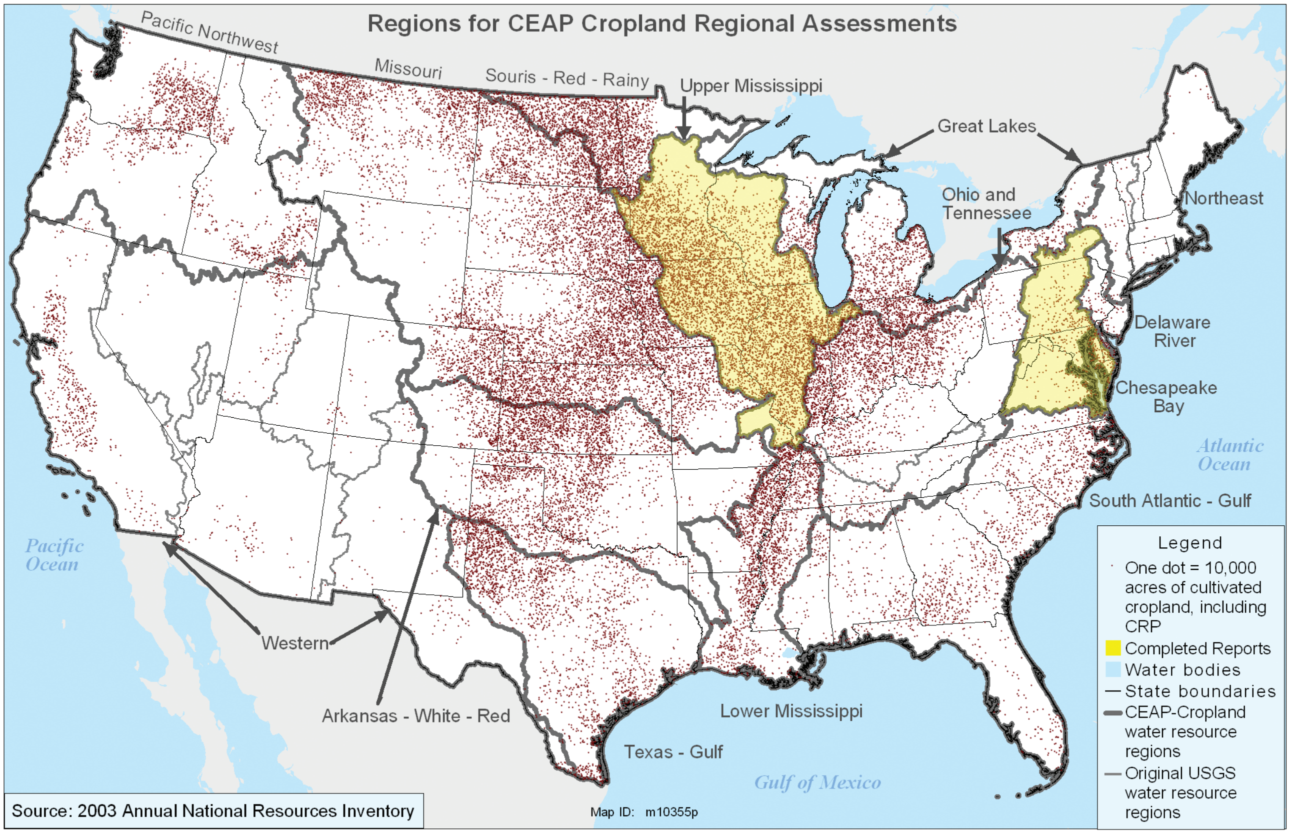
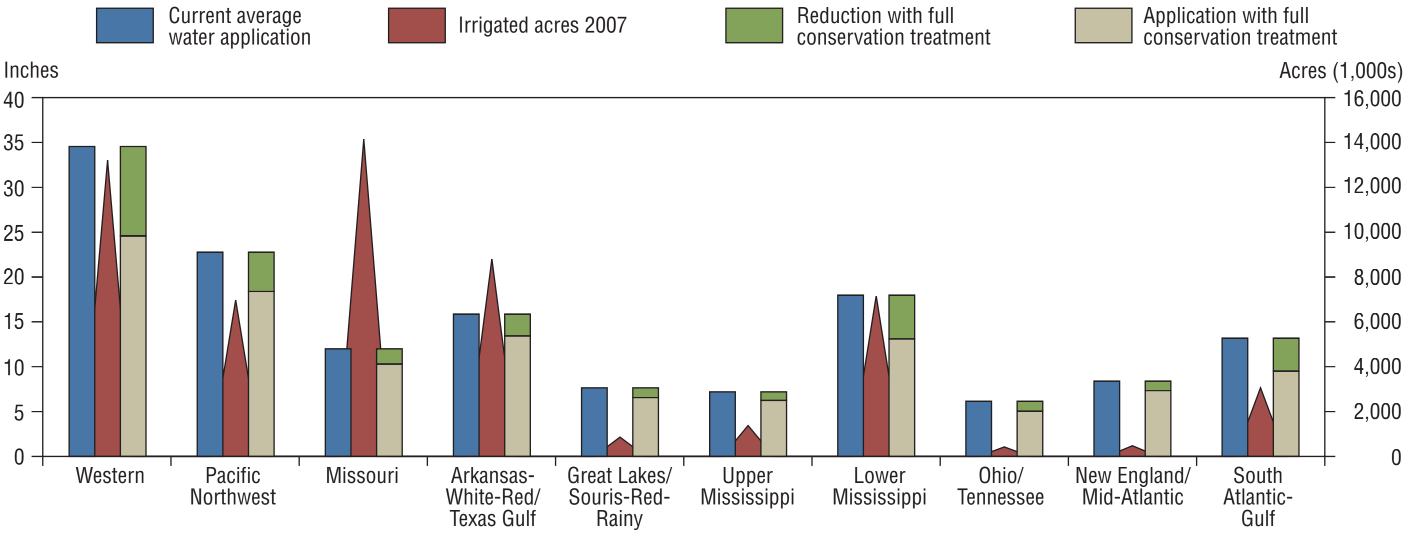


Figure 6-14.

Irrigated acres (2007) and current per acre water application depth and modeled depth reduction on cultivated cropland under full conservation treatment, by basin



Note: Estimated per acre application and reduction are calculated using CEAP estimates of percentage improvement by basin and actual current water application data from the Farm and Ranch Irrigation Survey, 2008. Estimated improvements do not reflect additional water needed for salinity control or frost prevention.

Source: USDA, Preliminary data, CEAP Cropland Assessment; and NASS, Census of Agriculture 2007; Farm and Ranch Irrigation Survey 2008 to supplement natural rainfall. In the more arid Western basins the amount was greater, averaging about 35 inches per acre and ranging from 22 to 62 inches per acre across its sub-basins, reflecting water needed for irrigation and salinity management in regions with less precipitation.

Potential exists to reduce water application while sustaining yields through implementation of improved technologies and practices that increase water efficiency and productivity. A comparison of current irrigation practices on cultivated cropland with alternative practices in a "full treatment" scenario shows that the potential water application reductions vary significantly by basin (fig. 6-14). The simulated reductions in irrigation water application reflect a focus on technological improvements such as transition from gravity and hand-move systems to center pivot or linear-move, low-pressure spray systems. Improvements in irrigation water management also have the potential to reduce water applications, and improved management is usually required to capture the potential in the improved technology.

Opportunities to improve water management exist across the Nation, but vary substantially by basin. The western and Lower Mississippi basins show the largest potential improvements, at about 30 percent of current average water application. These estimates reflect improving irrigation practices on all irrigated cultivated cropland in the basins and do not demonstrate potential efficiencies gained by focusing on those acres most in need of conservation treatment. The focus is at the field

The Conservation Effects Assessment Project

The Conservation Effects Assessment Project (CEAP) is a USDA effort to quantify the effects of conservation practices on U.S. agricultural lands. CEAP investigations are organized into four assessment components – cropland, grazing lands, wetlands, and wildlife. Major phases of the research effort include—

- Developing bibliographies and literature reviews to establish and document what is known and not known regarding the national assessment components.
- Conducting small watershed assessment studies to enhance the understanding of the measurable effects of conservation at watershed scales and to serve as verification points for the national assessment component.
- Conducting a statistically reliable survey of farmers to gather data on the types and extent of conservation measures in place on the landscape.
- Using state–of-the-art models to estimate the physical impacts of conservation measures on soil, water, and related natural resources.

The CEAP cropland assessment is nearly complete, and reports from several regions are now or soon will be available (fig. 6-13). The assessment uses computer models to estimate the effects of current conservation measures on reducing delivery of sediment, nitrogen, and phosphorus to waterways. The models also enable projections of additional conservation gains that could be made by treating additional cropland acreage within the basins. Acres are placed in one of three categories based on the relationship between the inherent site vulnerability and the level of conservation treatment in place. If a field's level of vulnerability exceeds the level of conservation treatment in place, then that field is identified as having a conservation need.

- **Low conservation treatment need** – These acres have conservation practices in place to manage field-level sediment and nutrient losses, as appropriate to the level of inherent site vulnerability.
- **Moderate conservation treatment need** – These acres have moderate levels of imbalance between the inherent site vulnerability and the conservation treatment in place. Field-level losses exceed acceptable levels by some amount.
- **High conservation treatment need** – These acres have highest level of imbalance between the inherent site vulnerability and the conservation treatment in place.

The resulting estimates of additional conservation benefits are based on implementation of comprehensive conservation treatment designed to add practices to complete a conservation system that would reduce edge-of-field sediment and nutrient losses to acceptable levels, which are used as a guide to estimate the acres needing additional treatment. Acceptable levels were derived by scientists through a series of professional and research forums and narrowed to the values used in this study by further examination of Agricultural Policy Environmental Extender (APEX) model output for all agricultural regions. The levels selected were shown to be feasible in all agricultural regions and fell within the range provided by the scientists. These acceptable levels were not used in this study as "tolerable thresholds" for field-level losses, and therefore are not intended to provide adequate protection of water quality, although for some environmental settings they may be suitable for that purpose. Evaluation of how much additional conservation treatment is needed to meet Federal, State, and/or local water quality goals in the region is beyond the scope of this study.

Existing conservation treatment was modified with additional practices to 1) apply nutrient management (form, rate, timing, and method) on all crops in the rotation, 2) control overland flow, and 3) trap materials leaving the field with edge-of-field mitigation. Comprehensive conservation treatment consists of well-established agricultural conservation practices and is intended to maintain capacity to produce food, feed, and fiber in the region.

While these results present only part of the overall conservation needs picture, they represent the next generation of tools for shaping a national soil and water conservation program. As USDA's CEAP effort continues to mature, these preliminary estimates will be followed with similar information for water quantity, grazing lands, wetlands, and wildlife habitat.

level and the potential to increase productivity; this does not necessarily translate into increased basin-wide productivity. These estimates do not include irrigated non-cultivated cropland (hayland, orchards) or irrigated pasture. Additional information is needed to determine the other uses of irrigation water (salinity control, frost prevention) and to estimate the effect of improved practices on the hydrologic cycle, including on water availability for other needs within the basin.

Sediment

Controlling soil erosion has been a main objective of USDA conservation efforts since the 1930s. The average annual wind and water erosion rate on cropland has dropped from 7.3 tons per acre in 1982 to 4.8 tons per acre in 2007 (USDA-NRCS 2009). The rate of decline began to level off in the late 1990s, and currently about 20 percent of the non-highly erodible cropland and 67 percent of the highly erodible cropland continues to erode excessively.[3]

Sediment loss. Erosive forces can move soil particles beyond the edge of the farm field. For the purposes of this assessment, adequate levels of sediment loss were assumed to average 2 tons per acre per year. The comprehensive conservation treatment scenario goes beyond soil loss tolerance (T), using numeric criteria for minimizing field level losses as the planning target. Table 6-1 and figures 6-15 and 6-16 show potential reductions in sediment loss for the major river basins and water resource regions in the conterminous United States.

[3] Excessive erosion reflects soil loss at greater than the soil loss tolerance rate (T), which is the maximum rate of annual soil loss that will permit crop productivity to be sustained economically and indefinitely on a given soil.

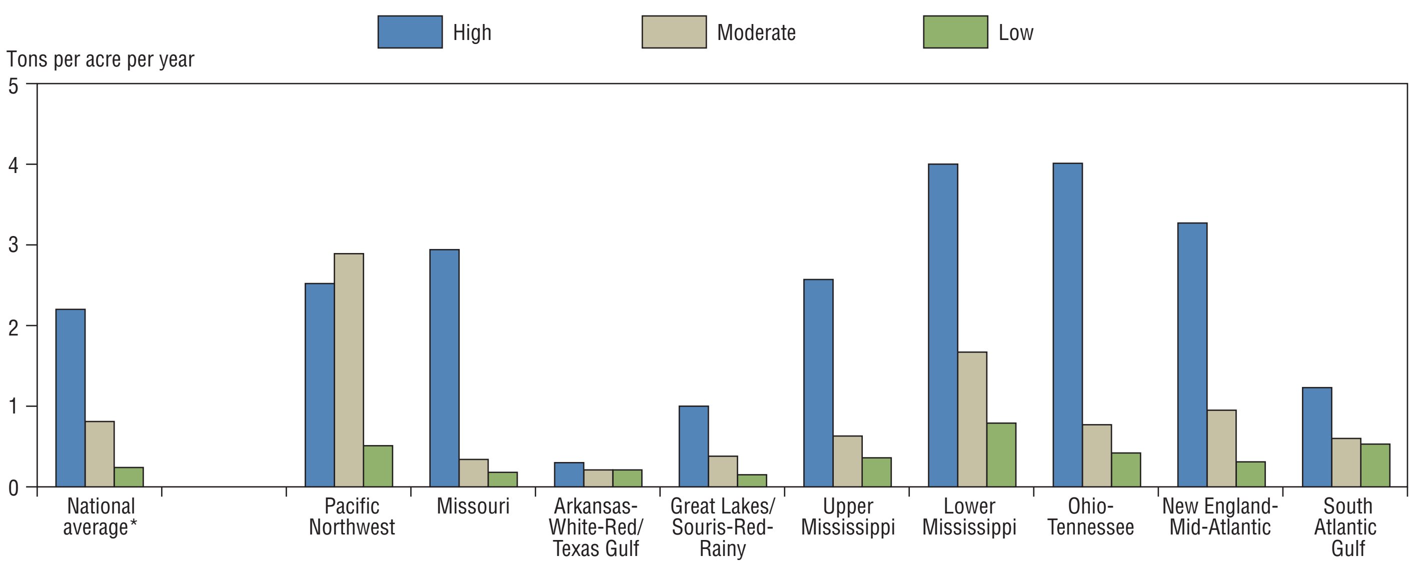
Nationwide, with respect to sediment loss—

- The greatest potential total reductions in sediment loss from high-treatment-need acres are in the Lower Mississippi (35.4 million tons), Ohio-Tennessee (24.1 million tons), and Upper Mississippi (23.1 million tons).
- Applying comprehensive conservation treatment[4] on the high-treatment-need acres in the Lower Mississippi, Ohio-Tennessee, New England-Mid Atlantic, Missouri, Upper Mississippi, and Pacific Northwest regions could reduce sediment losses by 2.5 tons per acre per year or more. Total sediment loss reductions would be less in the Missouri, New England-Mid Atlantic, and Pacific Northwest regions than in the other regions because of the relatively low number of high-treatment-need acres in those regions.
- Applying a comprehensive suite of conservation practices on the high-treatment-need acres in the Lower Mississippi, South Atlantic-Gulf, New England-Mid Atlantic, and Ohio-Tennessee regions would achieve 60 percent or more of total potential reductions in sediment losses in these four basins. Applying comprehensive conservation to all of the high and moderate treatment need acres in those basins and the Pacific Northwest would achieve 90 percent or more of total potential reduction in sediment losses in those basins.

[4] Comprehensive conservation treatment includes all needed conservation practices to complete a conservation system that would reduce sediment and nutrient losses at the edge of field.

Figure 6-15.

Potential reductions in sediment losses using additional conservation management on cultivated cropland, by conservation treatment need and basin



* Does not include estimates for the Western Basins, which are currently not available.
SOURCE: USDA, Preliminary data, CEAP Cropland Assessment

Table 6-1.

Potential average annual sediment loss reductions from cultivated cropland through application of comprehensive conservation treatment

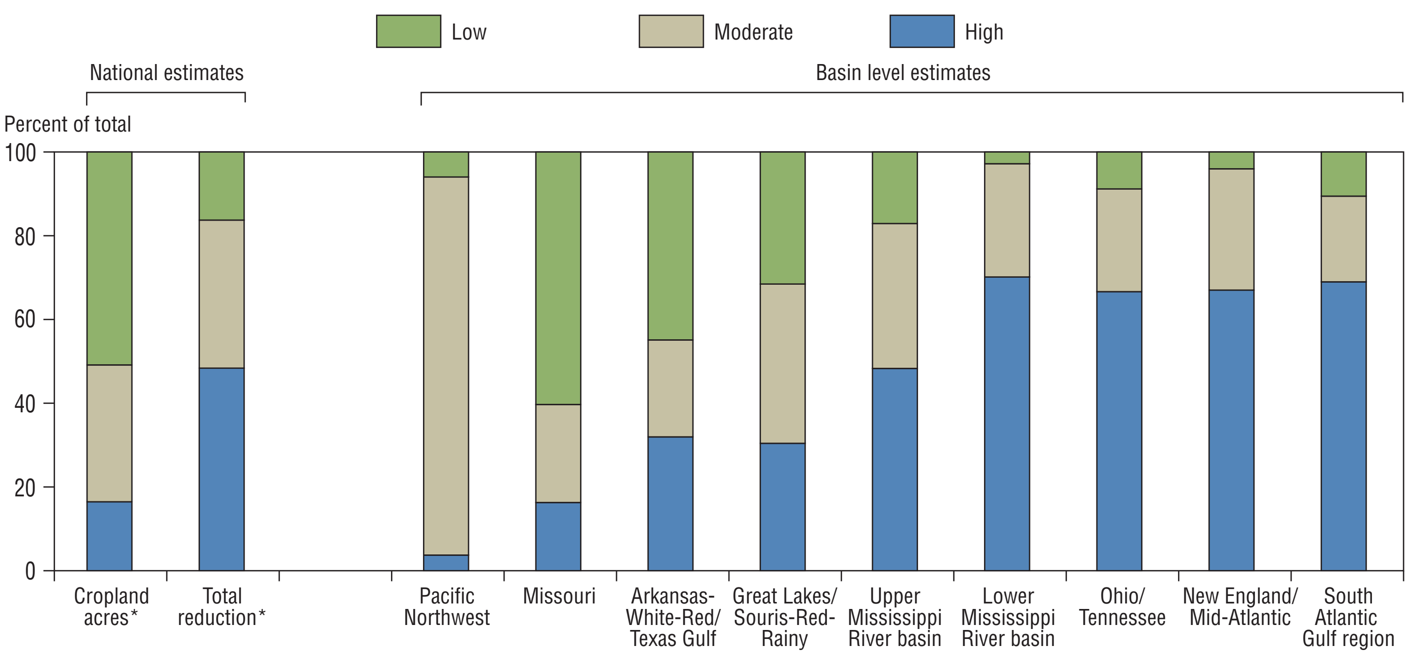
River Basin/ Water Resource Region	Application of comprehensive conservation treatment to—						All cultivated cropland in region
	High treatment need acres			Moderate treatment need acres			
	Area	Average annual reduction		Area	Average annual reduction		
	Million acres	*Million tons*	*Tons/acre*	*Million acres*	*Million tons*	*Tons/acre*	*Million acres*
Western	--	--	--	--	--	--	--
Pacific Northwest	0.4	1.0	2.5	8.2	23.7	2.9	11.6
Missouri	1.1	3.3	2.9	14.2	4.8	0.3	83.6
Arkansas-White-Red/Texas Gulf	12.2	3.6	0.3	12.7	2.6	0.2	48.8
Great Lakes/Souris-Red-Rainy	2.8	2.8	1.0	9.4	3.5	0.4	32.4
Upper Mississippi	9.0	23.1	2.6	26.2	16.5	0.6	58.2
Lower Mississippi	8.9	35.4	4.0	8.2	13.7	1.7	18.8
Ohio-Tennessee	6.0	24.1	4.0	11.5	8.9	0.8	25.0
New England-Mid Atlantic	1.9	6.3	3.3	2.9	2.7	1.0	6.0
South Atlantic-Gulf	6.7	8.3	1.2	4.1	2.5	0.6	13.2
ALL REGIONS	--	--	--	--	--	--	--

* Does not include estimates for the Western Basins, which are currently not available.
Source: USDA, Preliminary data, CEAP Cropland Assessment

Figure 6-16.

Proportion of potential sediment loss reduction through application of comprehensive conservation treatment on cultivated cropland, by treatment need and basin

Each bar in this chart shows the percentage of reduction in total sediment loss that could be achieved through comprehensive conservation treatment of the critically under-treated acres (blue), all remaining under-treated acres (tan), and all other acres of cultivated cropland (green).



* Does not include estimates for the Western Basins, which are currently not available.
Source: USDA, Preliminary data, CEAP Cropland Assessment

Nitrogen and phosphorus

Reducing nitrogen and phosphorus losses from farm fields to waterways is a high-priority conservation goal. While erosion-control practices reduce the loss of nutrients through surface runoff, they also can promote the infiltration of soluble nutrients, which may then move through subsurface pathways to rivers and streams. Where tile drains are common, they may intercept subsurface flow and route it directly to surface flows.

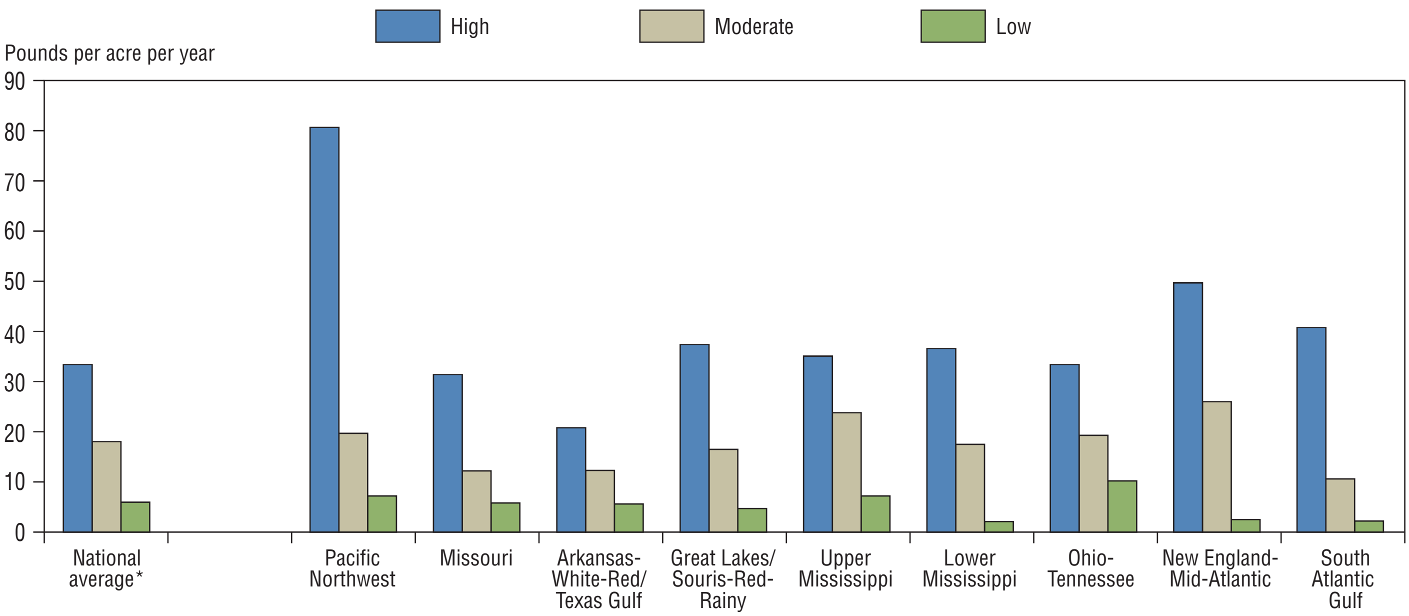
Nitrogen losses. Nitrogen can move beyond the edge of the field in overland flow in soluble form or attached to soil particles, or in soluble form through subsurface pathways. For the purposes of this assessment, adequate levels of nitrogen loss were assumed to average 40 pounds per acre per year. The comprehensive conservation treatment scenario goes beyond soil loss tolerance (T), using numeric criteria for minimizing field level losses as the planning target. Table 6-2 and figures 6-17 and 6-18 show potential reductions in nitrogen loss for the major river basins and water resource regions in the conterminous United States.

Nationwide, with respect to nitrogen loss—

- The greatest potential total reductions in nitrogen loss from high-treatment-need acres are in the Lower Mississippi (325 million pounds), Upper Mississippi (316 million pounds), South Atlantic-Gulf (274 million pounds), and Arkansas-White-Red/Texas Gulf (253 million pounds) basins.
- Applying comprehensive conservation treatment on the high treatment need acres in the Pacific Northwest, New England/Mid-Atlantic, and South Atlantic-Gulf regions could reduce nitrogen losses by more than 40 pounds per acre per year.

Figure 6-17.

Potential average annual per-acre nitrogen loss reductions on cultivated cropland through application of comprehensive conservation treatment



* Does not include estimates for the Western Basins, which are currently not available.

Source: USDA, Preliminary data, CEAP Cropland Assessment

Table 6-2.

Potential average annual nitrogen loss reductions from cultivated cropland through application of comprehensive conservation treatment

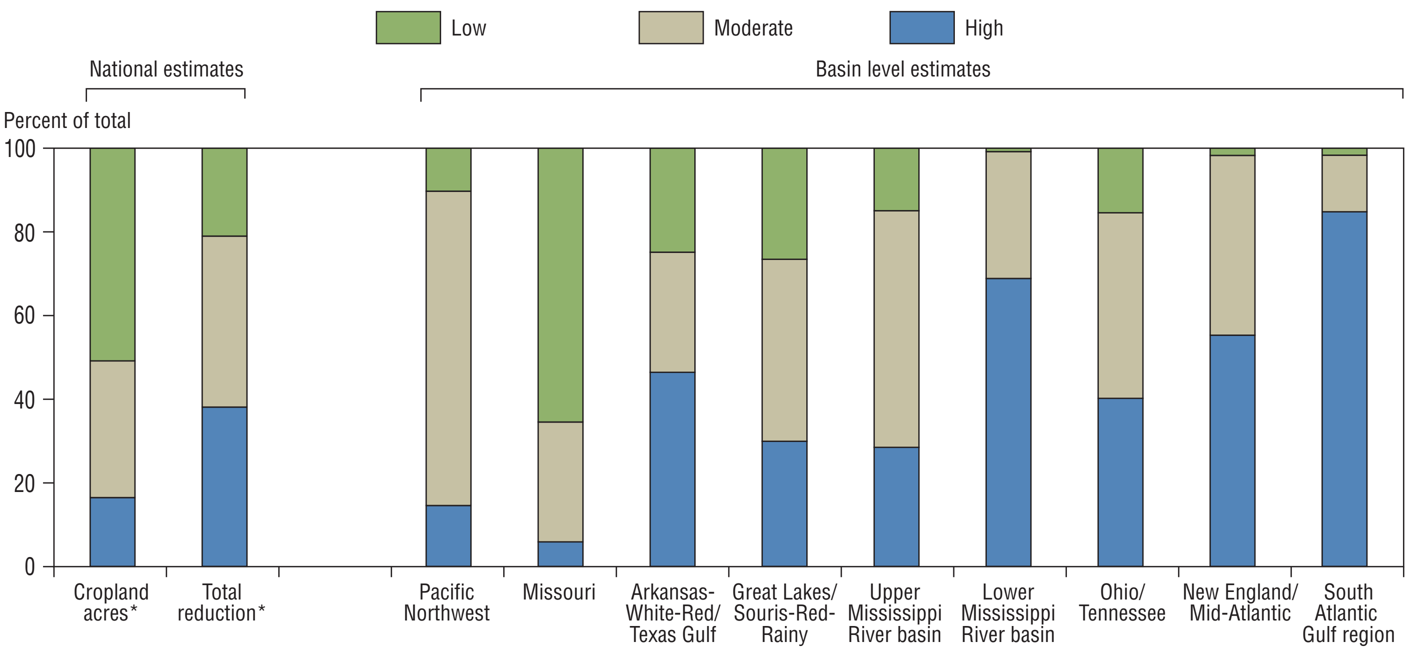
River Basin/ Water Resource Region	Application of comprehensive conservation treatment to— High treatment need acres: Area	High treatment need acres: Average annual reduction		Moderate treatment need acres: Area	Moderate treatment need acres: Average annual reduction		All cultivated cropland in region
	Million acres	*Million pounds*	*Pounds /acre*	*Million acres*	*Million pounds*	*Pounds/ acre*	*Million acres*
Western	--	--	--	--	--	--	--
Pacific Northwest	0.4	31.3	80.7	8.2	161.6	19.7	11.6
Missouri	1.1	35.4	31.4	14.2	173.2	12.2	83.6
Arkansas-White-Red/Texas Gulf	12.2	252.8	20.8	12.7	156.5	12.3	48.8
Great Lakes/Souris-Red-Rainy	2.8	106.2	37.4	9.4	154.5	16.5	32.4
Upper Mississippi	9.0	315.6	35.1	26.2	627.4	23.9	58.2
Lower Mississippi	8.9	324.5	36.6	8.2	143.0	17.5	18.8
Ohio-Tennessee	6.0	200.7	33.4	11.5	221.6	19.3	25.0
New England-Mid Atlantic	1.9	95.6	49.7	2.9	74.4	26.0	6.0
South Atlantic-Gulf	6.7	274.1	40.8	4.1	43.7	10.6	13.2
ALL REGIONS	--	--	--	--	--	--	--

* Does not include estimates for the Western Basins, which are currently not available.
Source: USDA, Preliminary data, CEAP Cropland Assessment

Figure 6-18.

Proportion of potential nitrogen loss reduction through application of comprehensive conservation treatment on cultivated cropland, by treatment need and basin

Each bar in this chart shows the percentage of reduction in total nitrogen loss that could be achieved through comprehensive conservation treatment of the high treatment need acres (blue), moderate treatment need acres (tan), and all other acres of cultivated cropland (green).



* Does not include estimates for the Western Basins, which are currently not available.
Source: USDA, Preliminary data, CEAP Cropland Assessment

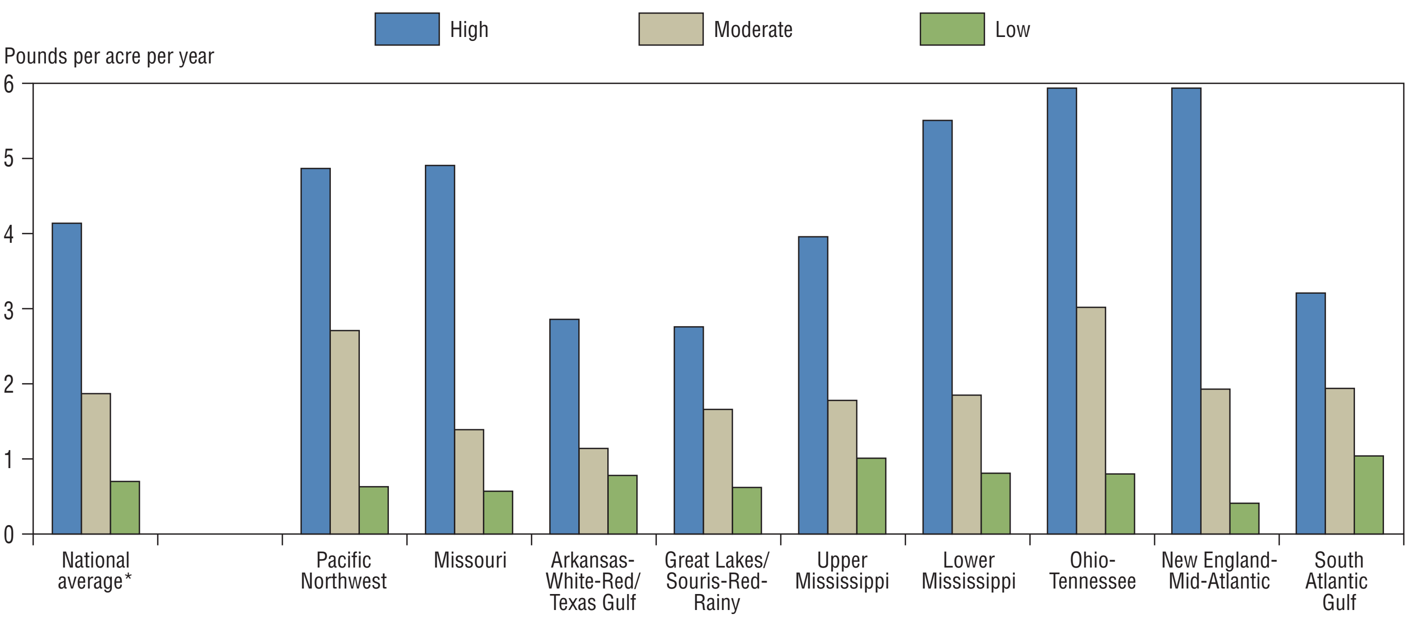
Phosphorus losses. Phosphorus can move beyond the edge of the field in overland flow either in soluble form or attached to soil particles, or in soluble form through subsurface pathways. For the purposes of this assessment, adequate levels of phosphorus loss were estimated to average 4 pounds per acre per year. The comprehensive conservation treatment scenario goes beyond soil loss tolerance (T), using numeric criteria for minimizing field level losses as the planning target. Table 6-3 and figures 6-19 and 6-20 show potential reductions in phosphorus losses for the major river basins and water resource regions in the conterminous United States.

Nationwide, with respect to phosphorus loss—

- The greatest potential total reductions in phosphorus loss from high-treatment-need acres are in the Lower Mississippi (48.8 million pounds), Ohio-Tennessee (35.7 million pounds), Upper Mississippi (35.6 million pounds), and Arkansas-White-Red (34.8 million pounds) basins.
- Applying comprehensive conservation treatment on the high-treatment-need acres in the New England-Mid Atlantic, Ohio-Tennessee, Lower Mississippi, Pacific Northwest, Missouri, and Upper Mississippi regions could reduce phosphorus losses by more than 4 pounds per acre per year.
- In three regions—Lower Mississippi, South Atlantic-Gulf and New England/Mid-Atlantic—applying conservation treatment to the high–treatment-need acres would achieve more than 60 percent of the total potential phosphorus loss reductions.

Figure 6-19.

Potential average annual per-acre phosphorus loss reductions on cultivated cropland through application of comprehensive conservation treatment



* Does not include estimates for the Western Basins, which are currently not available.

Source: USDA, Preliminary data, CEAP Cropland Assessment

Table 6-3.

Potential average annual phosphorus loss reductions from cultivated cropland through application of comprehensive conservation treatment

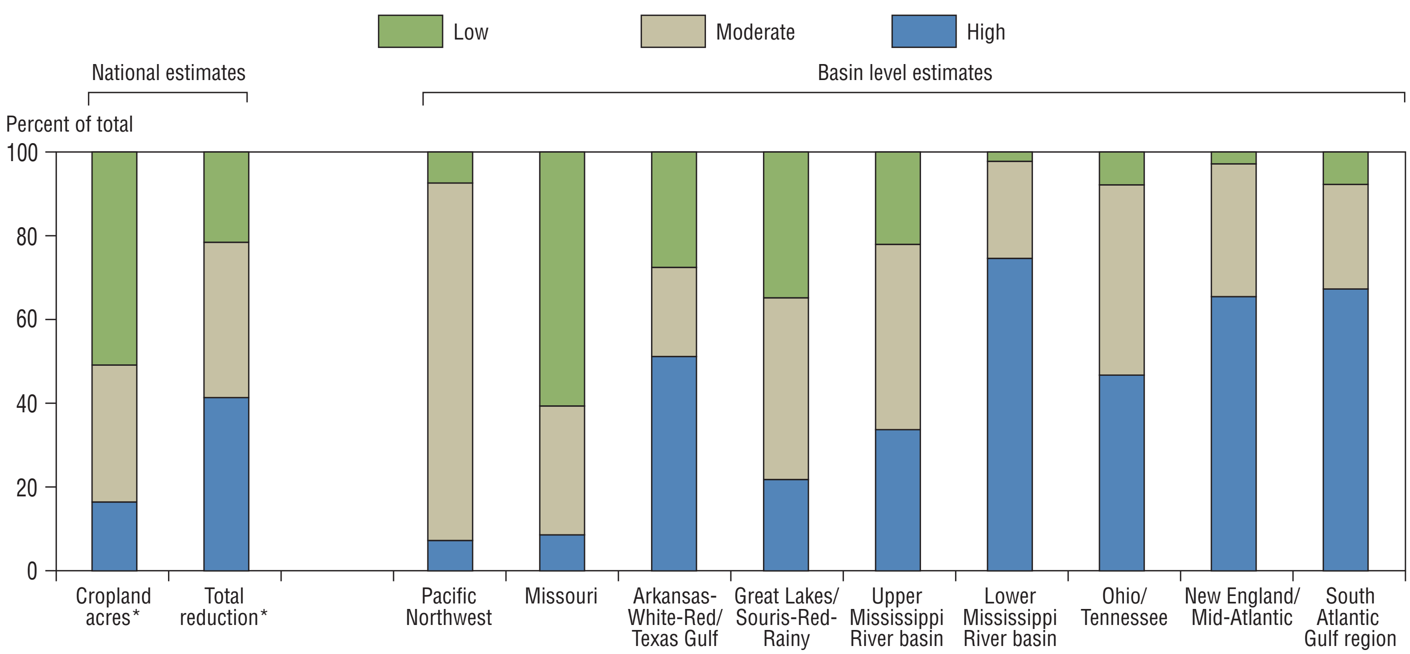
River Basin/ Water Resource Region	Application of comprehensive conservation treatment to–						All cultivated cropland in region
	High treatment need acres			Moderate treatment need acres			
	Area	Average annual reduction		Area	Average annual reduction		
	Million acres	*Million pounds*	*Pounds /acre*	*Million acres*	*Million pounds*	*Pounds/ acre*	*Million acres*
Western	--	--	--	--	--	--	--
Pacific Northwest	0.4	1.9	4.9	8.2	22.2	2.7	11.6
Missouri	1.1	5.5	4.9	14.2	19.8	1.4	83.6
Arkansas-White-Red/Texas Gulf	12.2	34.8	2.9	12.7	14.5	1.1	48.8
Great Lakes/Souris-Red-Rainy	2.8	7.9	2.8	9.4	15.6	1.7	32.4
Upper Mississippi	9.0	35.6	4.0	26.2	46.7	1.8	58.2
Lower Mississippi	8.9	48.8	5.5	8.2	15.1	1.9	18.8
Ohio-Tennessee	6.0	35.7	5.9	11.5	34.7	3.0	25.0
New England-Mid Atlantic	1.9	11.4	5.9	2.9	5.5	1.9	6.0
South Atlantic-Gulf	6.7	21.6	3.2	4.1	8.0	1.9	13.2
ALL REGIONS	--	--	--	--	--	--	

* Does not include estimates for the Western Basins, which are currently not available.
Source: USDA, Preliminary data, CEAP Cropland Assessment

Figure 6-20.

Proportion of potential phosphorus loss reduction through application of comprehensive conservation treatment on cultivated cropland, by treatment need and basin

Each bar in this chart shows the percentage of reduction in total sediment loss that could be achieved through comprehensive conservation treatment of the high treatment need acres (blue), moderate treatment need acres (tan), and all other acres of cultivated cropland (green).



* Does not include estimates for the Western Basins, which are currently not available.
Source: USDA, Preliminary data, CEAP Cropland Assessment

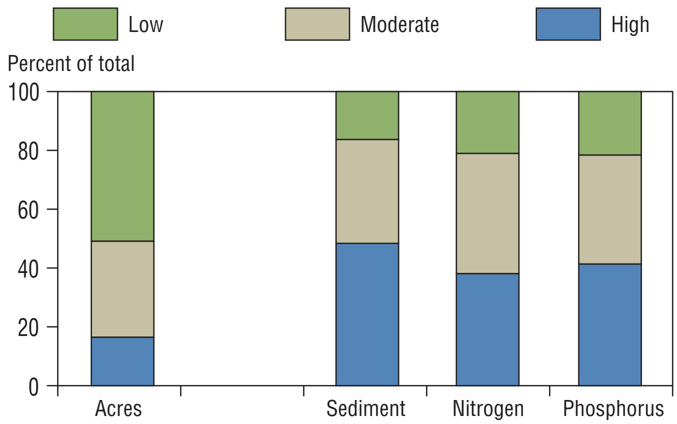
Conclusion

Nationwide, about 51 percent of cropland acres (151 million) have conservation treatment in place for controlling the loss of sediment and nutrients to acceptable levels, and another 33 percent (97 million acres) have moderate conservation treatment needs. Only 16 percent of all cultivated cropland acreage is identified as having high need of conservation treatment to reduce potential material losses from farm fields (fig. 6-21).

Conservation practices have the greatest effect on the more vulnerable acres, such as highly erodible land and soils prone to leaching. Across all basins, focusing on high-treatment-need acres generates a proportionally larger benefit relative to treating every acre (fig. 6-22). High-treatment-need acres account for about 16 percent of cultivated cropland, but with the application of comprehensive conservation treatment could deliver nearly 50 percent of the total potential sediment reductions, and about 40 percent of the potential nitrogen and phosphorus reductions. The comprehensive conservation treatment scenario is not indicative of the treatment required

Figure 6-22.

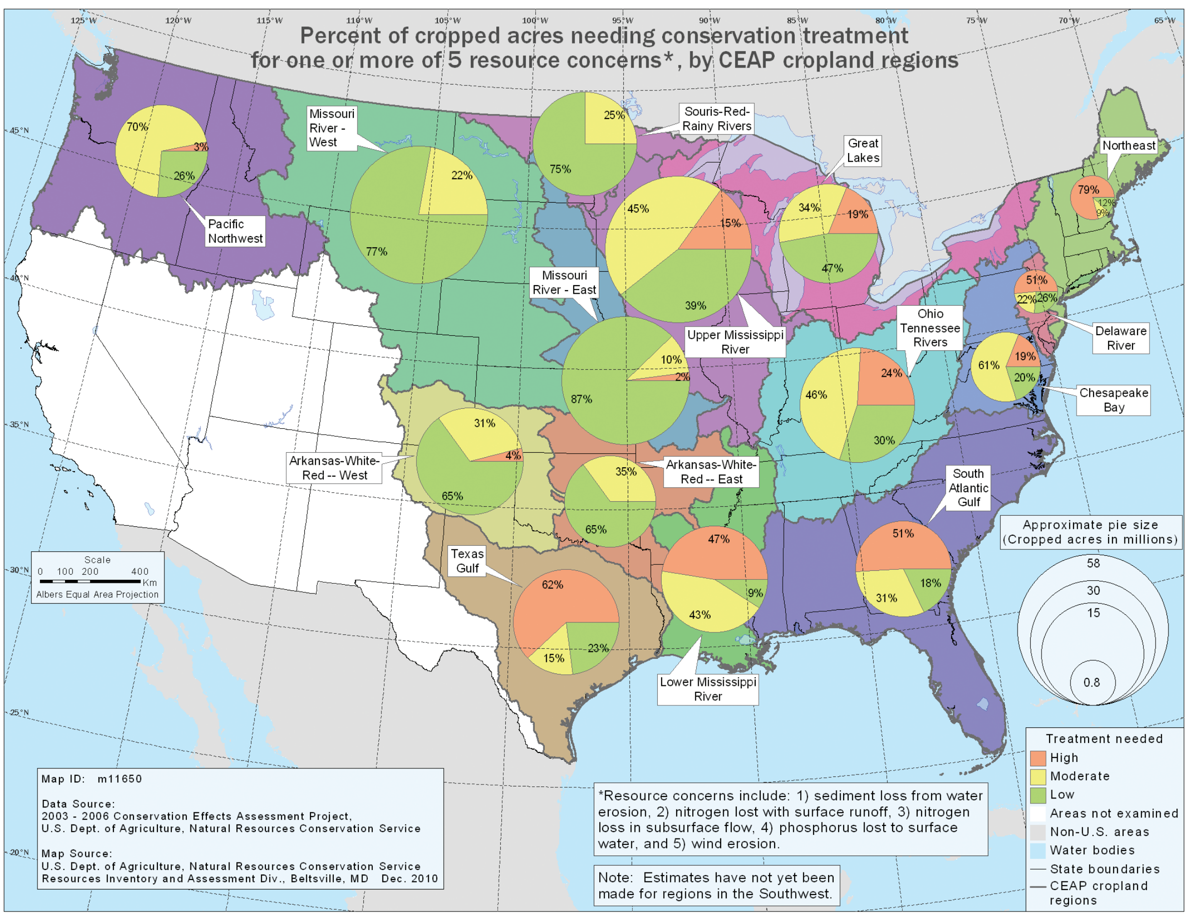
Proportion of potential loss reduction through application of comprehensive conservation management on cultivated cropland, by material and treatment need category



* Does not include estimates for the Western Basins, which are currently not available.
Source: USDA, Preliminary data, CEAP Cropland Assessment

Figure 6-21.

Conservation treatment need on cultivated cropland, by resource concern and treatment need category



* Does not include estimates for the Western Basins, which are currently not available.
Source: USDA, Preliminary data, CEAP Cropland Assessment

to protect water quality, although for some environments it may be suitable for this purpose. While conservation gains also may be achieved on low-treatment-need acres, the more significant gains are made on the under-treated acres.

Focusing on high-treatment-need acres may be efficient, but there are also good reasons to consider wider conservation treatment to address locally important water resource concerns. Applying comprehensive conservation treatment to all under-treated acres could achieve over 80 percent of the potential sediment delivery reductions (or 187 million tons per year), and about 79 and 78 percent of potential nitrogen and phosphorus reductions (3,400 and 385 million pounds), respectively.

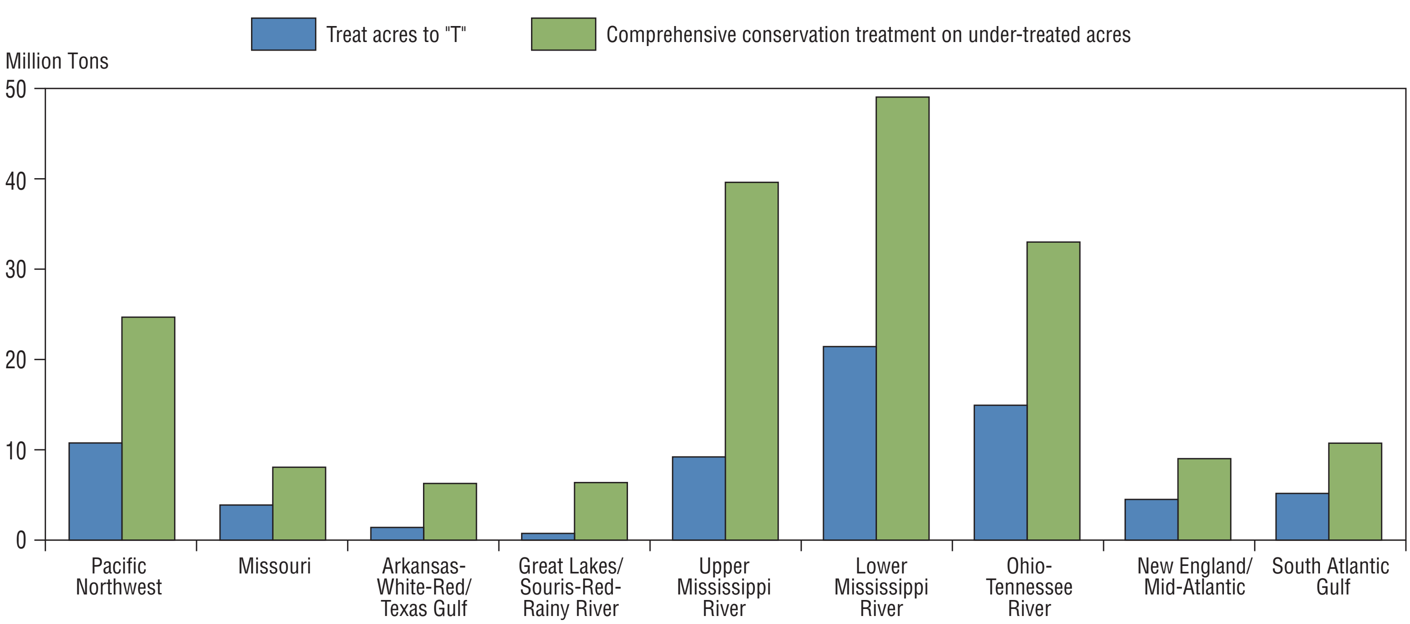
The results presented here indicate that agricultural conservation efforts on cultivated cropland have significant potential for reducing sediment and nutrient losses to surface and groundwater. The estimates are attainable field loss reductions using well-established agricultural and conservation technologies consisting of nutrient management and soil erosion control. The low-treatment-need scenario is used as a threshold to distinguish acreage needing conservation treatment. The comprehensive conservation treatment scenario goes beyond soil loss tolerance (T), using numeric criteria for minimizing field level losses as the planning target. While planning to T has generated significant environmental benefits (see chapter 3), it may not address the broader range of potential material losses from farming operations. Correspondingly, there are significant gains in conservation benefits that result under comprehensive conservation treatment relative to the current "T" threshold. Using sediment loss as an example, figure 6-23 shows the benefits from implementing comprehensive conservation treatment versus the implementation of practices to achieve T.

Nearly every basin has opportunity for potential reductions in irrigation water application. In this preliminary assessment, comprehensive conservation treatment on all irrigated cropland acres could provide an estimated 26-percent improvement in water use that could be used to increase water productivity or other aspects of water conservation. Continuing work is needed to evaluate more completely the potential benefits of improving irrigation water application.

Research will be critical to advancing the next generation of conservation technologies, including tools and methods to identify priority conservation needs, improve assessment of conservation impacts and benefits (e.g., assessment of bio-availability of nutrients), or support potential nutrient credit trading programs. Assessments of conservation needs can be used at multiple scales to focus efforts where they can generate substantial benefits for agriculture, communities, and the environment. However, assessments are not a substitute for local knowledge on conservation needs and outreach to individuals and communities. The longstanding Federal-State-local conservation partnership creates this critical link between local and national priorities in order to improve natural resources.

Figure 6-23.

Potential reductions in sediment losses on cultivated cropland - comparison of potential benefits of treatment to "T" with comprehensive conservation treatment on all under-treated acres, by basin



* Does not include estimates for the Western Basins, which are currently not available.

Source: USDA, Preliminary data, CEAP Cropland Assessment

Focusing conservation programs on local, State, and regional natural resource priorities

Conservation programs are directed toward the most pressing issues at local, State, and regional levels in a variety of ways, from national program priorities and allocation formulas that reflect natural resource uses and concerns among other factors to State- and local-level technical advice and program ranking criteria designed to direct funds toward the priority resource concerns. The Conservation Effects Assessment Project (CEAP) studies on cultivated cropland show that agricultural conservation efforts are addressing identified resource concerns, but that opportunity exists to accelerate progress by focusing on suites of conservation practices and the most vulnerable acres (USDA 2010). USDA is incorporating these lessons through a variety of strategic initiatives, such as the Mississippi River Basin Healthy Watersheds Initiative (MRBI).

From its headwaters in Minnesota to its outlet into the Gulf of Mexico, the Mississippi River travels through 10 States and over 2,300 miles. The Mississippi River Basin covers more than 1.2 million square miles and drains all or parts of 31 States. About 58 percent of the basin is in cropland, and the central part of the basin produces the majority of the Nation's corn, soybean, wheat, cattle, swine, and chickens (Goolsby and Battaglin 2000). Nutrient loading contributes to water quality problems at the local level and in the Gulf of Mexico. While agriculture has accomplished much through conservation measures, more opportunities exist to improve the health of the Mississippi River Basin. The CEAP cropland assessment of the Upper Mississippi River basin shows that conservation practices in place during the period 2003 to 2006 reduced phosphorus losses by 49 percent, nitrogen losses by 18 percent, and sediment losses by 69 percent as compared to conditions expected if conservation practices were not in use (USDA 2010). Yet, substantial gains could be made through improved nutrient management on the under-treated acres in the watershed.

The MRBI, established in 2010, will build on the past efforts of producers, USDA, partners, and other State and Federal agencies in a 13-State area. The effort focuses on 43 priority watersheds (8-digit hydrologic unit code [HUC]), ranging from 250,000 to 1,250,000 acres in size. In selecting priority watersheds, States used a consistent evaluation process that included information from the CEAP assessment; the USGS Spatially Referenced Regression on Watershed (SPARROW) attributes; State-level nutrient reduction strategies and priorities; State-level water quality data; and monitoring and modeling of nitrogen and phosphorous management in the watershed.

Existing conservation programs are being used to implement the MRBI, including partnership programs that leverage non-Federal resources to accelerate addressing conservation objectives in one or more 12-digit HUC subwatersheds within the designated priority watershed focus areas. Partners also have a crucial role in encouraging and supporting producer participation. This includes providing education and outreach activities; providing technical and educational assistance; targeting their own programs toward the priority watersheds; and assisting with monitoring, evaluation, and assessment.

The MRBI emphasizes a "systems approach," as highlighted in the CEAP findings, which recognizes that suites of practices are needed to comprehensively address water quality resource concerns. Twenty-seven core and 43 supporting conservation practices are identified, which are recognized methods for avoiding, trapping and controlling material losses from farm fields. A cornerstone of this approach is screening and ranking applicants to select the most critical acres and the suites of core and supporting conservation practices that will most effectively address agricultural nitrogen and phosphorous losses. Efforts to reduce nitrogen and sediment loadings are complemented by voluntary efforts to improve wildlife habitat and restore wetlands.

A three-tiered monitoring and evaluation approach is designed to assess environmental outcomes at the edge-of-field, instream, and 12-digit HUC levels. The resulting information will be an important element in documenting the progress made through strategic delivery of conservation assistance. Looking ahead, an additional focus will be on competitive opportunities for matching funds to implement innovative projects related to nutrient management, drainage water management, bio-filters, market-based approaches to conservation on a watershed scale, and other high-priority interest areas where field trials and demonstrations are needed.

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Glossary of Terms and Acronyms

Terms used in this report

Agricultural land. Cropland, pastureland, and rangeland.

Baseflow. Groundwater seepage into a stream channel.

Comprehensive conservation treatment. A level of treatment that includes all needed conservation practices to complete a conservation system that would reduce sediment and nutrient losses at the edge of field to established acceptable levels of (1) sediment loss of no more than 2 tons per acre per year, (2) nitrogen runoff of no more than 15 pounds per acre per year, (3) nitrogen leaching of no more than 25 pounds per acre per year, and (4) phosphorus runoff of no more than 4 pounds per acre per year.

Conservation practice. A specific treatment, such as a structural or vegetative measure or management technique commonly used to meet specific needs in planning and conservation, for which standards and specifications have been developed.

Conservation Reserve Program (CRP). The CRP provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. The program is administered by the Farm Service Agency, with the Natural Resources Conservation Service providing technical land eligibility determinations, conservation planning and practice implementation.

Cultivated cropland. A National Resources Inventory (NRI) Land cover/use category of land in *row crops* or *close-grown crops* and other cultivated cropland, for example, hayland or pastureland that is in a rotation with row crops or close-grown crops.

Erosion. The wearing away of the land surface by running water, waves, or moving ice and wind, or by such processes as mass wasting and corrosion (solution and other chemical processes). The term "geologic erosion" refers to natural erosion processes occurring over long (geologic) time spans. "Accelerated erosion" generically refers to erosion that exceeds what is presumed or estimated to be naturally occurring levels, and which is a direct result of human activities (e.g., cultivation and logging). See also "Sheet and rill erosion."

Estuarine wetlands. Wetlands occurring in the Estuarine System, one of five systems in the classification of wetlands and deepwater habitats (see Wetlands, Cowardin et al. 1979). Estuarine wetlands are tidal wetlands that are usually semienclosed by land but have open, partly obstructed or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land. The most common example is where a river flows into the ocean. (Cowardin, L.M., V. Carter, F.C. Golet, E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. U.S. Department of the Interior, Fish and Wildlife Service.)

Federal land. A land ownership category designating land that is owned by the Federal Government. It does not include, for example, trust lands administered by the Bureau of Indian Affairs or Tennessee Valley Authority (TVA) land. For the NRI, no data are collected for any year that land is in this ownership.

Forest land. A National Resources Inventory (NRI) Land cover/use category that is at least 10 percent stocked by single-stemmed woody species of any size that will be at least 4 meters (13 feet) tall at maturity. Also included is land bearing evidence of natural regeneration of tree cover (cut over forest or abandoned farmland) and not currently developed for nonforest use. Ten percent stocked, when viewed from a vertical direction, equates to an areal canopy cover of leaves and branches of 25 percent or greater. The minimum area for classification as forest land is 1 acre, and the area must be at least 100 feet wide.

Grazing lands. See "Pastureland" and "Rangeland."

Irrigated land. Land that shows evidence of being irrigated during the year of the inventory or of having been irrigated during 2 or more of the last 4 years. Water is supplied to crops by ditches, pipes, or other conduits. For the purposes of the NRI, *water spreading* is not considered irrigation.

National Resources Inventory (NRI). The National Resources Inventory (NRI) is a statistical survey of natural resource conditions and trends on non-Federal land in the United States. It is conducted by USDA's Natural Resources Conservation Service in cooperation with Iowa State University's Center for Survey Statistics and Methodology.

Noncultivated cropland. A National Resources Inventory (NRI) Land cover/use category that includes permanent hayland and horticultural cropland. *Hayland* is land that is managed for the production of forage crops that are machine harvested. The crop may be grasses, legumes, or a combination of both. Hayland also includes land in setaside or other short-term agricultural programs. *Horticultural cropland* is land that is used for growing fruit, nut, berry, vineyard, and other bush fruit and similar crops. Nurseries and other ornamental plantings are included.

Palustrine wetlands. Wetlands occurring in the Palustrine System, one of five systems in the classification of wetlands and deepwater habitats (see Wetlands, Cowardin et al. 1979). Palustrine wetlands include all nontidal wetlands dominated by trees, shrubs, persistent emergent plants, or emergent mosses or lichens, as well as small, shallow open water ponds or potholes. Palustrine wetlands are often called swamps, marshes, potholes, bogs, or fens. (Cowardin, L.M., V. Carter, F.C. Golet, E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. U.S. Department of the Interior, Fish and Wildlife Service.)

Pastureland. A National Resources Inventory (NRI) Land cover/use category of land managed primarily for the production of introduced forage plants for livestock grazing. Pastureland cover may consist of a single species in a pure stand, a grass mixture, or a grass-legume mixture. Management usually consists of cultural treatments: fertilization, weed control, reseeding or renovation, and control of grazing. For the NRI, includes land that has a vegetative cover of grasses, legumes, and/or forbs, regardless of whether or not it is being grazed by livestock.

Prime farmland. Land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is also available for these uses.

Rangeland. A National Resources Inventory (NRI) Land cover/use category on which the climax or potential plant cover is composed principally of native grasses, grasslike plants, forbs or shrubs suitable for grazing and browsing, and introduced forage species that are managed like rangeland. This would include areas where introduced hardy and persistent grasses, such as crested wheatgrass, are planted and such practices as deferred grazing, burning, chaining, and rotational grazing are used, with little or no chemicals or fertilizer being applied. Grasslands, savannas, many wetlands, some deserts, and tundra are considered to be rangeland. Certain communities of low forbs and shrubs, such as mesquite, chaparral, mountain shrub, and pinyon-juniper, are also included as rangeland.

Sheet and rill erosion. The removal of layers of soil from the land surface by the action of rainfall and runoff. It is the first stage in water erosion. See also "Erosion."

Soil loss tolerance factor (T factor). The maximum rate of annual soil loss that will permit crop productivity to be sustained economically and indefinitely on a given soil.

T factor. See "Soil loss tolerance factor."

Wetlands. Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year. (Cowardin, L.M., V. Carter, F.C. Golet, E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. U.S. Department of the Interior, Fish and Wildlife Service.)

Wetlands Reserve Program (WRP). The WRP is a voluntary program offering landowners the opportunity to protect, restore, and enhance wetlands on their property. The USDA Natural Resources Conservation Service (NRCS) provides technical and financial support to help landowners with their wetland restoration efforts. The NRCS goal is to achieve the greatest wetland functions and values, along with optimum wildlife habitat, on every acre enrolled in the program.

Wind erosion. The process of detachment, transport, and deposition of soil by wind. See also "Erosion."

Acronyms and abbreviations used in this report

AFRI	Agriculture and Food Research Initiative
ARS	Agricultural Research Service, an agency of the U.S. Department of Agriculture
Bt	*Bacillus thuringiensis*
CAFO	Concentrated Animal Feeding Operation
CEAP	Conservation Effects Assessment Project
CCRP	Continuous Conservation Reserve Program
CCSP	Climate Change Science Program
COMET-VR	Carbon Management Evaluation Tool – Voluntary Reporting of Greenhouse Gases
CNI	Conservation Needs Inventory
CRP	Conservation Reserve Program
DOE	U.S. Department of Energy
EIA	U.S. Energy Information Administration
EISA	Energy Independence and Security Act
EQIP	Environmental Quality Incentives Program
ERS	Economic Research Service, an agency of the U.S. Department of Agriculture
ESA	Endangered Species Act
FHM	Forest Health Monitoring program
FSA	Farm Service Agency, an agency of the U.S. Department of Agriculture
FWS	Fish and Wildlife Service, an agency of the U.S. Department of the Interior
GAO	Government Accountability Office
GLRI	Great Lakes Regional Initiative
GRACEnet	Greenhouse Gas Reduction through Agricultural Carbon Enhancement Network
ICCATF	Interagency Climate Change Adaptation Task Force
IPCC	Intergovernmental Panel on Climate Change
MLRA	Major Land Resource Area
NASS	National Agricultural Statistics Service, an agency of the U.S. Department of Agriculture
NIFA	National Institute of Food and Agriculture, an agency of the U.S. Department of Agriculture
NRCS	Natural Resources Conservation Service, an agency of the U.S. Department of Agriculture
NRI	National Resources Inventory
PET	Potential Evapotranspiration
RCA	Soil and Water Resources Conservation Act of 1977
RC&D	Resource Conservation and Development
RD	Rural Development, an agency of the U.S. Department of Agriculture
RPA	Forest and Rangeland Renewable Resources Planning Act
UMRB	Upper Mississippi River Basin
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
USEPA (or EPA)	U.S. Environmental Protection Agency
USFS	U.S. Forest Service, an agency of the U.S. Department of Agriculture
USGCRP	United States Global Change Research Program
USGS	U.S. Geological Survey, an agency of the U.S. Department of the Interior
WAOB	World Agricultural Outlook Board
WHIP	Wildlife Habitat Incentive Program
WRP	Wetlands Reserve Program