The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

United States
Department of
Agriculture

Economic
Research
Service

Economic
Information
Bulletin
Number 98

August 2012

Agricultural Resources and Environmental Indicators, 2012 Edition

Craig Osteen, Jessica Gottlieb, and Utpal Vasavada, editors

Economic Research Service
www.ers.usda.gov
Follow us on twitter at http://twitter.com/USDA_ERS

Access this report online:

www.ers.usda.gov/Publications/eib- economic-information-bulletin/eib98.aspx

Download the charts contained in this report:

- Go to the report's index page www.ers.usda.gov/publications/eib- economic-information-bulletin/eib98.aspx
- Click on the bulleted item "Download EIBeib98.zip"
- Open the chart you want, then save it to your computer

Recommended citation format for this publication:

Osteen, Craig, Jessica Gottlieb, and Utpal Vasavada (eds.), *Agricultural Resources and Environmental Indicators, 2012.* EIB-98, U.S. Department of Agriculture, Economic Research Service, August 2012.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and, where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

To file a complaint of discrimination write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Agricultural Resources and Environmental Indicators, 2012

Abstract

Agricultural Resources and Environmental Indicators, 2012, describes trends in economic, structural, resource, and environmental indicators in the agriculture sector, focusing on changes since the release of *Agricultural Resources and Environmental Indicators, 2006*. These indicators are useful to assess important changes in U.S. agriculture—the industry's development; its environmental effects; and the implications for economic, social, and environmental sustainability. This report tracks key resources, including natural, produced, and management resources, that are used in and affected by agricultural production, as well as structural changes in farm production and the economic conditions and policies that influence agricultural resource use and its environmental impacts. Each chapter provides a concise overview of a specific topic with links to sources of additional information.

Authors

Craig Osteen, Jessica Gottlieb, and Utpal Vasavada, editors; Marcel Aillery, Eldon Ball, Jayson Beckman, Allison Borchers, Roger Claassen, Kelly Day-Rubenstein, Robert Ebel, Jorge Fernandez-Cornejo, Catherine Greene, Paul Heisey, Daniel Hellerstein, Robert Hoppe, Wen Huang, Todd Kuethe, Michael Livingston, Cynthia Nickerson, Craig Osteen, Marc Ribaudo, Glenn Schaible, and Sun Ling Wang.

Keywords: Agricultural biotechnology, conservation policy, conservation programs, farm types, fertilizer use, land use, land values, organic production, pest management, productivity, research and development, soil management, water use.

Contents

Preface

Agricultural Resources and Environmental Indicators (AREI), 2012 Edition updates the AREI, 2006 Edition and describes recent trends in economic, structural, resource, and environmental indicators that are useful to assess important changes in U.S. agriculture, its development and environmental effects, and the implications for sustainability. *AREI, 2012 Edition* describes programs and policies that affect resource use, conservation, and environmental quality in agriculture. Each chapter provides a concise overview of one or more specific indicators with links to sources of additional information. Taken as a whole, the *AREI* provides a snapshot summary of the nexus between policies, production, and natural resource and environmental concerns in U.S. agriculture. Four previous versions of the *AREI* (1994, 1997, 2003, and 2006) are available on the ERS website.

Summary

Agricultural production depends on endowments such as knowledge, production technologies, and management skills, and it influences a wide range of natural resources, including land, water, and genetic material. Agricultural resource use depends on the decisions made by the operators of the Nation's 2.2 million farms, which are shaped, in turn, by market conditions, public policies, and the specific characteristics of individual farms and households. When making these decisions, farm operators have clear incentives to consider their own and their households' well-being, but incentives to consider more distant impacts are weaker.

What Is the Issue?

A new focus on social, economic, and environmental sustainability has increased demand for indepth information on agricultural production methods, their social and environmental effects, and ways to measure them. Consumers are now concerned not just with the cost of food, but also with long-term impacts on the environment and agricultural workers. However, there are no product- or process-based standards that regulate sustainable agricultural systems throughout the supply chain. Concise and accurate information about the current state of, and complex interactions between, public policies, economic conditions, farming practices, conservation, resources, and the environment can assist public and private decisionmaking.

What Did the Study Find?

Agricultural Resources and Environmental Indicators (AREI), 2012 discusses important economic, technology, policy, resource use, input use, and land management changes. Some changes can enhance while others degrade economic, social, or environmental sustainability. Notable findings include:

- Census data show that the **number of U.S. farms** varied between 2.1 and 2.2 million since 1992. In 2009, small farms made up 88 percent of all U.S. farms, but large-scale family and nonfamily farms accounted for more than 80 percent of the total value of production.

- In 2007, about 51 percent of the **2.3 billion acres in the United States was used for agricultural purposes**, including cropping, grazing (in pasture, range, and forests), and farmsteads and farm roads. Total cropland acreage in 2007 reached its lowest level since the Major Land Use series began in 1945. Over 1959-2007, forest-use land and grassland, pasture, and range also decreased, while land in special uses (primarily recreation areas, transportation, and national defense) and urban areas increased.

- From 2000 to 2010, national aggregate **farm real estate values** appreciated faster than residential values. Traditionally, farmland values were driven largely by the returns from agricultural activities, but today in some regions farmland values are influenced by factors such as urban influence and income from hunting leases. As a result, cropland values in these regions greatly exceed their implied agricultural use value.

- From 1948 to 2009, agricultural output grew 1.63 percent per year while aggregate input use increased only 0.11 percent annually, so positive growth in the farm sector was mainly due to **productivity growth** (1.52 percent per year).

- Total **agricultural research and development (R&D)** funding generally increased since 2000; private sector funding grew to exceed that of the public sector, which grew slowly and sporadically until 2006 before declining. Private sector R&D tends to emphasize marketable

goods, while public sector R&D tends to emphasize public goods like environmental protection, nutrition, and food safety.

- Corn, cotton, and soybean growers have widely adopted **genetically engineered herbicide-tolerant and insect-resistant seeds** since 1996. Despite higher prices for genetically engineered seed than for conventional seeds, U.S. farmers are realizing economic benefits from increased crop yields, lower pesticide costs, and/or management time savings.

- Real expenditures (2010 US$) and quantities for **pesticide** active ingredients declined an average 2.4 percent and 1.4 percent, respectively, per year during 1996-2007, even though expenditures and quantities applied increased from 2006 to 2007. However, herbicide use increased, and increasing glyphosate use on herbicide-tolerant crops and reduced diversity of weed management practices are associated with increased weed resistance.

- Commercial **fertilizer consumption** fell from 23 million short tons in 2004 to 21 million short tons in 2010, with high fertilizer prices contributing to the decline. Since 2004, nitrogen recovery rates (amount removed by harvested crop/amount applied) on corn and cotton have increased, and the shares of planted acreage where application rates exceed 125 percent of the crop's agronomic need have decreased. Phosphate recovery rates are relatively unchanged for corn and cotton. Mining phosphate in soybean plantings increased.

- In recent decades, onfarm **irrigation** efficiency—the share of applied water that is beneficially used by the crop—has increased: from 1984 to 2008, total irrigated acres in the West increased by 2.1 million acres, while water applied declined by nearly 100,000 acre-feet, reflecting improved water-use efficiency, as well as changes in irrigated acreage and regional cropping patterns.

- Since 2000, corn, cotton, soybean, and wheat acreage under **conservation tillage** (mulch, ridge, and no till) has increased, which may reduce soil erosion and water pollution but increase pest management costs. Over that same time, continuous corn and corn-inclusive rotations increased and continuous soybeans decreased due to higher corn prices, with uncertain effects on erosion and water pollution. **Erosion control structures and conservation buffers** are more widely used on highly erodible land than on other land, but overall, structures were more widely used and buffers less widely used on cotton and wheat than on corn and soybeans.

- From 2004 to 2011, **organic food sales** more than doubled from $11 billion to $25 billion, accounting for over 3.5 percent of food sales in 2011. In 2008, growers practiced certified organic production on less than 1 percent of U.S. cropland and pasture/rangeland, but the percentage is higher for fruit/vegetable crops and for dairy production.

- Federal funding for voluntary programs that encourage **land retirement and adoption of conservation practices** on working lands was $5.5 billion in 2010, higher than at any time since 1960 (when expressed in 2010 dollars); funding increased nearly tenfold for working-land conservation from 2003 to 2010. Enrollment in the Conservation Reserve Program (CRP) peaked at 36.8 million acres in 2007, but the 2008 Farm Act cut maximum enrollment to 32 million acres and high crop returns have discouraged new CRP bids, so 29 million acres were under 10- to 15-year contracts as of June 2012. Goals of the CRP include soil conservation, improved water and air quality, and enhanced wildlife habitat. Total 2008-12 authorized funding for the Environmental Quality Incentive Program is $7.25 billion; 60 percent is targeted for resource concerns in poultry and livestock production.

Farm Resources and Land Use

Farm Numbers and Size

Robert A. Hoppe

Farm Numbers Stabilize

After peaking at 6.8 million farms in 1935, the number of U.S. farms fell sharply until the early 1970s (fig. 1.1.1). Falling farm numbers during this period reflect growing productivity in agriculture and increased nonfarm employment opportunities. Growing productivity led to excess capacity in agriculture, farm consolidation, and the exit of farm operators to work in the nonfarm economy. The decline in farm numbers slowed in the 1980s and halted in the 1990s, reflecting increases in the number of very small farms whose operators do not depend on farming for their livelihood. By 2007, there were about 2.2 million farms.

Because the amount of farmland did not decrease as much as the number of farms, farms today have more acreage, on average. Farms averaged 418 acres in 2007, compared with 155 acres in 1935. But averages can be deceiving because of the diversity of today's farms. Farms range from very small retirement and residential farms to large operations with sales in the millions of dollars. Part of this diversity stems from the low sales threshold ($1,000) necessary for an operation to qualify as a farm.

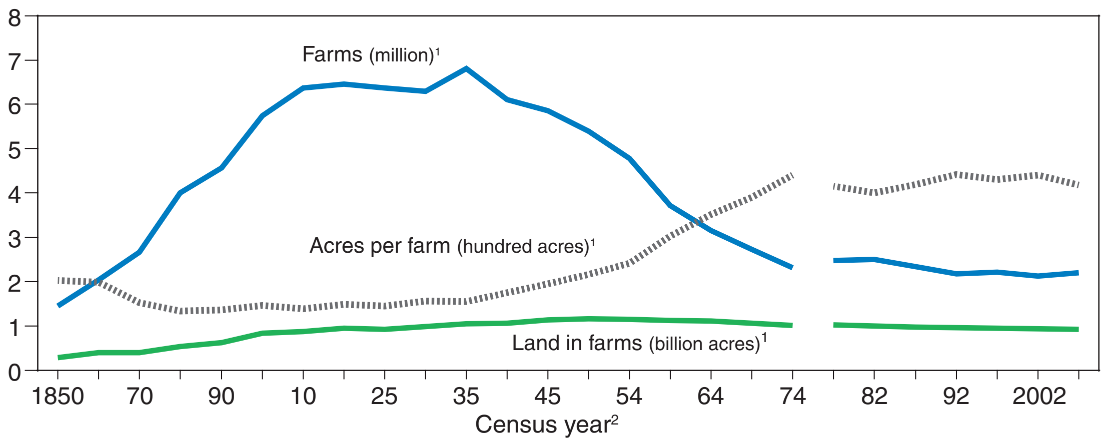
Farm Diversity—Classifying Small and Large Farms

One way to view the diversity of farms is to categorize them into more homogeneous groups. A farm classification developed by USDA's Economic Research Service identifies four groups of small family farms (annual sales less than $250,000): retirement, residential/lifestyle, farming-

Figure 1.1.1

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

Most of the decline in the farm count occurred between 1935 and 1974



[1]The break in the lines after 1974 reflects the introduction of an adjustment to estimates of the farm count and land in farms. Beginning in 1978, the data are adjusted to compensate for undercoverage by the census of agriculture.
[2]Census years are shown for 10-year intervals from 1850 to 1920, with 4- or 5-year intervals starting in 1925.
Source: USDA, ERS, based on census of agriculture data.

occupation/low-sales, and farming-occupation/medium-sales (see box, "Farm Types"). The classification also identifies large family farms, very large family farms, and nonfamily farms.

Small farms dominate the farm count, making up 88 percent of all U.S. farms in 2009 (table 1.1.1). Production, however, is concentrated among large-scale family farms (large and very large family farms) as well as nonfamily farms, which together account for more than 80 percent of the value of production. Very large family farms (annual sales above $500,000) alone accounted for 56 percent of U.S. farm production in 2009.

Implications of Farm Size for Government Programs

Medium-sales small farms, large family farms, and very large family farms receive a disproportionate share of commodity program payments relative to their 15-percent share of farms. Receipt of commodity program payments depends on past or current production of specific commodities covered by farm programs. Since these farms harvest about four-fifths of the land in program commodities (largely food and feed grains, oilseeds, and cotton), they receive a similar share of commodity program payments.

However, land-retirement programs—the Conservation Reserve Program, Conservation Reserve Enhancement Program, and Wetlands Reserve Program—are targeted at environmentally sensitive land, not the production of commodities. Since small farms account for 62 percent of the land owned by farms, they play a large role in natural resource and environmental policy.

Retirement, residential/lifestyle, and low-sales farms together received 69 percent of land-retirement payments in 2009. Participating farmers in each of the three groups tend to enroll large shares of their land in these programs: 52 percent of the land operated for retirement farms, 38 percent for residential/lifestyle farms, and 25 percent for low-sales farms. In contrast, enrollment ranges from 5 to 12 percent for participating high-sales, large, and very large farms.

Farm Types

The farm classification developed by ERS focuses on the "family farm," or any farm where the majority of the business is owned by the operator and individuals related to the operator, including relatives who do not live in the operator's household. The 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.

Small family farms (gross sales less than $250,000)	**Large-scale family farms** (gross sales of $250,000 or more)
Retirement farms. Small farms whose operators report 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 family farms whose operators report farming as their major occupation. • **Low-sales farms.** Gross sales less than $100,000. • **Medium-sales farms.** 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** **Nonfamily farms.** Any farm where the operator and persons related to the operator do not own a majority of the business.

Table 1.1.1

Distribution of farms, production, land, and Government payments by type of farm, 2009

Type of farm	Farms	Value of production	Farmland owned[1]	Type of Government payment: Commodity[2]	Land retirement[3]	Working-land[4]	Total payments
	Percent of U.S. total						
Small family farms:							
Retirement	20.0	1.7	12.7	3.5	33.7	5.2	9.3
Residential/lifestyle	41.3	4.2	17.5	6.2	21.0	10.6	9.3
Farming-occupation:							
Low sales	21.3	4.3	19.3	7.0	14.7	8.6	8.6
Medium sales	5.0	6.8	12.2	11.9	6.4	8.7	10.6
Large-scale farms:							
Large family farms	4.3	12.3	12.9	20.1	5.8	16.0	17.1
Very large family farms	5.2	56.4	14.7	46.2	8.7	42.9	38.9
Nonfamily farms	2.8	14.3	10.7	5.1	9.6	8.1	6.2
All farms	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1]Includes land owned by the farm. Excludes land owned by nonfarm landlords.
[2]Includes direct payments, countercyclical payments, loan deficiency payments, marketing loan gains, net value of commodity certificates, disaster payments, and Milk Income Loss Contract payments.
[3]Include the Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), and Wetlands Reserve Program (WRP).
[4]Includes the Environmental Quality Incentive Program (EQIP), Conservation Security Program (CSP), and Conservation Stewardship Program (CStP).

Source: USDA, National Agricultural Statistics Service and Economic Research Service, 2009 Agricultural Resource Management Survey, Phase III.

Because their main job is off-farm, residential/lifestyle operators are limited in the amount of time they can spend farming. As a result, residential/lifestyle farmers find land-retirement programs attractive, since participation in these programs requires little time. Given their life-cycle position, many retired farmers have land available to put into conservation uses. The same forces may also be acting on low-sales operators, who average 59 years of age and may be scaling down their operations.

Working-land programs provide technical and financial assistance to farmers using conservation practices on land in production. The distribution of working-land payments between small and large-scale family farms is similar to that of commodity program payments, with roughly three-fifths of the payments going to large-scale farms.

References

Hoppe, Robert A., and David E. Banker. 2010. *Structure and Finances of U.S. Farms: Family Farm Report, 2010 Edition*, EIB-66, U.S. Dept. of Agriculture, Economic Research Service, July. http://www.ers.usda.gov/publications/eib-economic-information-bulletin/eib66.aspx

Hoppe, Robert A., James M. MacDonald, and Penni Korb. 2010. *Small Farms in the United States: Persistence Under Pressure*, EIB-63, U.S. Dept. of Agriculture, Economic Research Service, Feb. http://www.ers.usda.gov/publications/eib-economic-information-bulletin/eib63.aspx

Farm Resources and Land Use

Major Land Uses in the United States

Cynthia Nickerson

The U.S. land area totals nearly 2.3 billion acres. In 2007, forest uses accounted for the largest share of land use (671 million acres, 30 percent), followed by grassland pasture and range (614 million acres, 27 percent); cropland (408 million acres, 18 percent); special uses including recreation areas, transportation, national defense, and farmsteads (313 million acres, 14 percent); miscellaneous other uses (197 million acres, 9 percent); and urban land (61 million acres, 3 percent). About 51 percent of the land base is used for agricultural purposes, including cropping, grazing (in pasture, range, and forests), and farmsteads/farm roads.

Land Uses Vary by Region and Over Time

Since ERS' Major Land Uses (MLU) series began in 1945, forest uses of land have accounted for the largest share of the Nation's land base, due to extensive forests in Alaska. In the conterminous 48 States, grassland pasture and range represents the largest share of the land base. Land-use patterns vary greatly by region, reflecting differences in soils, climate, topography, population, and the relative profitability of having land in a particular use. For example, cropland accounts for 54 percent of all land in the Corn Belt but only 12 percent in the Northeast (fig. 1.2.1). Similarly, variation exists among States within a region. Almost two-thirds of North Dakota is cropland, versus 41 percent in South Dakota. State-level estimates are available in the ERS Major Land Uses data product (http://www.ers.usda.gov/data-products/major-land-uses.aspx).

Land shifts in and out of uses for a variety of reasons. Changing commodity and timber prices, agricultural and natural resource policies and, more recently, bioenergy policies prompt private landowners to shift land to uses that maximize returns to land. Land near urban areas is also subject to residential, commercial, and industrial development pressure; however, once converted to an urban use, land rarely transitions back to less intensive agricultural or forestry uses.

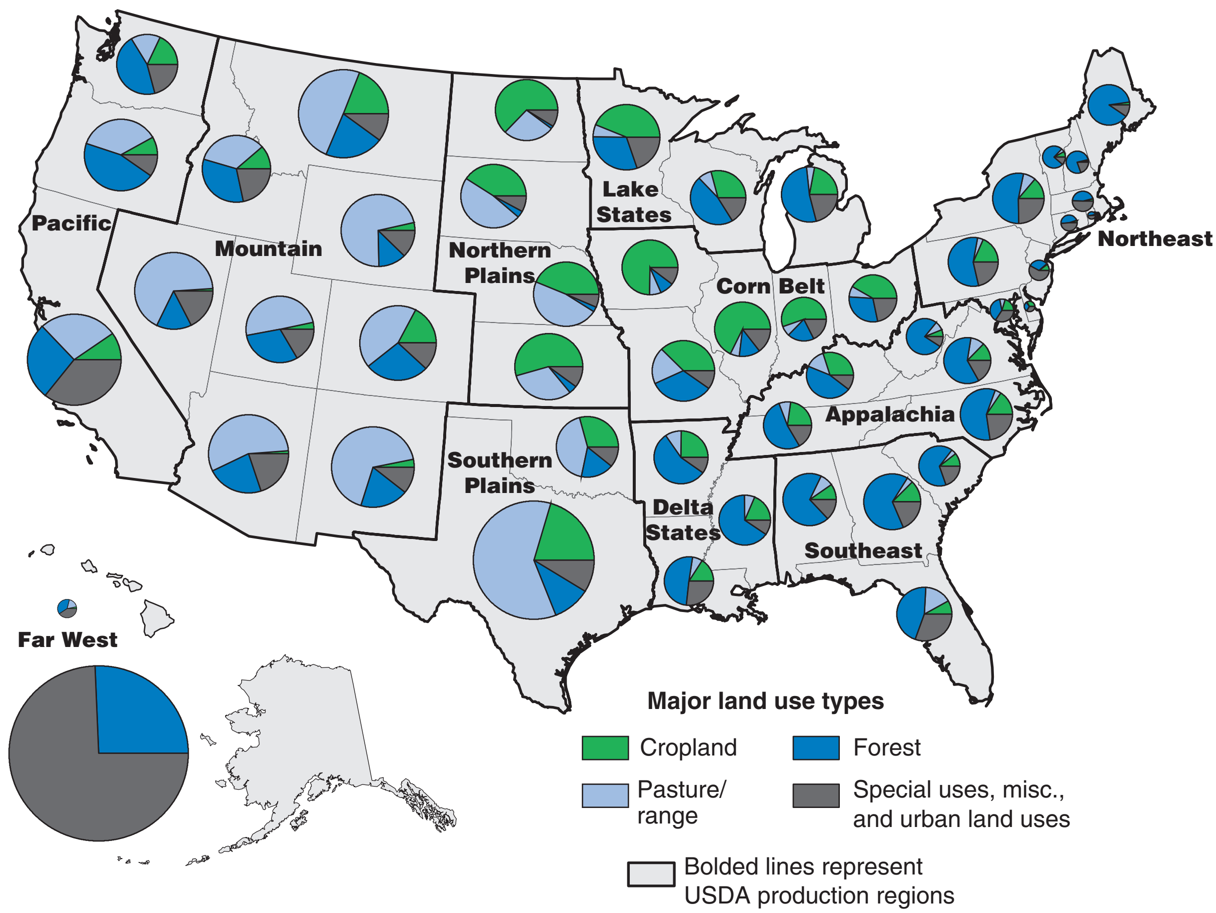
Total cropland area, forest-use land, and grassland pasture and range declined nearly 11, 8, and 3 percent, respectively, over 1959-2007, whereas land in special uses and in urban uses increased (fig. 1.2.2). Trends vary by region, however. For example, while cropland used for crops (the dominant component of total cropland) increased in the Corn Belt over the last five decades, both the Northeast and Southeast have experienced a long-term decline in cropland due to urban pressures and a comparative disadvantage in many crops.

In 2007, total cropland area—which includes cropland used for crops, idled cropland, and cropland used for pasture—reached its lowest level since the MLU series began in 1945 (fig. 1.2.3). Significant changes in cropland used for crops during this period were largely the result of large swings in production levels and in land idled under Federal acreage reduction programs.

While land use changes occur annually, most land tends to remain in the same land use category from year to year. USDA's National Resources Inventory data reveal that over 2002-07, 96-99 percent of privately owned crop, pasture/range, and forest land remained in its pre-existing use. Over 1982-2007, 78, 86, and 92 percent of cropland, pasture/range, and forest land, respectively, remained in those uses.

Figure 1.2.1

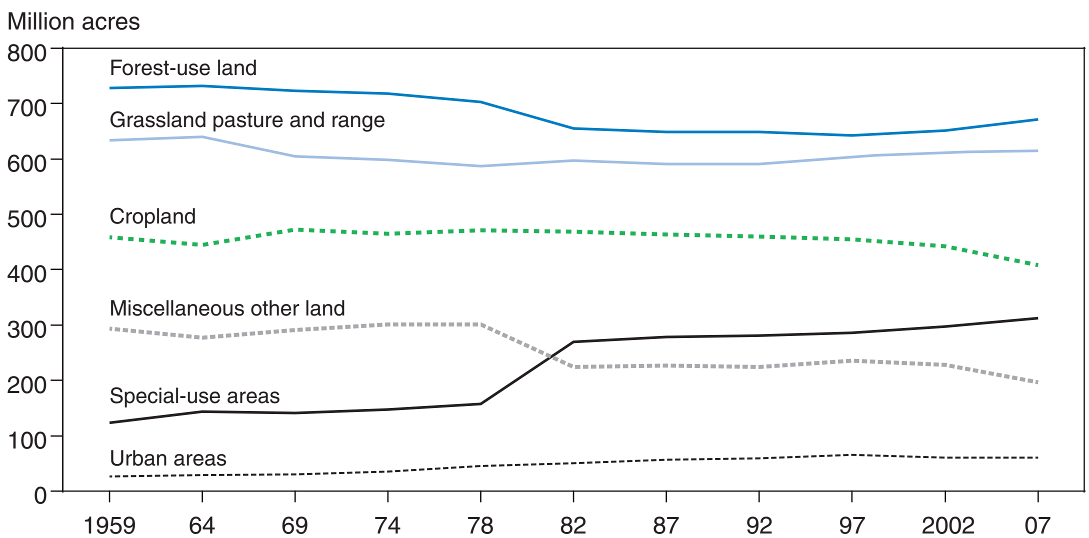
Major land use shares by State, 2007



Source: See sources in Nickerson et al., 2011.

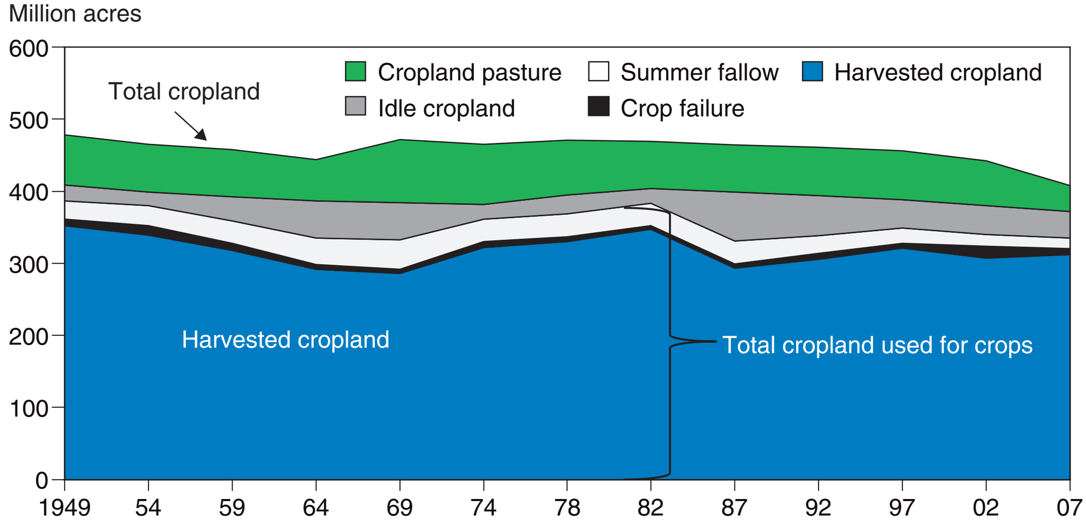
Figure 1.2.2

Major uses of U.S. land, 1959-2007



Source: See sources in Nickerson et al., 2011.

Figure 1.2.3
Major uses of U.S. cropland, 1949-2007



Source: See sources in Nickerson et al., 2011.

Even when cropland acreage appears relatively constant, the mix of crops produced changes in response to market forces and policy changes. Historically high prices for corn in recent years have contributed to significant increases in land planted to corn, which—at 92.6 million acres in 2007—was at its highest level in more than 44 years. During this same timespan (1963-2007), soybeans and wheat increased to 64.1 and 51.0 million harvested acres (up 124 percent and 5 percent), while oats declined from 21.3 to 1.5 million acres and sorghum declined from 17 to 7.2 million acres. At 10.4 million acres in 2007, cotton acreage was at its lowest level since 1963.

References

Nickerson, Cynthia, Robert Ebel, Allison Borchers, and Fernando Carriazo. 2011. *Major Uses of Land in the United States, 2007*, EIB-89, U.S. Department of Agriculture, Economic Research Service.

Nickerson, Cynthia. ERS Data Sets on Major Land Uses. Available at: http://www.ers.usda.gov/data-products/major-land-uses.aspx

For more information, see…

U.S. Department of Agriculture, Economic Research Service. 2011. *"Land Use, Land Value & Tenure," http://www.ers.usda.gov/topics/farm-economy/land-use,-land-value-tenure.aspx*.

Farm Resources and Land Use

Farm Real Estate Values and Cash Rent

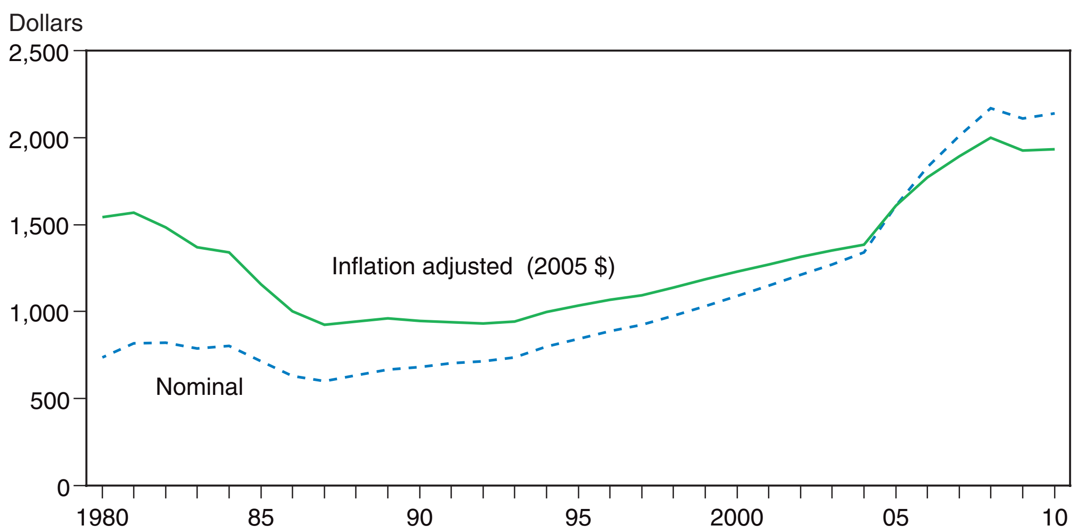
Allison Borchers and Todd Kuethe

Farm real estate (all agricultural land and buildings) accounts for the largest share of total farm assets, at roughly 84 percent in 2009. Farm real estate values underpin the financial health of farm operations and support farm household and community financial well-being. Therefore, prevailing farm real estate values play an important role in agricultural policy related to farm income and finance, farmland conservation, program payments, and farm ownership and tenure. Farm real estate values have increased consistently following the 1980s farm crisis and have exhibited above-average growth in recent years (fig. 1.3.1). From 2000 to 2010, national aggregate farm real estate values appreciated at an average of 7 percent annually (4.7 percent in inflation-adjusted terms). In contrast, residential real estate values appreciated 3.2 percent annually over the same period, according to the Federal Housing Finance Administration's housing price index. Residential prices famously declined at an average annual rate of 4.4 percent from 2007 to 2010, while farm real estate values continued to increase at an annual rate of 2.4 percent.

Farm Real Estate Values Exhibit Regional Variation

Regional variation in farmland values is significant, owing to general economic conditions, the health of the local farm economy, public policy, and location-specific characteristics. In the Northeast, 2010 farm real estate values were over twice the national average, whereas values in the Mountain region were less than half the national average (table 1.3.1). High farm real estate values in the Pacific States and Corn Belt are partly a reflection of high-value specialty crops and favorable prices for field crops, respectively. In the Mountain region, the predominance of cattle ranching results in lower per-acre value of agricultural land.

Figure 1.3.1
National average farm real estate value per acre, 1980-2010



Source: USDA, National Agricultural Statistics Service: inflation adjustment via GDP Implicit Price Deflator.

Farmland Values Often Deviate From Agricultural Use Value

Traditionally, farmland values were driven largely by the returns from agricultural activities. Cash rental payments are generally considered a measure of agricultural returns to farmland. Historically, U.S. cropland has maintained a substantial premium over pastureland due to higher per-acre returns, as evidenced by cropland's higher rental rates (table 1.3.1).

In many areas today, farmland values are influenced by factors other than agricultural productivity, such as urban influence and natural or rural amenities. The capitalized value of expected rents (rental rate divided by 10-year Treasury note) is a broad indicator of the amount of farmland value due to agricultural use. When the ratio of farmland values to capitalized rents exceeds 1.0, it suggests a deviation between the market value of farmland and its implied agricultural use value. In States such as Florida and New Jersey, cropland values greatly exceed their implied agricultural use value (fig. 1.3.2). In more rural States such as South Dakota, cropland values are mostly determined by agricultural use.

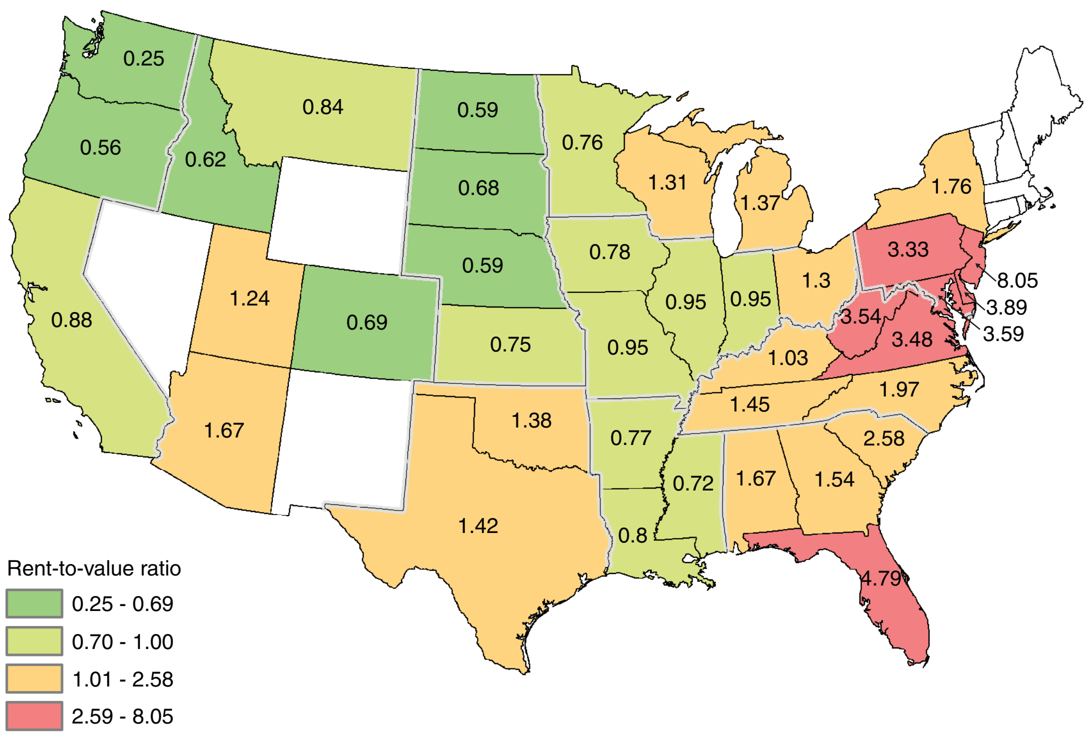
The value differential between cropland and pastureland has been declining in recent years in most regions, with the Southeast and Delta States recently seeing pastureland values (but not rents) exceeding cropland values. This is attributed, in part, to nonfarm factors such as income from hunting leases (Henderson and Moore, 2006) and proximity to urban areas (Flanders et al., 2004) increasing farmland values. Income from nonfarm factors decreases the value differential between cropland and pasture land values that existed due to differences in agricultural returns.

Table 1.3.1
Value and cash rent by farm production region, 2010

	Farm real estate	Cropland		Pasture	
	Value	Value	Rent	Value	Rent
	------$ per acre------				
Northeast	4,690	5,220	54	3,150	26
Lake States	3,300	3,090	107	1,760	27
Corn Belt	3,680	4,000	152	1,940	30
Northern Plains	1,070	1,390	71	515	16
Appalachia	3,520	3,590	71	3,300	20
Southeast	3,570	3,750	62	4,030	18
Delta	2,230	1,920	84	2,140	16
Southern Plains	1,530	1,430	34	1,340	7
Mountain	911	1,530	75	518	4
Pacific	4,050	5,070	219	1,700	15
48 States	**2,140**	**2,700**	**102**	**1,070**	**11**

Source: USDA, National Agricultural Statistics Service.

Figure 1.3.2
Cropland rent-to-value ratio by State, 2010



Source: USDA, National Agricultural Statistics Service. NASS does not publish value or rent estimates for some States due to insufficient coverage.

This article is drawn from…

Flanders, A., F. White, and C. Escalante. 2004. "Equilibrium of Land Values from Agricultural and General Economic Factors for Cropland and Pasture Capitalization in Georgia," *Journal of Agribusiness* 22:49-60.

Henderson, Jason, and Sean Moore. 2006. "The Capitalization of Wildlife Recreation Income into Farmland Values," *Journal of Agricultural and Applied Economics* 38(3):597-610, Dec.

Nickerson, Cynthia, Mitchell Morehart, Todd Kuethe, Jayson Beckman, Jennifer Ifft, and Ryan Williams. 2012. *Trends in U.S. Farmland Values and Ownership*, EIB-92, U.S. Dept of Agriculture, Economic Research Service. http://www.ers.usda.gov/publications/eib-economic-information-bulletin/eib92.aspx

U.S. Department of Agriculture, Economic Research Service. 2011. "Land Use, Land Value & Tenure." http://www.ers.usda.gov/topics/farm-economy/land-use,-land-value-tenure.aspx

U.S. Department of Agriculture, National Agricultural Statistics Service. 2010. *Land Values and Cash Rents 2010 Summary*. http://usda.mannlib.cornell.edu/usda/nass/AgriLandVa//2010s/2010/AgriLandVa-08-04-2010.pdf

Productivity and Knowledge Resources

Productivity Growth in U.S. Agriculture

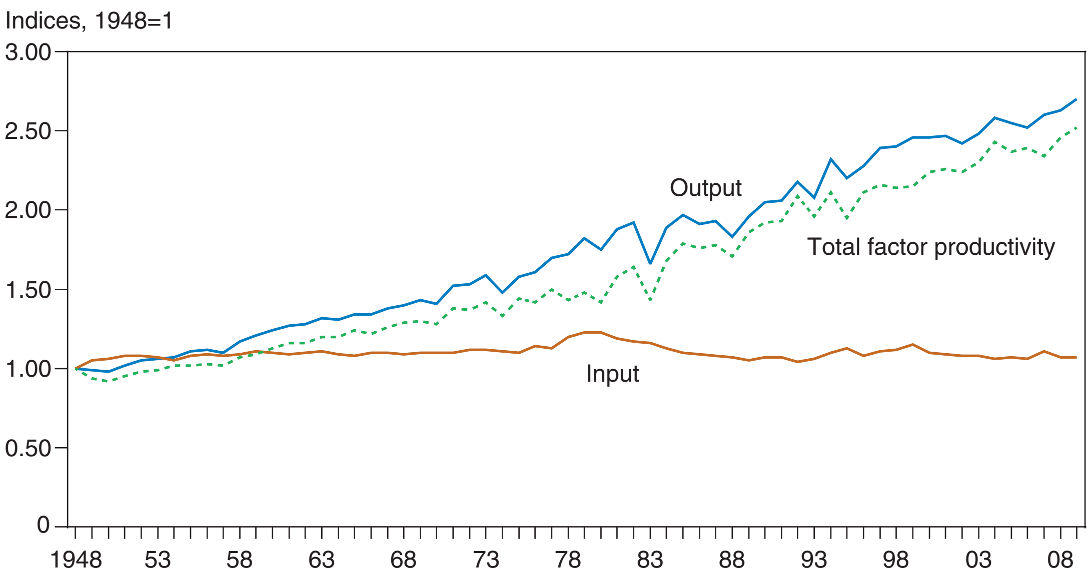
Eldon Ball and Sun Ling Wang

U.S. agricultural output has nearly tripled since 1948. The level of U.S. farm output in 2009 was 170 percent above the 1948 level, reflecting an average annual growth rate of 1.63 percent. Aggregate input use increased only 0.11 percent annually over the same span, so the positive growth in farm sector output was due almost solely to productivity growth (fig. 2.1.1).

Productivity can be measured by a single factor such as corn production per acre (yield or land productivity) or per unit of labor (labor productivity). But such measures can be misleading. For example, yields could increase simply because farmers are adding more of other inputs, such as chemicals or machinery. USDA's Economic Research Service produces measures of total factor productivity (TFP) that account for the use of all inputs to the production process.

Under the USDA-ERS TFP measure, annual productivity growth is the difference between growth of agricultural output and the growth of all inputs taken together (Ball et al., 1997; Ball et al., 2011). Productivity, therefore, measures changes in the efficiency with which inputs are transformed into outputs. Inputs are adjusted for changes in quality, such as improvements in the efficacy of chemicals and changes in the demographics of the farm workforce. As a result, agricultural productivity is driven by innovations in onfarm tasks, changes in the organization and structure of the farm sector, research aimed at improvements in farm production, and random events like weather.

Figure 2.1.1
U.S. agricultural inputs were steady while total factor productivity expanded from 1948 to 2009



Source: USDA, Economic Research Service data product, Agricultural Productivity in the United States.

Patterns in Output and Productivity Growth

Output growth derives from growth in the use of inputs (capital, land, labor, materials) and total factor productivity growth. Input growth has been the main source of economic growth for the U.S. economy as a whole and for most sectors. However, in agriculture, productivity growth has been the main source of growth in output, while input growth has been of marginal impact. Yet, the composition of the input mix changed dramatically. While labor use declined by 78 percent and land use by 27 percent over 1948-2009, materials (intermediate goods) use grew by 140 percent. Nevertheless, TFP growth in U.S. agriculture has been robust, at 1.52 percent per year over 1948-2009, a rate exceeding that of most U.S. industries and most other nations' agricultural sectors (Jorgenson et al., 1987; Ball et al., 2010).

Labor

The record of productivity growth in agriculture is all the more remarkable given labor's long-term contraction. Over 1948-2009, labor input declined, on average, 2.51 percent each year in the agricultural sector, a rate unmatched by any nonfarm sector. The historic decline in farm labor—both farmers and farm laborers—occurred as workers sought higher wages and other income opportunities in the nonfarm sector. This rate of decline in labor input appears to have slowed since the 1970s (table 2.1.1) as average household incomes in the farm and nonfarm sectors have converged (Hoppe and Banker, 2010).

Capital

Capital input in agriculture exhibits a different pattern of growth than labor. During 1973-79, U.S. agriculture expanded rapidly, fueled by a growth in exports resulting from increased global liquidity, rising incomes, and production shortfalls in other parts of the world. U.S. farm exports surged from an average $4.8 billion in 1950-70 to $9.4 billion in 1972 and $17.7 billion in 1973. Exports continued to increase through 1981, when they peaked at $43.3 billion. In addition, domestic forces—including a drop in interest rates and rising inflation—contributed to an increase in borrowing for the purchase of land and equipment. For much of the 1970s, real interest rates were close to zero and at times negative, reducing the cost of capital. Capital input

Table 2.1.1
Sources of growth in the U.S. farm sector (average annual growth rates in percent)

	1948-2009	1948-53	1953-57	1957-60	1960-66	1966-69	1969-73	1973-79	1979-81	1981-90	1990-2000	2000-07	2007-09
Output growth	1.63	1.18	0.96	4.03	1.21	2.24	2.65	2.26	1.54	0.96	1.84	0.77	1.88
Sources of growth													
Input growth	0.11	1.34	0.28	0.50	0.05	-0.08	0.46	1.64	-1.85	-1.22	0.31	0.14	-1.80
Labor	-0.52	-0.81	-1.08	-0.83	-0.81	-0.61	-0.38	-0.19	-0.22	-0.43	-0.34	-0.35	-0.64
Capital	0.02	0.54	0.15	0.03	0.08	0.32	0.14	0.32	0.23	-0.61	-0.21	0.05	0.35
Land	-0.08	0.02	-0.17	-0.16	-0.07	-0.22	-0.29	0.00	-0.12	-0.09	0.00	-0.08	-0.12
Materials	0.69	1.58	1.38	1.45	0.85	0.43	0.99	1.50	-1.74	-0.09	0.87	0.52	-1.39
Total factor productivity	1.52	-0.16	0.69	3.60	1.16	1.69	1.97	0.76	3.62	2.17	1.64	0.72	5.89

in agriculture increased 2 percent per year between 1973 and 1979, adding an average 0.32 percentage points per year to the output growth (table 2.1.1). The contribution from capital growth continued to the 1979-1981 period.

However, the economic environment changed in the early 1980s. Restrictive monetary policy by the Federal Reserve pushed interest rates up sharply. The dollar appreciated on foreign exchange markets. The average real interest cost on variable-rate debt rose to nearly 16 percent in 1981-83. Real interest rates remained high for many years thereafter, as Federal Reserve policy grew more stringent due to large fiscal deficits. This mix of fiscal stimulus and monetary restraint slowed the growth in export-dependent sectors of the economy, including agriculture. Growth in agricultural output slowed to about 0.96 percent per year during 1981-90, versus 2.26 percent over 1973-79 (table 2.1.1). Capital's contribution to output growth was negative during 1981-90; declining capital stocks reduced output growth by -0.61 percentage points per year.

The real cost of funds generally declined from the mid-2000s, spurring increased investment in machinery and equipment. Capital input increased at 0.50 percent per annum, and the contribution of capital input to output growth averaged 0.05 percentage points per year between 2000 and 2007. Capital input continued to grow over the 2007-2009 period with the contribution to output growth averaging 0.35 percentage points.

Land and Material Inputs

Land's contribution to growth in agricultural output was negative for all recent time periods but 1973-79. Over 1948-2009, the contribution of land to output growth was -0.08 percentage points per year.

The positive growth in materials (including fertilizer, pesticides, fuel, and purchased services) reflects the substitution of those inputs for other inputs. Material inputs' contribution averaged 0.69 percent per year over 1948-2009. This offsets the negative contributions of labor and land, making the contribution of all inputs essentially flat. Among the materials, agricultural chemicals grew faster than others at an annual rate of 2.54 percentage points. While labor input declined and capital investment slowed in recent years, purchased services, including contract labor and machinery custom work services, increased at an annual rate of 2.54 percentage points over 1948-2009. Material growth was faster and contributed more to output growth before 1979 than after.

Productivity Growth

With an annual growth rate of 1.52 percent per year over 1948-2009, farm sector productivity increased by 152 percent over the past 61 years. As a consequence, and in the absence of input growth between 1948 and 2009, productivity growth almost single-handedly drove the 170-percent increase in farm output above its 1948 level. TFP growth can fluctuate considerably from year to year, largely in response to weather events or to changes in input use. In 2007, producers altered cropping patterns in response to an expansion in demand for corn-based ethanol. Farmers increased corn acreage sharply and boosted chemical use without raising average corn yields or TFP.

Long-term agricultural productivity is driven by innovations in animal and crop genetics, chemicals, equipment, and farm organization. Public agricultural research funding, which historically has driven innovation, has been flat in recent years (see chapter, "Agricultural Research and Technology Development"), raising concerns about current and future U.S. productivity growth. Although there is no evidence of a long-run productivity slowdown in U.S. agriculture, steady investment in agricultural research is essential if agricultural production is to meet growing worldwide demand.

References

Ball, V. Eldon, Jean-Christophe Bureau, Richard Nehring, and Agapi Somwaru. 1997. "Agricultural Productivity Revisited," *American Journal of Agricultural Economics*, Vol. 79, No. 4, pp. 1045-1063.

Ball, V. Eldon, Jean-Pierre Butault, Carlos San Juan, and Ricardo Mora. 2010. "Productivity and International Competitiveness of European Union and United States Agriculture," *Agricultural Economics* 41, pp. 611-627.

Ball, Eldon, Sun Ling Wang, and Richard Nehring. 2011. Agricultural Productivity in the United States: Data Documentation and Methods. http://www.ers.usda.gov/data-products/agricultural-productivity-in-the-us/documentation-and-methods.aspx

Hoppe, Robert A., and David E. Banker 2010. *Structure and Finances of U.S. Farms.* U.S. Department of Agriculture, Economic Research Service. EIB-66, July.

Jorgenson, D., F. Gollop, and B. Fraumeni. 1987. *Productivity and U.S. Economic Growth*. Cambridge, MA: Harvard University Press.

The data are drawn from:

USDA-ERS Data on Agricultural Productivity in the United States, http://www.ers.usda.gov/data-products/agricultural-productivity-in-the-us.aspx

Productivity and Knowledge Resources

Agricultural Research and Development

Kelly Day-Rubenstein and Paul Heisey

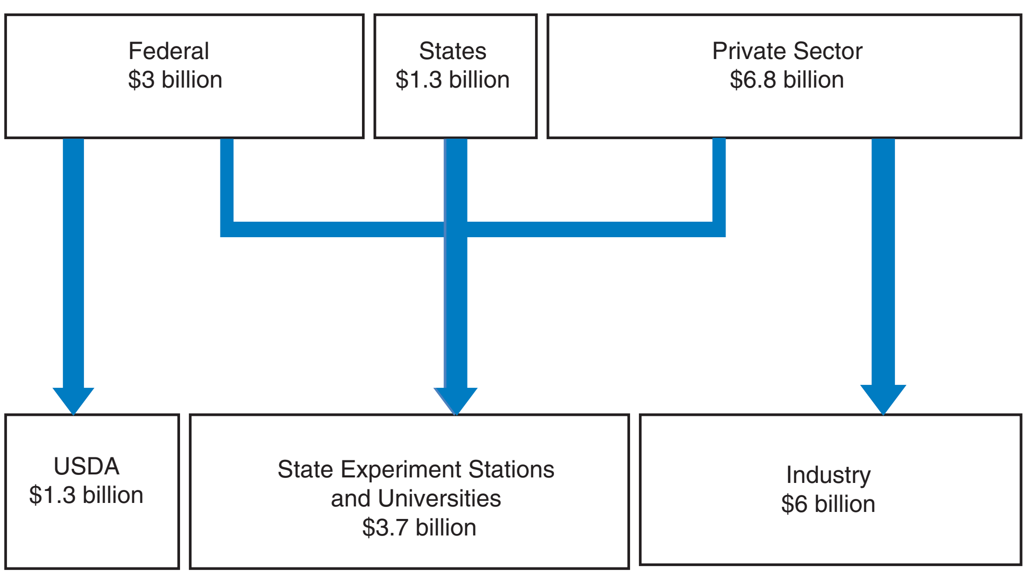
Agriculture is a science-based industry. Nearly all production improvements are the result of research and development (R&D) in the areas of mechanics (e.g., farm equipment), biology (e.g., plant varieties and animal breeds), or management (e.g., integrated pest management). Likewise, the consumers of agricultural products also depend on scientific reports for information about nutrition, food safety, and environmental quality.

Much of the science used in agriculture comes from the life sciences. For example, plant varieties need resistance to pests and diseases and tolerance to nonbiological stresses such as drought and heat. Some stressors can be managed chemically or physically, for example, by controlling pests with insecticides or delivering water by irrigation. Even in these cases, the biological basis of the plant or pest must be understood. But many stressors can be managed best by utilizing inherent resistance in the plant or animal variety. Because pests and diseases evolve, R&D (particularly prebreeding and breeding) is continually needed to maintain or improve yields per acre.

Multiple Institutions Operate in a Complex System

Agriculture has benefited from a unique Federal-State agricultural research and extension system, with a history of collaboration with the private sector. The upper portion of the flow chart (figure 2.2.1) shows the level of funding by each institution: the private sector leads, followed by the Federal Government and the States. The lower portion of the chart shows who conducts the research. Federal-level research, funded at about $1.3 billion in 2006, generally addresses issues of national importance. State-level research received $3.7 billion in 2006 and may be regionally applicable, though research at academic institutions may be broad in scope. Private sector research is nearest to the marketplace, and the private sector spends the most on

Figure 2.2.1
Funders and performers of U.S. food and agricultural research in 2006

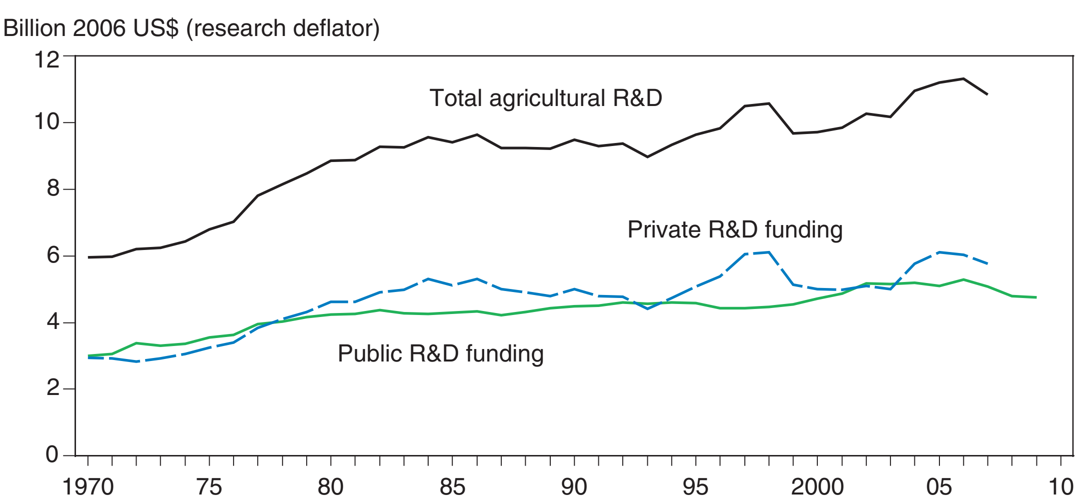


research—$6 billion in 2006. The system is characterized by numerous linkages between institutions. For instance, State-level institutions receive funds from several Federal agencies other than USDA, and USDA funds State-level institutions through a variety of instruments. The private sector and USDA exchange funds or conduct joint research through cooperative agreements, contracts, and trusts. The relationships shown in the figure represent only the major flows of funds at a highly aggregated level.

Private Sector Research Increases, While Public Research Remains Stagnant

Over the past 40 years, agricultural R&D has increased, and funding now totals about $11 billion per year. Figure 2.2.2 shows the trends in funding for different sectors from 1970-2009. Historically, public institutions played a direct role in developing new technologies and encouraging their commercialization and adoption by farmers. Advances in the biological sciences, beginning with hybridization in the 1930s, and expanded intellectual property rights protection have stimulated private sector efforts in R&D. These now exceed public sector efforts, although private sector funding has been more variable. Since about 1980, public sector agricultural research funding has been stagnant for long periods of time. Over the long run, Federal funding of research in many different areas has fluctuated in real terms, with only health-related research showing a steady increase over 50 years or more. From 1990 to the mid-2000s, Federal funding of the National Institutes of Health (NIH) and the National Science Foundation (NSF) grew much more rapidly than Federal funding of agricultural research or many other research areas. Public research funding is dependent on many factors, including general budgetary conditions, perceived national (or State-level) needs, and the degree to which the users of research can influence appropriations. Political support for agricultural research may relate to the perceived importance of agriculture. At present, the share of production agriculture in U.S. Gross Domestic Product has shrunk to just over 2 percent.

Figure 2.2.2
Real agricultural research and development (R&D) funding, 1970-2009



Source: U.S. Department of Agriculture, Economic Research Service. 2012. "Agricultural Research Funding in the Public and Private Sectors," data product, http://www.ers.usda.gov/data-products/agricultural-research-funding-in-the-public-and-private-sectors.aspx

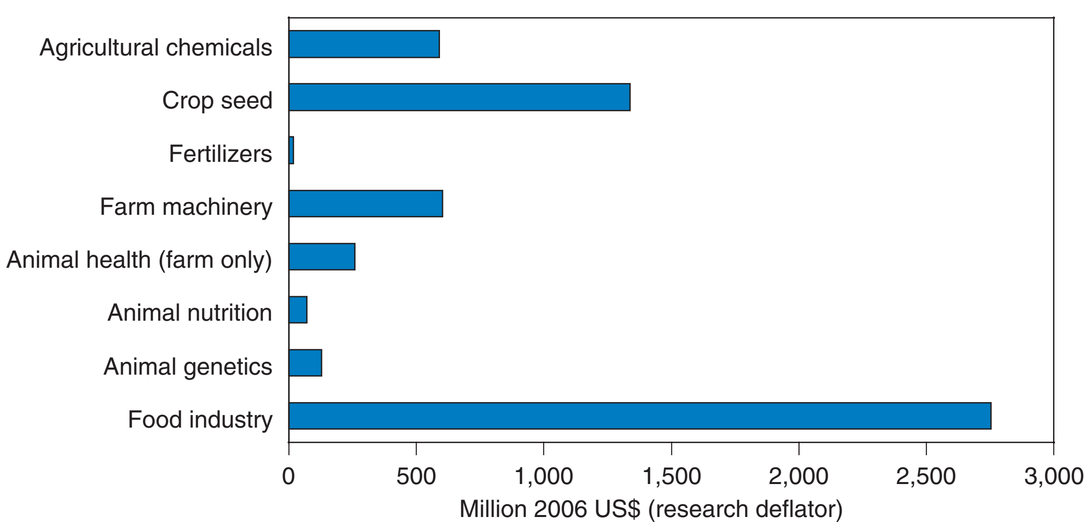
Private and Public R&D Emphases Differ, Despite Some Overlap

Although there is some overlap between broad private and public R&D themes, in many ways public and private research are complementary rather than competitive. Little incentive exists for private firms to pursue public-goods research because the results benefit society as a whole, rather than the specific innovator. Thus, the private sector focuses mainly on R&D related to marketable goods. The food industry accounts for the largest category of private R&D (though this may also include marketing research). Advances in research in biology, microbiology, and computing created new technological opportunities for private companies. For example, gene transfer technologies enable researchers to tailor crops for specific uses, such as resistance to disease, pests, herbicides, or harsh environmental conditions. Crop seed is now the second largest category of private sector research. The share of crop seed research as a proportion of all private sector research has grown at the same time the share of agricultural chemicals research has fallen. Agricultural chemicals and farm machinery have obvious marketable qualities. Biological advances have allowed for combined crop seed and agricultural chemical technologies, such as herbicide-resistant varieties.

The change in focus in the private sector allows more public resources to be devoted to more fundamental technology research on scientific problems. The two largest categories, plant and animal R&D, account for more than half of total public agricultural research. Much of the research within the plant and animal categories addresses basic biological research or research with limited appropriability. Public research has also increased in applied areas with public-good characteristics, such as environmental protection and nutrition and food safety. Almost 20 percent of total funding is spent on natural resource and environmental R&D, and its importance has grown over time. Public research generally operates on a longer timeframe as well, which allows it to address problems with little probability of short-term payoff. Although USDA patents and licenses technologies that are near to the marketplace, such intellectual property rights are used primarily as a means of transferring technologies and encouraging their development.

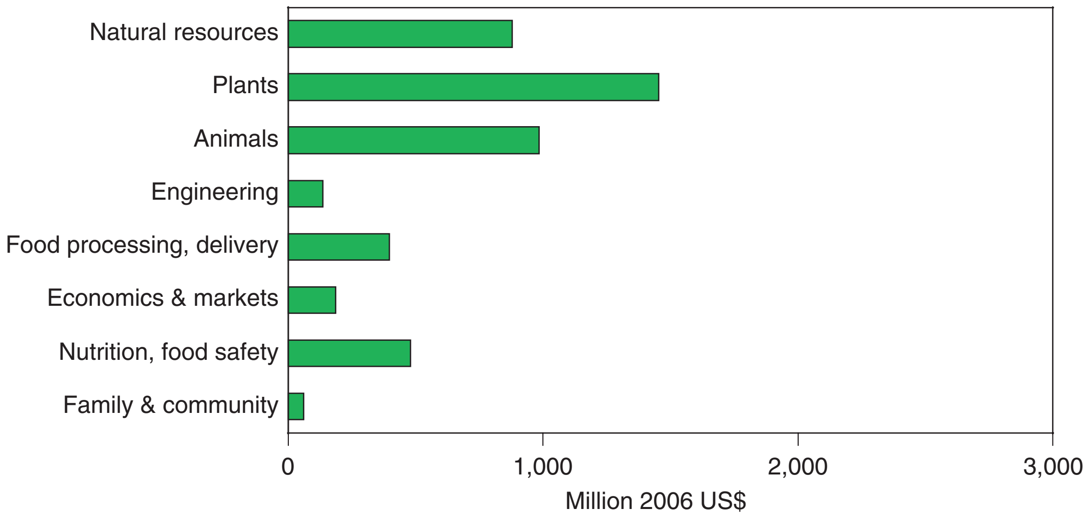
Figure 2.2.3

U.S. private agricultural research and development (R&D) by industry, 2007



Source: Fuglie et al., 2011.

Figure 2.2.4
Public agricultural research, 2009



Source: USDA Current Research Information System, Funding Summaries (http://cris.csrees.usda.gov/fsummaries.html), as adapted by ERS.

References

Fuglie, Keith O., P. Heisey, J. L. King, C. E. Pray, K. Day-Rubenstein, D. Schimmelpfennig, S. L. Wang and R. Karmarkar-Deshmukh. 2011. *Research Investments and Market Structure in the Food Processing, Agricultural Input, and Biofuel Industries Worldwide*, ERR-130, U.S. Dept. of Agriculture, Economic Research Service, Dec.

Fuglie, Keith and P. W. Heisey. 2007. *Economic Returns to Public Agricultural Research*, EB-10, U.S. Dept. of Agriculture, Economic Research Service, Sept.

Fuglie, Keith, Nicole Ballenger, Kelly Day, Cassandra Klotz, Michael Ollinger, John Reilly, Utpal Vasavada, and Jet Yee. 1996. *Agricultural Research and Development: Public and Private Investments Under Alternative Markets and Institutions*, AER-735, May.

Schimmelpfennig, David, and Paul Heisey. 2009. *U.S. Public Agricultural Research: Changes in Funding Sources and Shifts in Emphasis, 1980-2005*, EIB-45, U.S. Dept. of Agriculture, Economic Research Service, March.

U.S. Department of Agriculture, Economic Research Service. 2012. “Agricultural Science Policy,” topic page. http://www.ers.usda.gov/topics/farm-economy/agricultural-science-policy.aspx

Productivity and Knowledge Resources

Biotechnology and Seed Use for Major U.S. Crops

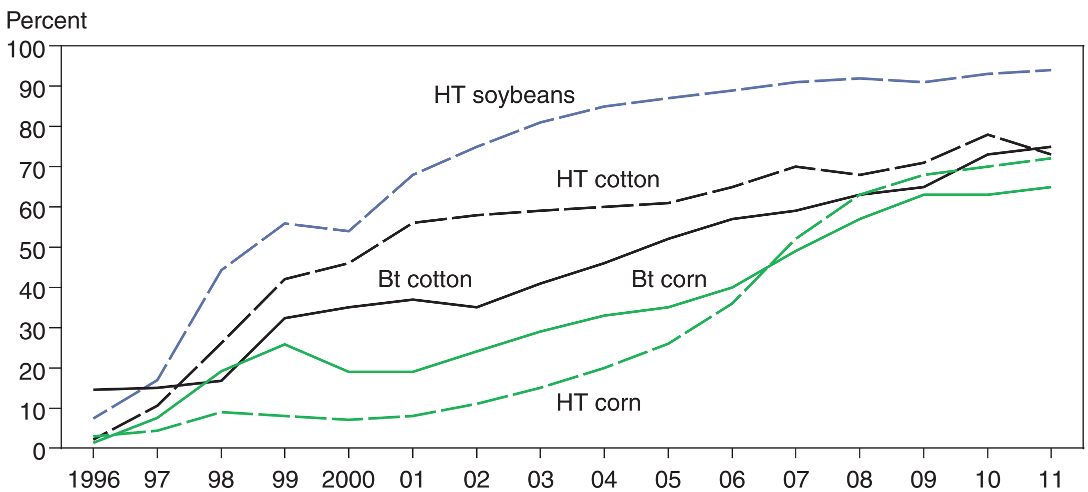
Jorge Fernandez-Cornejo

Genetically Engineered Crops Have Expanded Rapidly

U.S. farmers have embraced genetically engineered (GE) seeds for soybeans, cotton, and corn since their commercial introduction over 15 years ago (fig. 2.3.1). GE seeds have genes that provide specific traits such as herbicide tolerance (HT) and insect resistance. HT crops tolerate potent herbicides, allowing adopters of these varieties to control pervasive weeds more effectively. Insect-resistant (Bt) crops contain genes from the soil bacterium *Bacillus thuringiensis* that produces a protein toxic to specific insects, protecting the plant over its entire life.

Although other traits are being developed (including virus and fungus resistance; cold and drought resistance; and enhanced protein, oil, or vitamin content), crops with HT and Bt traits are the most prominent GE crops currently on the market. While other crop varieties have been developed (e.g., HT canola, HT sugar beets, and HT alfalfa), corn, cotton, and soybeans make up the bulk of the acres planted to GE crops. By 2011, U.S. farmers were using HT soybeans on 94 percent of all planted soybean acres. HT cotton occupied 73 percent of cotton acreage, and HT corn accounted for 72 percent of corn acreage in 2011. Adoption of Bt crops has also expanded rapidly; Bt cotton reached 75 percent of planted cotton acreage in 2011, and Bt corn use grew from about 1 percent of corn acreage in 1996 to 65 percent in 2011. Including varieties with either HT and/or Bt traits, GE crops accounted for 88 percent of all planted corn acres in 2011, 94 percent of soybean acres, and 90 percent of cotton acres.

Figure 2.3.1
Adoption of genetically engineered crops in the U.S., 1996-2011



Data for each crop category include varieties with both HT and Bt (stacked) traits.

Source: USDA-ERS (2011), using USDA-NASS data.

Benefits of GE Seeds Outweigh Added Cost for Most U.S. Farmers

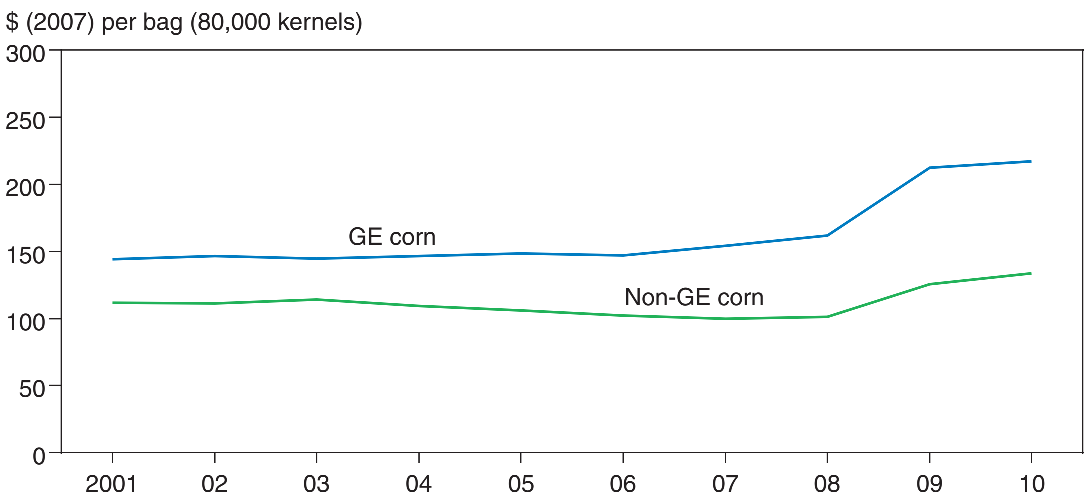
Despite the higher prices for GE seed compared to conventional seed (figs. 2.3.2-2.3.3), U.S. farmers are realizing economic benefits from increased crop yields, and/or lower pesticide costs, and management time savings. The impacts of GE crops vary with the crop, technology, pest infestation levels, and other factors. For example, Bt crops may lead to yield gains and/or lower insecticide costs, while HT crops lead to savings in management time. Moreover, farmers adopting the HT varieties for corn, cotton, and soybeans often substitute glyphosate for more toxic herbicides.

HT crops also facilitate the adoption of conservation tillage. By enabling more crop residue to be safely left in the field, conservation tillage reduces soil erosion by wind and water, increases water retention, and reduces soil degradation and water and chemical runoff.

Despite its net benefits, however, consumer concerns may have limited acceptance of GE crops, particularly in Europe. In addition, farmers' reliance on glyphosate has recently led to the evolution of weed resistance to this herbicide, reducing the effectiveness of the weed-management tool. On the other hand, insect resistance to Bt crops has been limited and of "little economic and agronomic significance" (National Research Council, 2010).

Figure 2.3.2

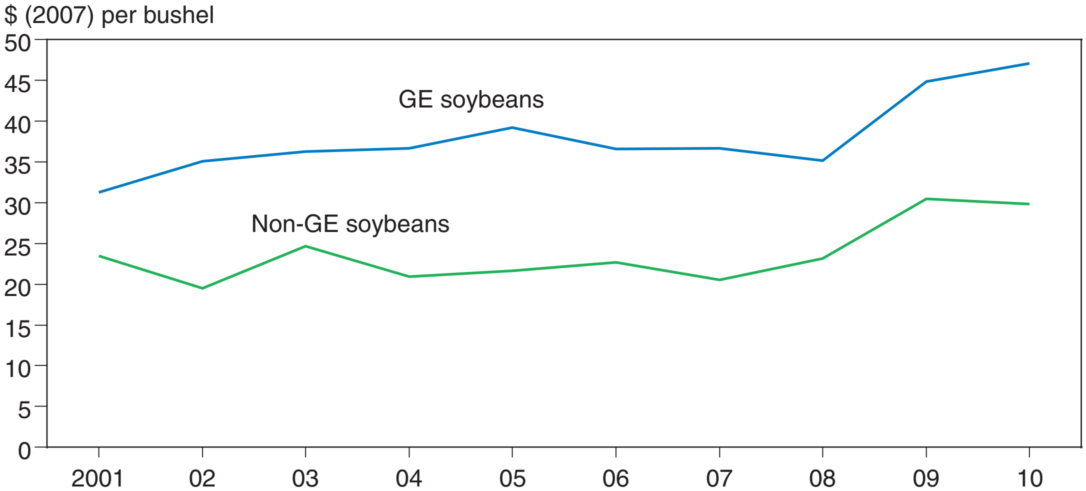
Prices of genetically engineered seed versus non-GE seed for corn, 2001-10



Source: USDA/NASS, *Agricultural Prices Summary* (annual); USDA/NASS, *Quick Stats*.

Figure 2.3.3

Prices of genetically engineered seed versus non-GE seed for soybeans, 2001-10



Source: USDA/NASS, Agricultural Prices Summary (annual); USDA/NASS, Quick Stats.

References

Fernandez-Cornejo, J., and M. Caswell. 2006. *The First Decade of Genetically Engineered Crops in the United States*, EIB-11, Economic Research Service, U.S. Dept of Agriculture, April. http://www.ers.usda.gov/publications/eib-economic-information-bulletin/eib11.aspx/

Fernandez-Cornejo, J., with contributions from A. Mishra, R. Nehring, C. Hendricks, A. Gregory, and M. Southern. 2007. *Off-Farm Income, Technology Adoption and Farm Economic Performance*, ERR-36, Economic Research Service, U.S. Dept of Agriculture, Feb. http://www.ers.usda.gov/publications/err-economic-research-report/err36.aspx

National Research Council (NRC). 2010. *The Impact of Genetically Engineered Crops on Farm Sustainability in the United States*. Washington DC: The National Academies Press. April.

U.S. Department of Agriculture, Economic Research Service. 2011. “Adoption of Genetically Engineered Crops in the U.S.” http://www.ers.usda.gov/data-products/adoption-of-genetically-engineered-crops-in-the-us.aspx.

Agricultural Production Management

Pest Management

Mike Livingston and Craig Osteen

U.S. crop producers use a variety of practices to reduce yield losses to pests, such as scouting fields to determine whether and when pesticide applications might be required. Genetically engineered insect-resistant (Bt) and herbicide-tolerant (HT) crops are also available for conventional producers. Producers of certified organic crops are much more reliant on production practices that bypass synthetic chemicals, such as crop rotation, adjustments to planting and harvesting dates, and the use of beneficial organisms. Many such methods are also widely practiced by conventional producers.

Pesticides

According to U.S. Environmental Protection Agency (EPA) *Pesticides Industry Sales and Usage* reports, U.S. agricultural producers spent $7.87 billion on 684 million pounds of pesticide active ingredient in 2007, 7.2 percent and 6.4 percent more than was spent and applied in 2006. However, real expenditures (in 2010 dollars) and quantities declined 2.4 percent and 1.4 percent, respectively, per year during 1996-2007, on average. During this period, herbicides and plant growth regulators accounted for 63 percent of both expenditures and quantities applied, insecticides and miticides for 21 percent of expenditures and 11 percent of quantity, fungicides for 10 percent and 7 percent, and other chemicals (e.g., nematicides, fumigants, and rodenticides) for 7 percent of expenditures and 20 percent of quantities applied. U.S. corn, cotton, fall potatoes, soybeans, and wheat accounted for nearly two-thirds of pesticide quantities applied.

In this chapter, we examine pesticide use and management practices for these five crops more closely, using detailed Agricultural Resource Management Survey (ARMS) data. Total pesticide use on these crops was stable during 1982-2010, increasing in some years and declining in others, with an average annual increase of 0.2 percent (fig. 3.1.1).[1] Herbicide and insecticide quantities applied declined 0.2 percent and 3.9 percent per year, while fungicide and other-chemical (e.g., desiccants, growth regulators, and vine killers) quantities increased 3.3 and 6.0 percent (O'Donoghue et al., 2011; Osteen and Livingston, 2006).

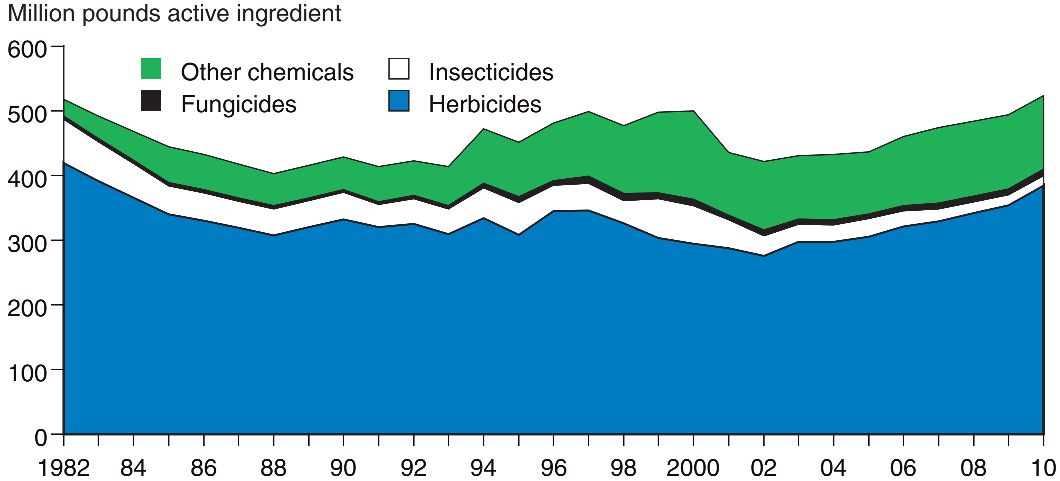
Changes in the use of pesticides during this period are due to several factors, including the widespread adoption of genetically engineered crops, the expiration of the glyphosate patent in 2000, the availability of new compounds with lower application rates, boll-weevil eradication, and changes in pesticide prices, which increased slowly compared to the prices of other inputs such as fertilizer (fig. 3.1.2).

Of the five crops, 53 percent of the pesticide total was applied to corn in 1982, followed by soybeans (28 percent), cotton (9.6 percent), fall potatoes (4.8 percent), and wheat (4.5 percent). Corn's share declined to 43 percent in 2010, while fall potatoes' share increased to 20 percent (because of large increases in the application of other chemicals, particularly vine killers such as sulfuric acid). Herbicides accounted for the largest share of pesticides applied throughout 1982-2010, while the other-chemicals category increased most in share. Corn accounted for the

[1]These estimates do not include sulfur, oils, and unconventional pesticides.

Figure 3.1.1

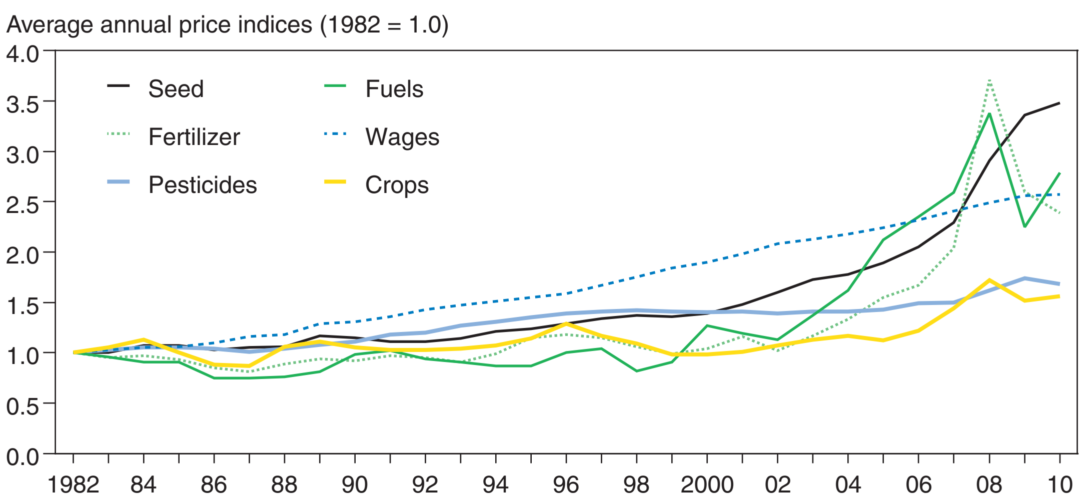
Pesticide active ingredients applied to corn, cotton, fall potatoes, soybeans, and wheat, 1982-2010



Source: O'Donoghue et al., 2011; Osteen and Livingston, 2006.

Figure 3.1.2

Price indices for seed, fertilizer, pesticides, fuels, wages, and crops, 1982-2010



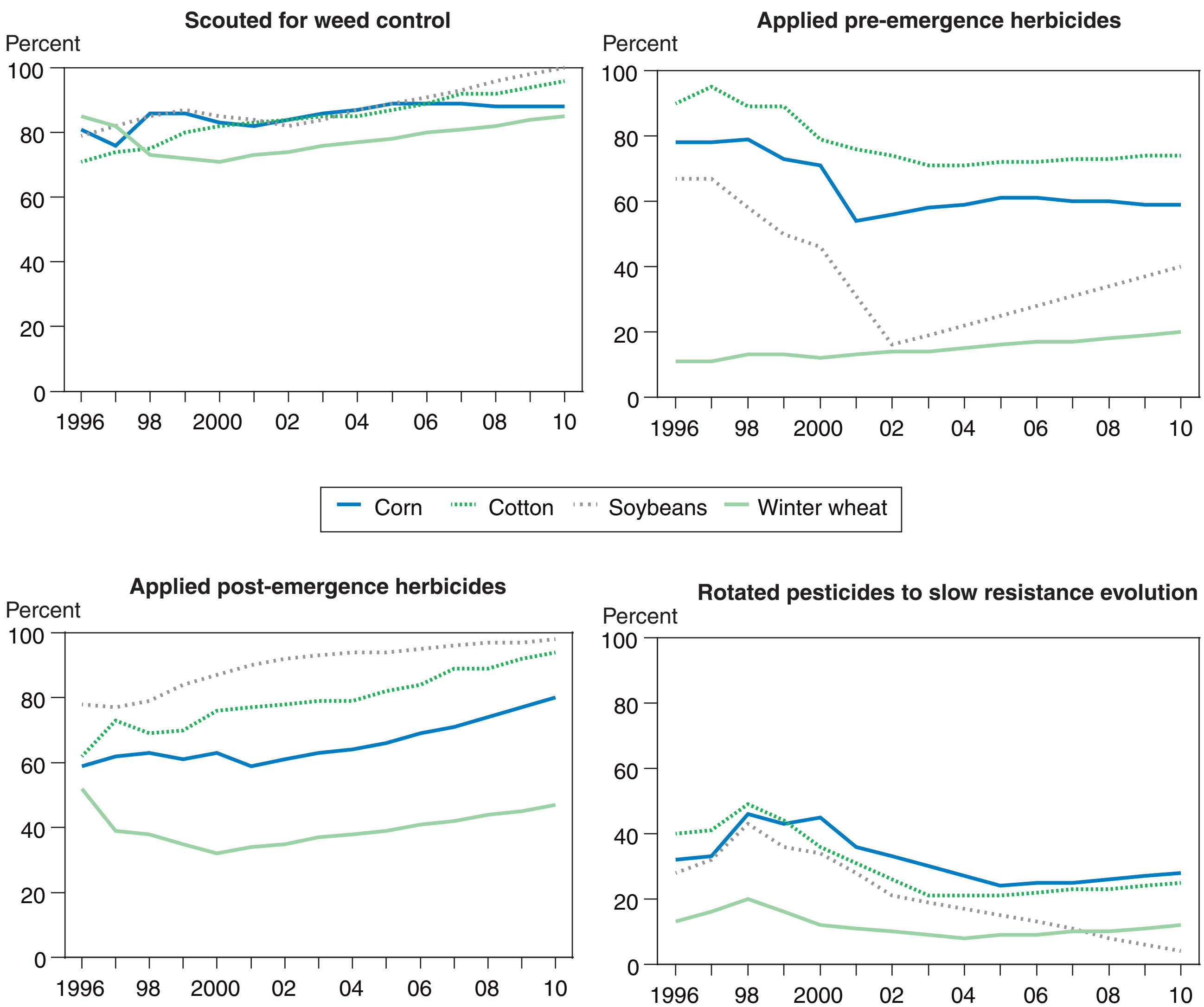
Source: USDA, NASS, 2012.

majority of herbicide and insecticide use until the early 1990s, after which cotton accounted for the majority of insecticide use due to boll-weevil eradication efforts. The majority of fungicides and other chemicals were applied to fall potatoes.

Management Practices

ARMS data on pest management practices first became available in 1996 and indicate that fields were scouted for weed control on the majority of acres planted to corn, cotton, soybeans, and winter wheat, and that weed scouting intensity increased during 1996-2007 (fig. 3.1.3). With the

Figure 3.1.3
Planted acres under selected pest management practices, 1996-2010



Source: USDA, Economic Research Service and National Agricultural Statistics Service, Agricultural Resource Management Survey.

widespread adoption of herbicide-tolerant (HT) corn, cotton, and soybeans during 1996-2007, the use of post-emergence herbicides increased, particularly for soybeans, while the use of pre-emergence herbicides first declined and then leveled off, for corn and cotton, and increased for soybeans. The percentage of winter-wheat acres receiving pre-emergence herbicides increased slowly and steadily during this period, while the percentage of acres receiving post-emergence herbicides declined and then increased somewhat.

The share of planted acres on which pesticides are rotated to slow resistance trended downward during 1996-2007, particularly for soybeans. This trend—along with the widespread adoption of HT crops and the popularity of glyphosate—might help explain why glyphosate resistance is an emerging problem facing producers of corn, cotton, and soybeans.

Changes in insect management practices are less apparent. Fields were scouted for insect control on the majority of planted acres, and the only discernible change over 1996-2007 occurred in soybeans, where the share of planted acres scouted increased slightly, perhaps because of the recent introduction of the soybean aphid.

References

O'Donoghue, Erik J., Bob Hoppe, David Banker, Robert Ebel, Keith Fuglie, Penni Korb, Michael J. Livingston, Cynthia Nickerson, and Carmen Sandretto. 2011. *The Changing Organization of U.S. Farming*. EIB-88, U.S. Department of Agriculture, Economic Research Service, Dec. http://www.ers.usda.gov/publications/eib-economic-information-bulletin/eib88.aspx.

Osteen, C., and M. Livingston. 2006. "Pest Management Practices," pp. 107-116, in K. Wiebe and N. Gollehon, eds. *Agricultural Resources and Environmental Indicators*, EIB-16, Economic Research Service, July. http://www.ers.usda.gov/publications/eib-economic-information-bulletin/eib16.aspx.

U.S. Department of Agriculture. 2012. *Quick Stats*, National Agricultural Statistics Service. http://quickstats.nass.usda.gov/.

For more information, see…

U.S. Department of Agriculture, Economic Research Service. 2012. *"Chemical Inputs," http://www.ers.usda.gov/topics/farm-practices-management/chemical-inputs.aspx*.

Agricultural Production Management

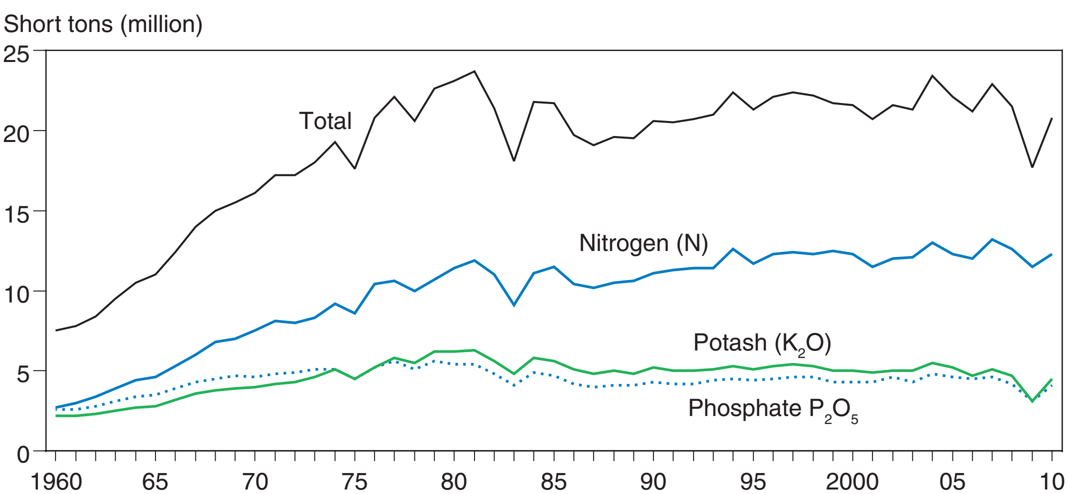
Nutrient Management

Wen Huang and Jayson Beckman

Nitrogen, phosphate, and potash are essential in the production of crops used for food, feed, fiber, and biofuel. Applied annually, most of these nutrients are absorbed by the crops, but when applied in excess, they can be lost to the environment through volatilization into the air, leaching into ground water, emission from soil to air, or runoff into surface water. These losses can be reduced by adoption of best management practices (BMPs) that match nutrient supply for crop needs, minimize nutrient losses, and enhance plants' capability to uptake nutrients. U.S. farmers have used BMPs (such as soil testing for nitrogen and timing nitrogen application) to reduce fertilizer costs, increase profitability, protect the environment, and conserve natural resources. This chapter examines the trends of plant nutrient use and nutrient use efficiency—nutrient recovery rate and share of planted acres with excess nutrient use—for major U.S. crops.

Nutrient consumption has been volatile since 2004. Commercial fertilizer consumption increased rapidly before 1982 as more acreage was devoted to high-yield crop varieties and hybrids that responded favorably to more intensive fertilizer use. As global demand for grains grew, nutrient consumption peaked at 24 million tons in 1981. When grain demand dropped in 1983, Government payment-in-kind programs idled record acres and reduced nutrient consumption to 18 million tons. Nutrient use then moved steadily upward, largely due to an increase in corn plantings. (Corn, on average, uses the most fertilizer of all crops.) Beginning in 2004, fertilizer consumption was volatile due to highly variable corn plantings and volatile fertilizer prices in the biofuels era. Record fertilizer prices in 2009 reduced consumption to 18 million tons, a 24-percent decline from 2004. As fertilizer prices declined in 2010, consumption rebounded to 21 million tons.

Figure 3.2.1
Fertilizer use in U.S. agriculture, 1960-2010

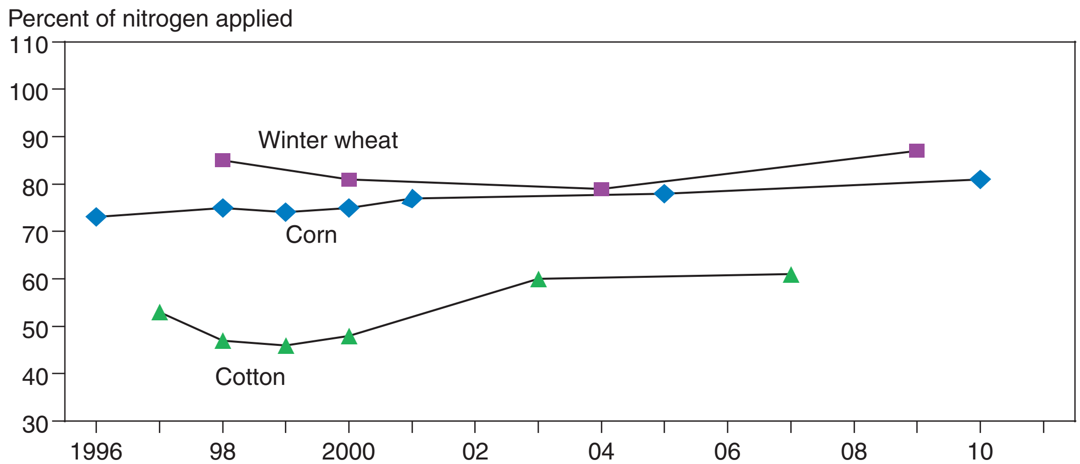


Source: USDA, Economic Research Service, using data from Association of American Plant Food Control Officials and The Fertilizer Institute.

Nitrogen fertilizer use has increased more rapidly than phosphate and potash due to the development of seed varieties with more favorable yield responses to nitrogenous fertilizers. Corn—with many planted acres under intensive fertilizer application—accounted for around 46 percent of the U.S. fertilizer consumption in 2010.

Farmers are improving nutrient recovery rates for most crops. Nutrient recovery rate is the ratio of the amount of nutrient in the harvested crop to the amount of nutrient applied. Partial recovery occurs when the amount applied exceeds the amount removed. For corn, nitrogen recovery efficiency increased from 73 percent in 1987 to 81 percent 2010, while phosphate recovery hovered near 100 percent. For soybeans, phosphate recovery is above 100 percent,

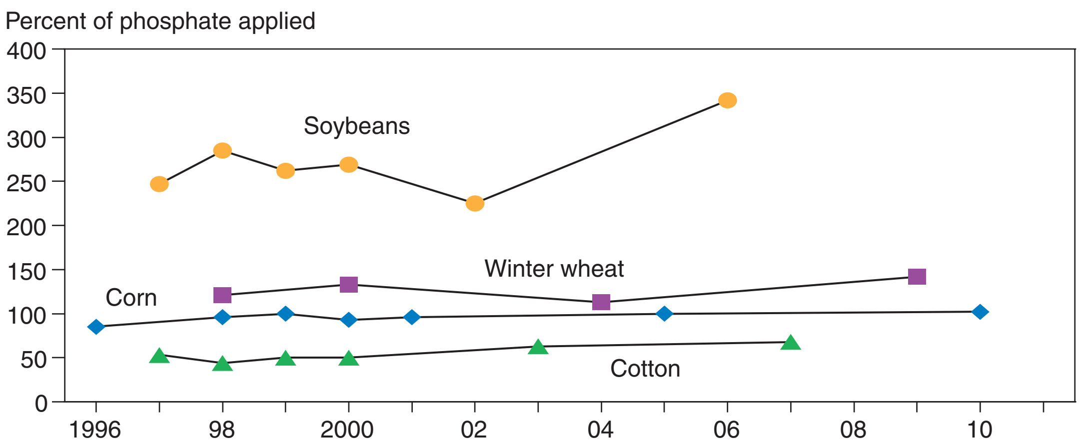
Figure 3.2.2
Crops' nitrogen recovery rates



Recovery efficiency is the average of recovery efficiencies from each observation. A 100-percent recovery is achieved when the amount of nitrogen removed from a field is equal to the amount of nitrogen applied to the field.

Source: USDA, Economic Research Service's calculation using individual observations from ARMS survey.

Figure 3.2.3
Crops' phosphate recovery rates



Recovery efficiency is the average of recovery efficiencies from each observations. A 100-percent recovery is achieved when the amount of phostphate removed from a field is equal to the amount of phosphate applied to the field. Efficiency above 100 percent indicates more phosphate is removed than applied.

Source: USDA, Economic Research Service's calculation using individual observations from ARMS survey.

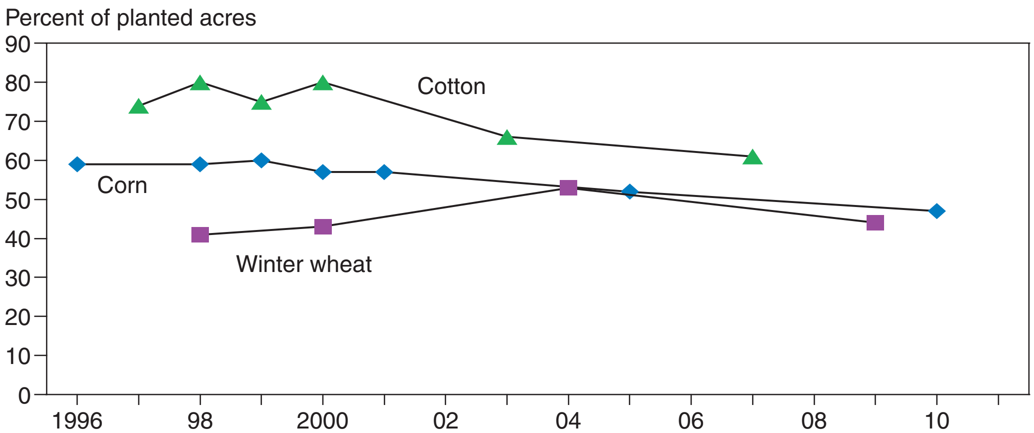
suggesting that phosphates are actually mined from the soil. Continued plant mining of phosphate may reduce soil productivity in the long run.

Farmers are reducing planted acres with excess nutrient use for most crops. For corn, the share of planted acres with excess nitrogen applied (above 25 percent of the crop's needs) declined from 59 percent in 1996 to 47 percent in 2010, while the share of acres with excess phosphate declined from 43 percent in 1996 to 31 percent in 2010. Other crops also exhibit either declining or unchanged shares of planted acres with excess use of nitrogen or phosphate.

Yield increase is the major factor in improving nutrient use efficiency in corn in recent years. Higher yields result in more nutrients being removed from the soil, thus reducing nutrient losses. Yields (and efficiency) have benefited from increased crop rotation (corn planted after soybeans), soil testing for nitrogen, use of GE seeds to reduce pest damage, increase in seeding rate, and adoption of precision technology (such as yield monitors and soil map).

Figure 3.2.4

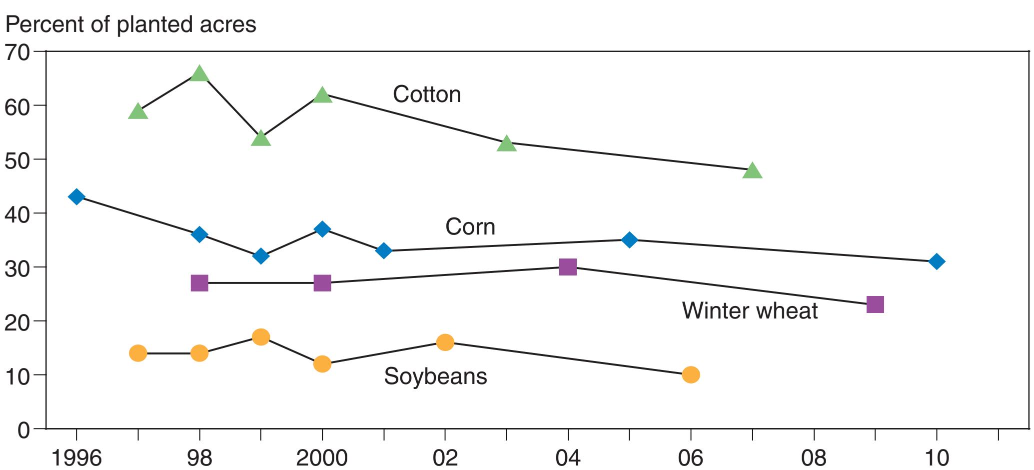
Planted acres receiving nitrogen above 25 percent of crop's agronomic need



Source: USDA, Economic Research Service's calculation using individual observations from ARMS survey.

Figure 3.2.5

Planted acres receiving phosphate above 25 percent of crop's agronomic need



Source: USDA, Economic Research Service's calculation using individual observations from ARMS survey.

References

Huang, Wen-yuan. 2007. *Impact of Rising Natural Gas Prices on U.S. Ammonia Supply*. WRS-0702, U.S. Department of Agriculture, Economic Research Service, Aug.

Huang, Wen-yuan. 2009. *Factors Contributing to the Recent Increase in U.S. Fertilizer Prices*, *2002-08*. AR-33, U.S. Department of Agriculture, Economic Research Service, Feb. http://www.ers.usda.gov/publications/ar-agricultural-resources-situation-and-outlook/ar-33.aspx

Huang, Wen-yuan. 1997. “Nutrient Management,” *Agricultural Resources and Environmental Indicators, 1996-97.* Agricultural Handbook 712, U.S. Department of Agriculture, Economic Research Service, July. http://www.ers.usda.gov/publications/ah-agricultural-handbook/ah712.aspx

Taylor, Harold. 1997. “Nutrients,” *Agricultural Resources and Environmental Indicators, 1996-97.* Agricultural Handbook 712, U.S. Department of Agriculture, Economic Research Service, July. http://www.ers.usda.gov/publications/ah-agricultural-handbook/ah712.aspx

U.S. Department of Agriculture, Economic Research Service. 2012. “U.S. Fertilizer Use and Price.” http://www.ers.usda.gov/data-products/fertilizer-use-and-price.aspx

U.S. Department of Agriculture, Economic Research Service. 2012. “ARMS Financial and Crop Production Practices.” http://www.ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices.aspx

Agricultural Production Management

U.S. Irrigated Agriculture: Water Management and Conservation

Glenn D. Schaible and Marcel P. Aillery

Irrigated agriculture makes a significant contribution to the value of U.S. agricultural production, but also accounts for the largest share of the Nation's consumptive water use. In 2007, irrigated farms accounted for 55 percent ($78.3 billion) of the total value of crop sales while also supporting the livestock and poultry sectors through irrigated production of animal forage and feed crops. Roughly 57 million acres—or 7.5 percent of all U.S. cropland and pastureland—were irrigated in 2007, nearly three-quarters of it in the 17 Western States.[1] From 2002 to 2007, irrigated acres increased by nearly 1.3 million acres across the United States, with Nebraska accounting for nearly a million additional acres. However, in recent decades irrigation has continued to expand in the humid Eastern United States.[2] USDA's Farm & Ranch Irrigation Survey (FRIS) reports that in 2008, irrigated agriculture applied 91.2 million acre-feet of water,[3] over four-fifths of it in the West. The U.S. Geological Survey (USGS), which monitors water use by economic sector, estimates that irrigated agriculture accounted for 37 percent of the Nation's freshwater withdrawals in 2005. Agriculture, however, represents 80-90 percent of U.S. consumptive water use.[4]

Challenges for Agriculture Under a Changing Water Environment

Population and economic growth, Native American water-right claims, and water quality/environmental priorities are increasing the demand for water resources. Expansion of the U.S. energy sector is also expected to increase regional demands for water. Climate change is projected to shrink water supplies through reduced snowpack, warming temperatures, and shifting precipitation patterns and cause water demand to increase across much of the West. These trends place added pressure on existing water allocations, heightening the importance of water conservation for a sustainable irrigated agriculture sector.

The future of irrigated agriculture will be influenced by the ability of producers to improve onfarm water management for crop production. Enhanced water-use efficiency can be achieved through both upgrades in physical water application systems and improved water-management practices. In addition, complementary water resource management at the farm and watershed levels—for example, use of conserved water rights, groundwater and surface-water withdrawal restrictions, drought water banks, and option water markets—can encourage producers to reduce crop consumptive use while facilitating the reallocation of water to higher valued uses.

---

[1]Washington, Oregon, California, Idaho, Nevada, Arizona, Montana, Wyoming, Colorado, Utah, New Mexico, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas.

[2]Since 1998, irrigated acres in the 31 Eastern States have increased by nearly 20 percent. As of 2007, 2 Eastern States—Arkansas and Florida—were among the 12 leading irrigation States, accounting for about 8 and 3 percent, respectively, of U.S. irrigated acres.

[3]An acre-foot represents the volume of water needed to cover 1 acre at a depth of 1 foot, equivalent to 325,851 gallons.

[4]Consumptive water use, as defined by the U.S. Geological Survey, is the portion of water withdrawn that is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment.

Onfarm Irrigation Efficiency: Opportunities for Continued Improvement

Water-use efficiency gains provide many farm-level benefits, including enhanced productivity of applied water; improved efficiency of production inputs for labor, energy, or chemicals; and higher farm returns. The potential for water savings at a watershed scale will depend, however, on local hydrologic factors and net changes in crop consumptive use. Whether or not improved water-use efficiency eases basin-level water-supply constraints, onfarm water conservation may contribute to farmer and societal welfare, improved fish and wildlife habitat, and reduced ecosystem and human health risks associated with environmental degradation.

In recent decades, onfarm irrigation efficiency—the share of applied water that is beneficially used by the crop—has increased. FRIS survey data reveal a marked shift to more efficient irrigation application systems, reducing average per-acre applied water rates across crops and regions. While an important concern across U.S. irrigated agriculture, irrigation efficiency is of particular importance across the arid Western States, where water demand for agriculture is greatest and where competing water demands and shifting water regimes under climate change are projected to place additional strain on available water supplies for agriculture. In 1984, gravity systems—which used roughly 54 percent more water per acre than pressurized systems, on average—accounted for more than 70 percent of all water applied for crop agriculture in the 17 Western States. By 2008, gravity systems applied less than half of all irrigation water, while water used with pressure systems accounted for 52 percent of water applied (fig. 3.3.1).

At the same time, continued efficiency advances were achieved with both gravity and pressure systems. By 2008, fewer acre-feet of water were required to irrigate a greater number of acres, reflecting improved water-use efficiency, as well as changes in irrigated acreage distributions and regional cropping patterns. From 1984 to 2008, total irrigated acres in the West increased by 2.1 million acres, while water applied declined by nearly 100,000 acre-feet. In 2008, applied water rates in the region averaged 2.4 acre-feet per acre for gravity systems and 1.4 acre-feet for pressure systems.[5]

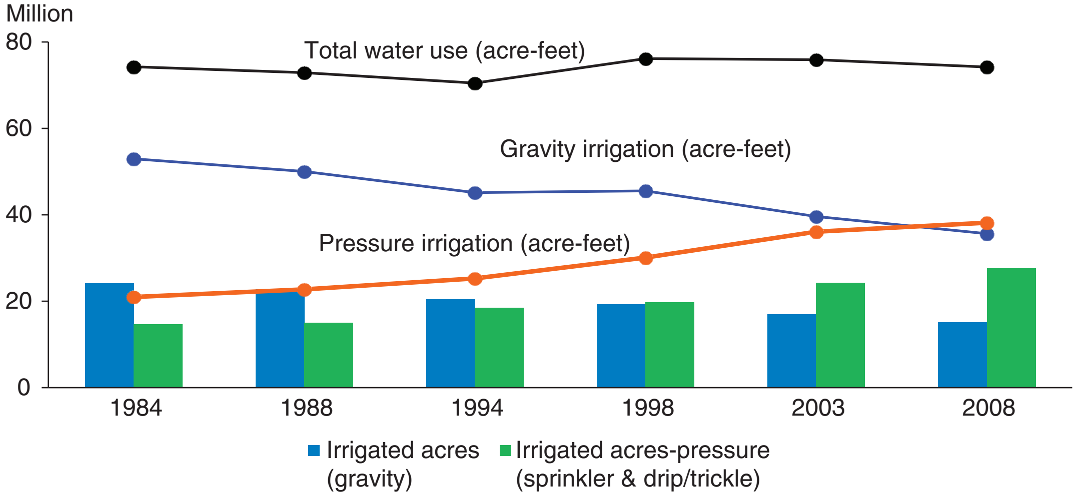
While substantial technological innovation has already occurred in U.S. irrigated agriculture, additional water-use efficiency gains are achievable. Figure 3.3.2 shows changes, from 1994 to 2008, in the share of Western irrigated acres using more efficient irrigation systems (as defined in the figure's legend). More than half of irrigated cropland acres in the West continue to be irrigated with more traditional, less efficient application systems, for both gravity and pressure irrigation systems. Continued investment in irrigation efficiency will depend on adoption incentives at the farm level, including factors that influence investment returns (e.g., crop value, water/energy, and system upgrade costs), access to capital, and production risk.

Private and Public Investment in Irrigation Improvements

Irrigators continue to make significant capital investments in irrigation equipment and infrastructure. Approximately $2.15 billion was spent on irrigation systems (beyond expenditures for maintenance and repair) across U.S. farms in 2008. Nearly three-fourths of these capital investments were on land in the West, where the vast majority of irrigated land is located. About

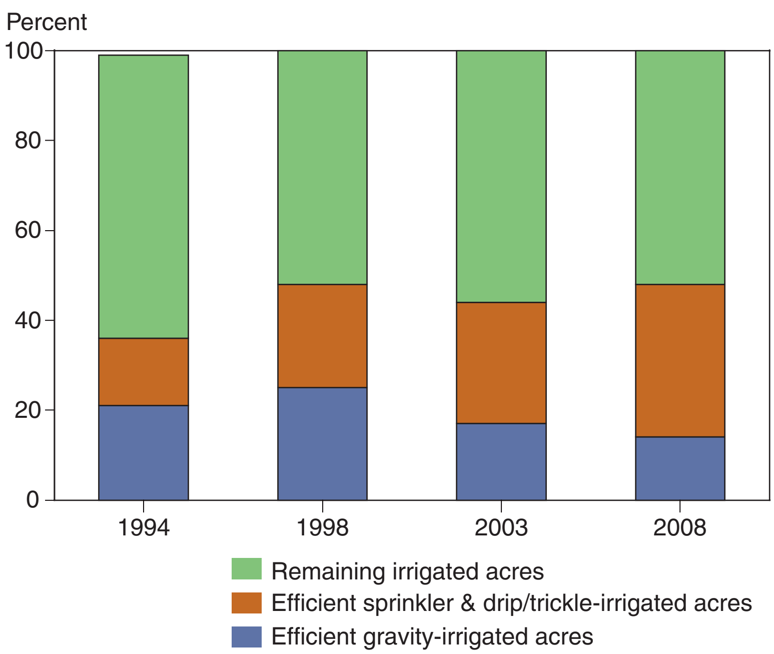
[5]Application rates may vary significantly across subregions based on crops grown, consumptive water requirements, water costs for surface and groundwater sources, local water-use regulations, and other factors.

Figure 3.3.1
Trends in irrigated acres and water applied, Western States, 1984-2008



Source: USDA, National Agricultural Statistics Service, Farm & Ranch Irrigation Surveys (1984, 1988, 1994, 1998, 2003, and 2008).

Figure 3.3.2
Efficient irrigation (as a percent of total irrigated acres), by system type, for 17 Western States, 1994-2008



Traditional irrigation includes systems other than those defined above for more efficient gravity/sprinkler irrigation (largely including high-pressure sprinkler and unlined furrow and flood systems without field borders).

More efficient pressure-sprinkler irrigation includes acres irrigated using either drip/trickle systems or lower pressure sprinkler systems [pressure per square inch (PSI) < 30].

More efficient gravity irrigation includes furrow irrigated acres using above- or below-ground pipe, or a lined open-ditch field water-delivery system, plus acres in flood irrigation (between borders or within basins) on farms using laser-leveling and pipe or lined open-ditch field water-delivery systems.

Source: USDA, National Agricultural Statistics Service, Farm & Ranch Irrigation Surveys (1994-2008).

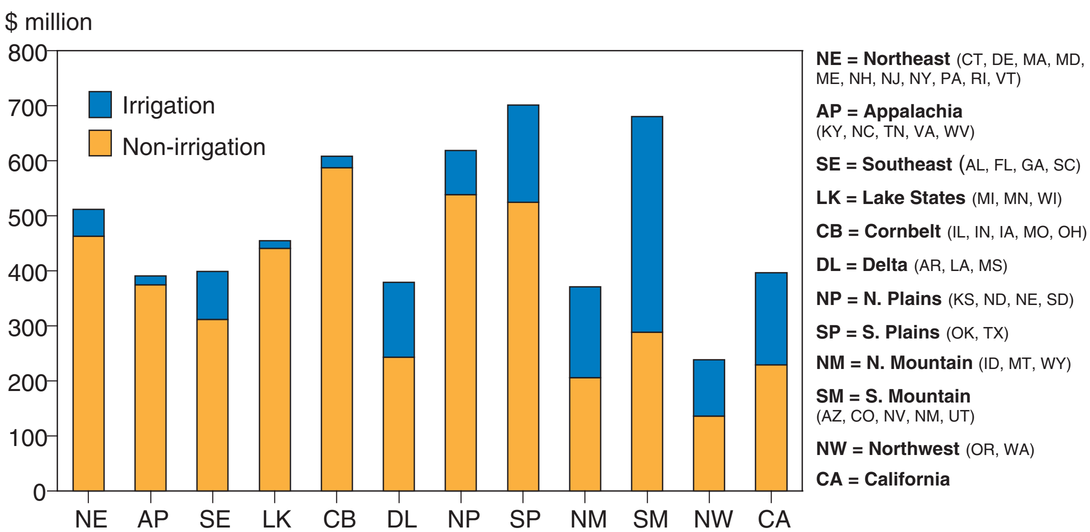
52 percent of on-farm expenditures in the West were driven by replacement of existing equipment and machinery; upgrades in irrigation facilities and equipment (where water conservation was identified as the primary purpose) accounted for 17 percent. Investment in new equipment accounted for nearly 31 percent of all investment expenditures.

The majority of U.S. irrigation investment is financed privately; fewer than 10 percent of farms reporting irrigation improvements in 2003 or 2008 received public cost-share assistance. Over half of the farms receiving public assistance for irrigation investments made use of USDA's Environmental Quality Incentives Program (EQIP), though these farms represented less than 5 percent of all irrigated farms that made irrigation investments in 2003 or 2008. However, EQIP funding has had an important cumulative impact on irrigation investments. Nationally, irrigation practices accounted for roughly a quarter of total EQIP cost-share funding obligations ($5.7 billion) from 2004 to 2010.

The magnitude of public irrigation investment under EQIP varies across the United States (fig. 3.3.3), reflecting, in part, the relative importance of irrigation to the regional agricultural economy, as well as Federal program funding guidelines and State contract-ranking criteria. In the Western States, funding of irrigation practices as a share of total EQIP outlays (2004-10) ranged from 13 percent for the Northern Plains to 58 percent for the Southern Mountain States. Irrigation practices account for a relatively small share of program expenditures in the Corn Belt, Lake States, Appalachia, and Northeast regions. Since 2004, however, EQIP funding shares for irrigation practices have generally increased in the Eastern States, in contrast with declining funding shares for irrigation practices across the West.

Figure 3.3.3

EQIP funding of irrigation practices by region, 2004-10



Source: USDA, Natural Resources Conservation Service, EQIP data 2004-10.

Reference

Schaible, Glenn, and Marcel Aillery, 2012. *Water Conservation in Irrigated Agriculture: Trends and Challenges in the Face of Emerging Demands*. EIB-99. USDA, Economic Research Service.

Agricultural Production Management

Soil Management and Conservation

Robert Ebel

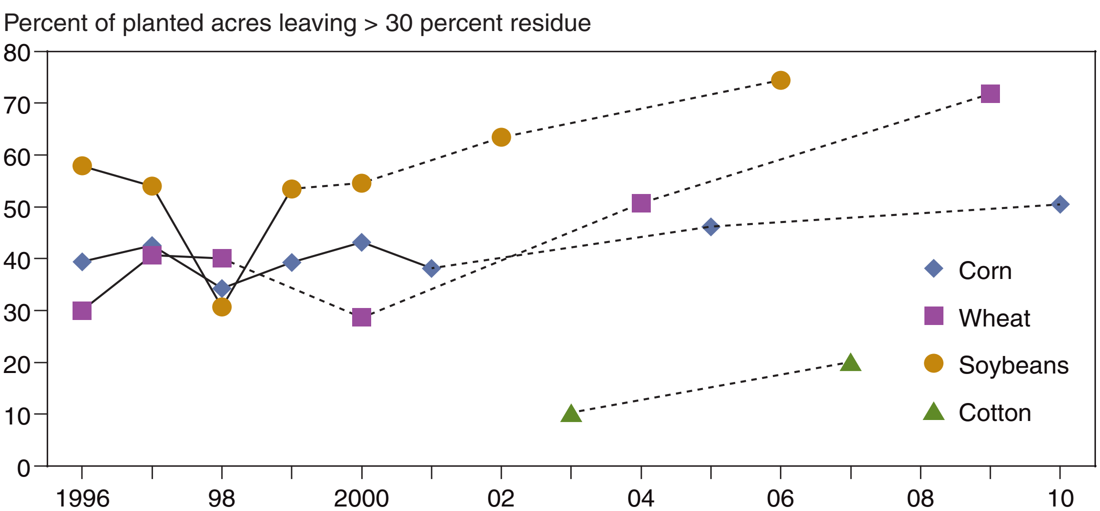
Soil quality, also referred to as soil health, is a function of inherent chemical, physical, and biological characteristics of the soil and management choices leading to dynamic changes in soil properties and processes. While soil characteristics such as texture and distance to bedrock may not be easily or quickly altered, farm management strategies for crop residue management, crop rotations, and soil conservation structures can improve or maintain dynamic soil quality, mitigate environmental damage, and raise economic returns. Soil quality reflects the capacity of soil to facilitate nutrient cycling; regulate water flow; maintain physical stability; neutralize environmental pollutants; and provide habitat, food, and fiber.

No-till Drives Increase in Conservation Tillage

The amount and type of tillage used in crop residue management systems has become a critical issue for farm managers and policymakers alike as fuel prices rise, air quality issues continue to gain attention, crop mixes requiring increased soil moisture increase in acreage, and the carbon sequestration potential of agricultural soils gains policy relevance. “No-till” farming has seen increases in acreage across all major crops. Conservation tillage that maintains residue cover provides environmental benefits and improves both agronomic and economic efficiency. The reduction in fuel and labor expenditures due to fewer tillage passes over the field can boost farm profits. Additionally, farms using crop residue management retain more moisture by trapping snow, decreasing water evaporation from the top layer of soil, and improving water infiltration to plant root systems. Environmental benefits include reduced soil erosion and water pollution

Figure 3.4.1

Conservation tillage for major crops, 1996-2010



Note: Solid lines connect annual observations; dotted lines connect sporadic observation of tillage practices for specific crops.

Source: USDA, Economic Research Service and National Agricultural Statistics Service, Agricultural Resource Management Survey, various years.

Table 3.4.1

Tillage categories as defined by residue remaining after planting

Residue and tillage management				
		Conservation tillage		
Conventional tillage	Reduced tillage	Mulch till	Ridge till	No till
<15 percent residue cover remaining	15-30 percent residue cover remaining	30 percent or greater of the soil surface covered by residue after planting.		
Moldboard plow or other intensive tillage used such as chisel or disc. Cultivation and/or herbicides for weed control.	No use of moldboard plow and intensity of tillage reduced. Cultivation and/or herbicides for weed control.	Soil is disturbed prior to planting, using less intensive tillage tools. Cultivation and/or herbicide for weed control.	Only ridges are tilled. Residue left on surface between ridges. The ridge is the seedbed.	No tillage performed. Weed control typically accomplished primarily with herbicides.

(via reduced sediment, fertilizer, and pesticide runoff), and improved air quality (as soil particulates do not become airborne). Reductions in tillage may, however, be associated with increased pest management costs in some climates and crops.

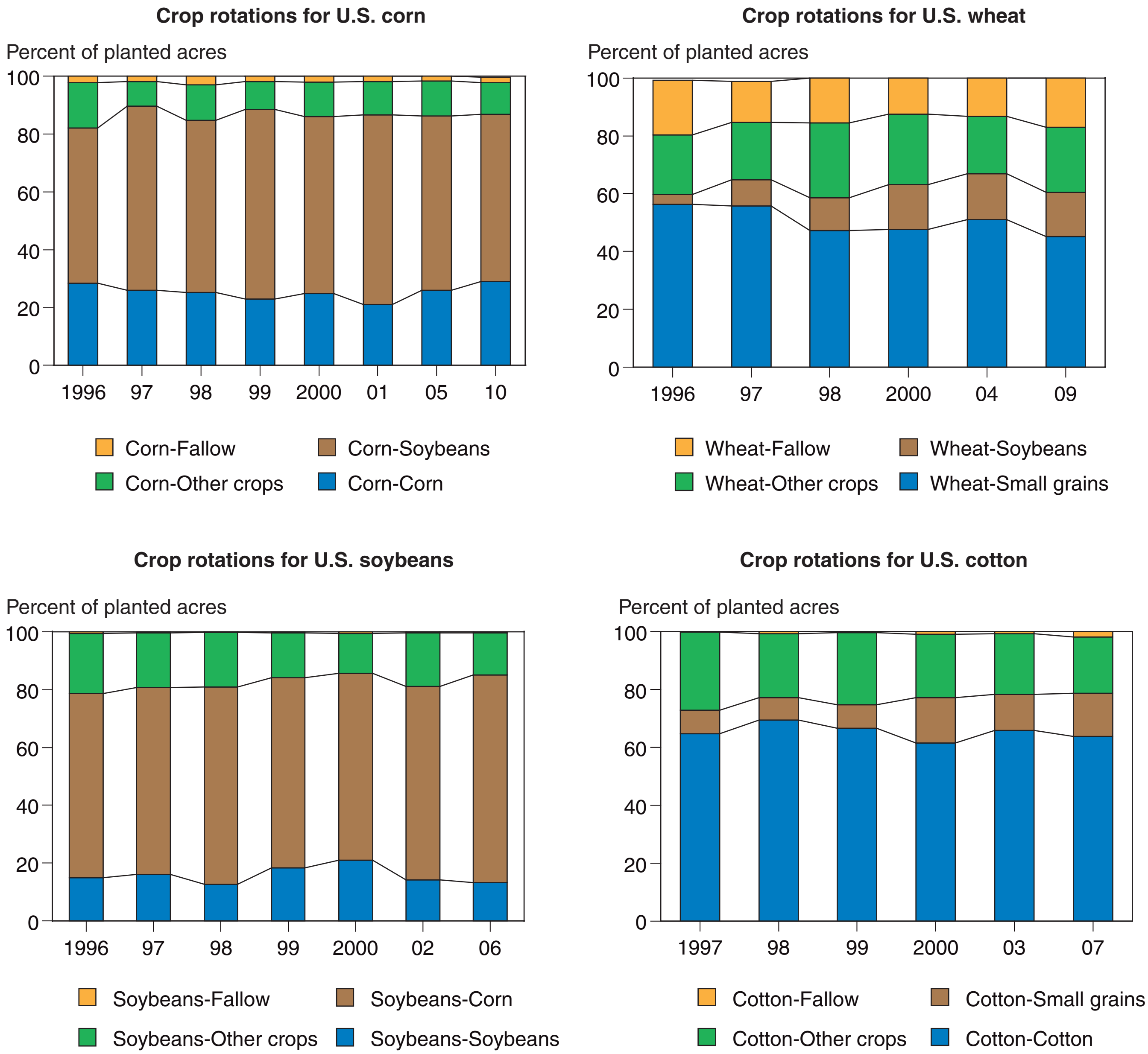
The choice of tillage system varies widely across U.S. regions. The Northern Plains region (which includes the Dakotas, Nebraska, and Kansas) has the highest rate of conservation tillage for corn (64 percent in 2010), and high rates of adoption for wheat and soybeans as well. Soybean growers have had the highest rates of conservation tillage—only the Delta region (Louisiana, Mississippi, Alabama) had adoption rates below 70 percent in 2006. Across all crops, rates of conservation tillage in Southern States lag Northern rates because of differing agronomic conditions in the South, including agricultural pest problems and post-harvest residue composition of dominant crops.

Corn-Soybeans and Continuous Cropping Remain Dominant Cropping Patterns

The choice to **rotate crops**—which helps to cycle nutrients, break pest cycles, and maintain or improve soil quality—is contingent on the relative rates of return for candidate crops. Rotations may consist of strictly spring-planted crops, or may involve fall-planted crops or cover crops. The most common rotation, corn and soybeans, demonstrates several of the major agronomic and environmental advantages to crop rotation. By alternating a nitrogen-dependent grain (corn) with a nitrogen-fixing legume (soybeans), nitrogen fertilizer needs are reduced. Yields have been shown to increase for grain-legume rotations irrespective of fertilizer rates. Weeds, insects, and disease are disrupted by crop rotation, which allows farmers to save on pesticide application and costs. Rotating closely grown crops, such as small grains, with row crops increases vegetative cover and can reduce soil losses due to water and wind erosion, thereby reducing nutrient and pesticide runoff into waterways. Crop rotations that include legumes, row crops, and small grains are most effective at disrupting weed, insect, and disease cycles.

Market factors—including relative commodity prices and input prices—greatly affect crop rotation decisions. The past decade has seen increased corn grain prices in addition to higher commercial fertilizer prices. High corn prices could lead to more continuous corn, while a desire to contain fertilizer expenses could encourage rotation of crops that require less fertilizer.

Figure 3.4.2
Cropping patterns for major crops, 1996-2010



Source: USDA, Economic Research Service and National Agricultural Statistics Service, Agricultural Resource Management Survey.

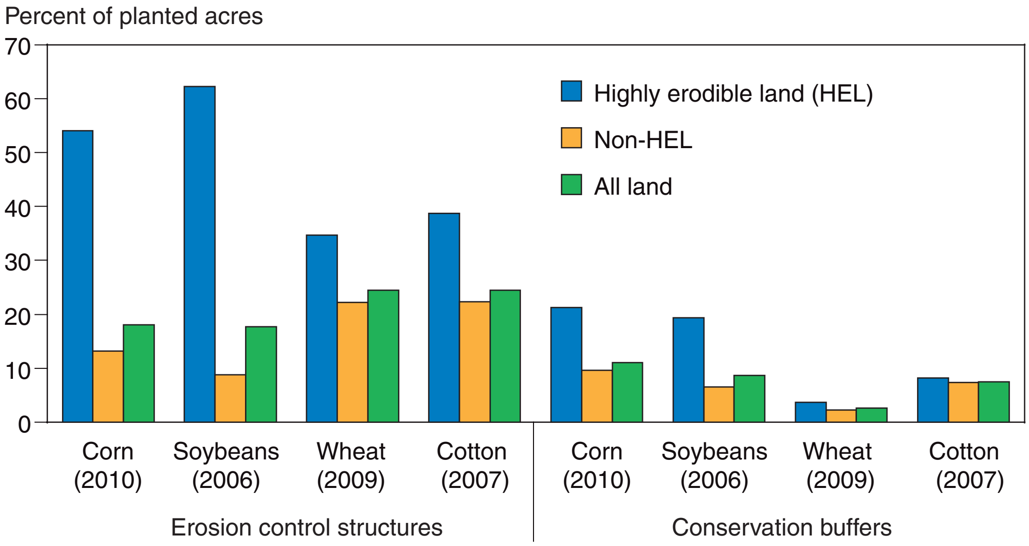
Agricultural Resource Management Survey (ARMS) results for corn and soybeans indicate a small increase in corn in rotation and continuous corn over the past decade.

Conservation Structures Help To Minimize Erosion

Conservation programs such as the Environmental Quality Incentives Program and the Conservation Stewardship Program help farmers to implement best management practices, including the installation of soil **conservation structures and vegetative measures**. Conservation structures are especially useful and encouraged on land that USDA's Natural Resources Conservation Service (NRCS) considers highly erodible land (HEL). NRCS estimates that over 27 percent of U.S. cropland was highly erodible in 2007.

Structures and vegetation such as terraces, grassed waterways, grade stabilization structures, filter strips, and riparian buffers can reduce soil erosion and sedimentation and chemical runoff in local waterways. Filter strips and riparian buffers are rows of vegetation planted next to waterways in order to trap surface runoff from agricultural fields. Terraces and other grade stabilization structures are earthen structures that transform long sloping fields into a series of more moderately sloped fields, thus slowing the movement of sediment. Grassed waterways are areas of permanent vegetation placed where surface water flow concentrates.

Figure 3.4.3
Conservation structure use among major crops, 2006-2010



Source: USDA, Economic Research Service and National Agricultural Statistics Service, Agricultural Resource Management Survey.

References

Horowitz, J., R. Ebel, and K. Ueda. 2010. "*No-Till" Farming Is a Growing Practice*, EIB-70, U.S. Department of Agriculture, Economic Research Service, http://www.ers.usda.gov/publications/eib-economic-information-bulletin/eib70.aspx

Sandretto, C., and J. Payne. 2006. "Soil Management and Conservation," *Agricultural Resources and Environmental Indicators*, K. Wiebe and N. Gollehon, eds. EIB-16, U.S. Department of Agriculture, Economic Research Service, July. http://www.ers.usda.gov/publications/eib-economic-information-bulletin/eib16.aspx

U.S. Department of Agriculture, Economic Research Service. 2012. "Chemical Inputs." http://www.ers.usda.gov/topics/farm-practices-management/chemical-inputs.aspx

U.S. Department of Agriculture, Economic Research Service. Agricultural Resource Management Survey data, http://www.ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices.aspx

Agricultural Production Management

Organic Farming Systems

Catherine Greene and Robert Ebel

The organic label is the most prominent food eco-label in the United States. In 2000, USDA published national organic standards that reflected decades of private-sector development. USDA's national regulatory program is designed to facilitate interstate trade, reduce consumer fraud, and provide consumer assurance that all organic products sold in the United States meet a high national standard. All organic growers, processors, and distributors are required to meet the national standard and be certified by a USDA-accredited State or private group unless they sell less than $5,000 annually in organic products.

USDA regulations define organic farming as an ecological production system that fosters resource cycling, promotes ecological balance, and conserves biodiversity. Organic farmers are required to avoid most synthetic chemicals and must adopt practices that maintain or improve soil conditions and minimize erosion. Organic production systems can be used to increase farm income, as well as reduce pesticide residues in water and food, reduce nutrient pollution, improve soil tilth and organic matter, lower energy use, reduce greenhouse emissions, and enhance biodiversity (U.S. Department of Health and Human Services, 2010; Greene et al., 2009; Ribaudo et al., 2008).

In 2005, USDA began to include targeted oversamples of organic producers in its Agricultural Resource Management Survey (ARMS), which collects detailed information about farmers' production practices, as well as costs and returns in major farm sectors. Some of the differences in practices and characteristics of organic and conventional production systems are apparent from survey responses by soybean, wheat, apple, and corn producers (fig. 3.5.1).

Consumer Demand Drives Growth in the Organic Sector

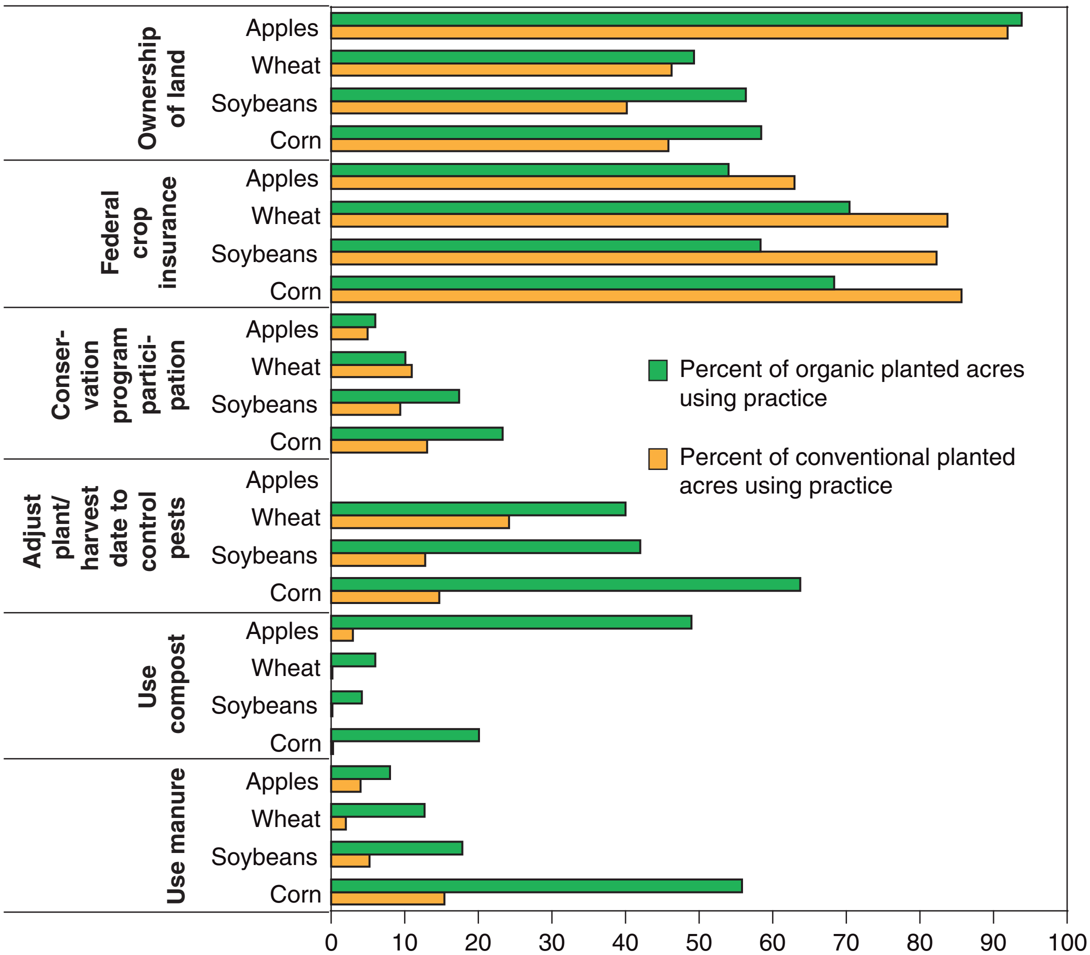
Organic food sales in the United States have increased from approximately $11 billion in 2004 to an estimated $25 billion in 2011 (fig. 3.5.2). Market penetration has also grown steadily; organic food products accounted for more than 3.5 percent of total U.S. food sales in 2011. Although the annual growth rate for organic food sales fell from the double-digit range in 2008 as the U.S. economy slowed, it still far outpaces the annual growth rate in all food sales (*Nutrition Business Journal*, 2012).

Adoption of Organic Systems Is Highest for Specialty Crops

U.S. producers dedicated approximately 4.8 million acres of farmland—2.7 million acres of cropland and 2.1 million acres of rangeland and pasture—to organic production systems in 2008 (latest year for which data are available). Top States for certified organic cropland include California, Wisconsin, North Dakota, Texas, and Minnesota (fig. 3.5.3). Top States for certified organic pasture and rangeland are Wyoming, New Mexico, Texas, California, and South Dakota. Overall, the adoption of organic farming systems is low—only about 0.7 percent of all U.S. cropland and 0.5 percent of all U.S. pasture was certified organic in 2008.

Figure 3.5.1

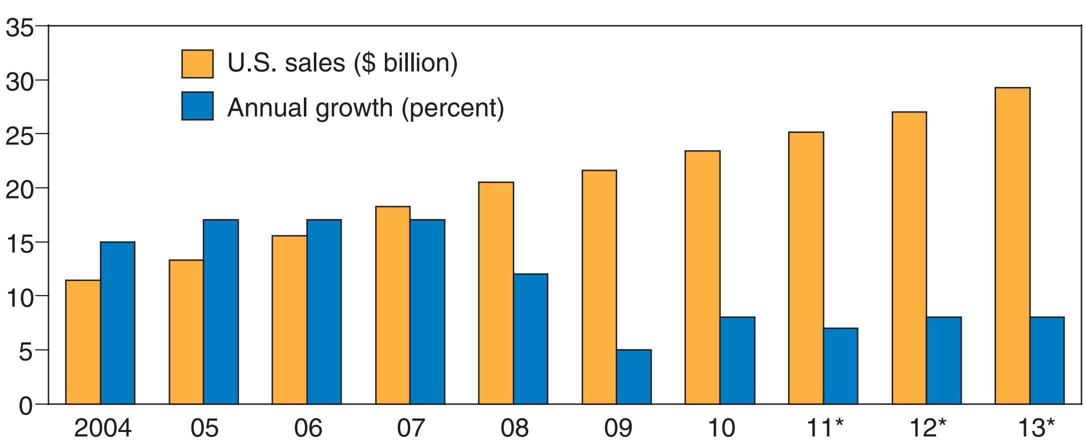
U.S. organic and conventional operations: selected characteristics and practices



Source: USDA, Economic Research Service and National Agricultural Statistics Service, based on data from the Agricultural Resource Management Survey.

Figure 3.5.2

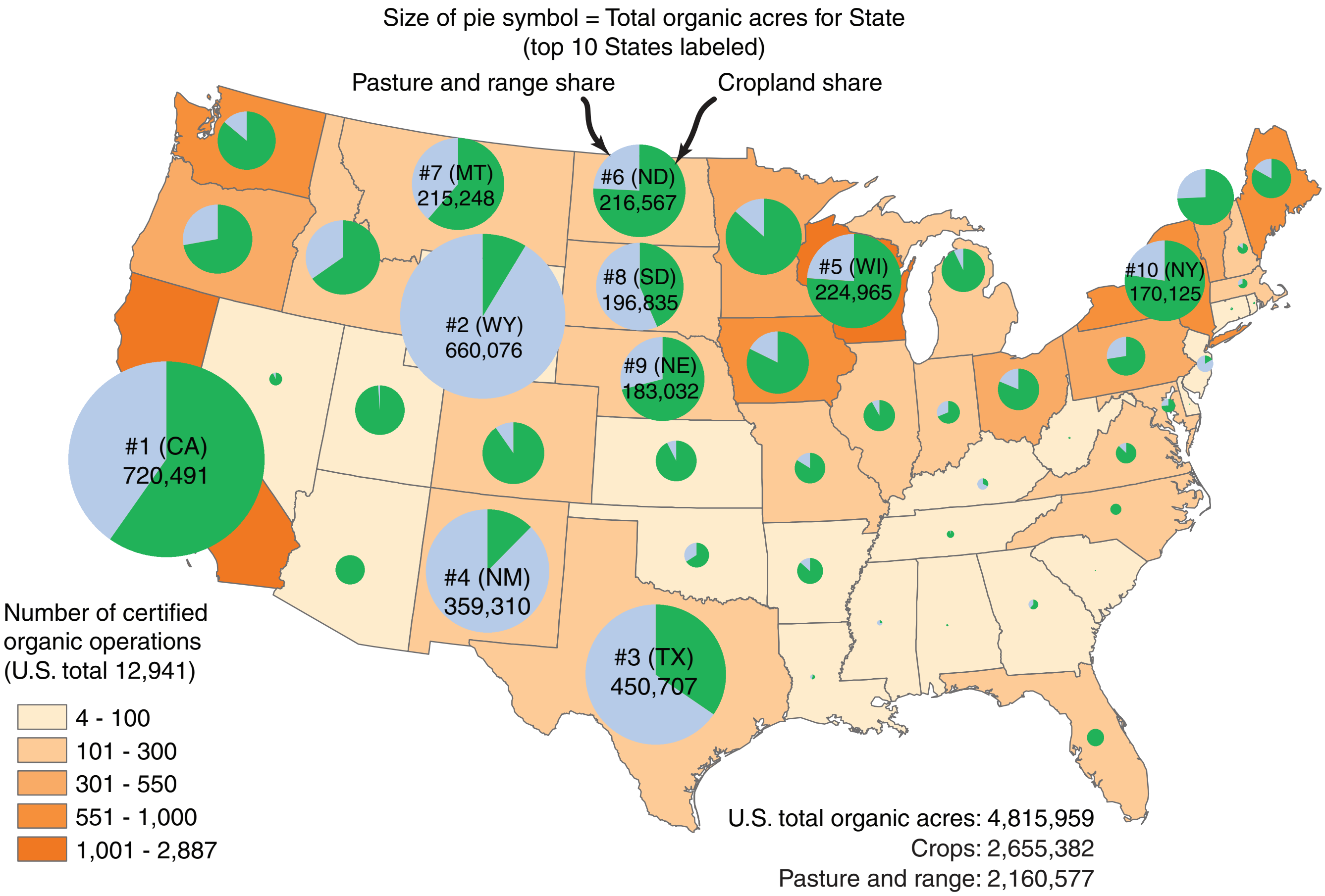
Organic food sales in the United States, 2004-2013



* 2011-13 estimates or projections. Source: *Nutrition Business Journal.*

Figure 3.5.3

Organic operations accounted for less than 1 percent of total crop acreage in 2008



Source: USDA, Economic Research Service, based on information from USDA-accredited certifiers.

Still, many U.S. producers are embracing organic farming in order to lower input costs, conserve nonrenewable resources, capture high-value markets, and boost farm income. While only a small percentage of the top U.S. field crops—corn (0.2 percent), soybeans (0.2 percent), and wheat (0.7 percent)—were certified organic in 2008, nearly 9 percent of U.S. vegetable crop acres and 3 percent of U.S. fruit and tree nut acres were grown under certified organic farming systems. Markets for organic vegetables, fruits, and herbs have been developing for decades in the United States, and fresh produce is still the top-selling organic category in retail sales. Organic livestock was beginning to catch up with produce in 2008, with 2.7 percent of U.S. dairy cows and 1.5 percent of layer hens managed under certified organic systems.

Obstacles to adoption by farmers include high managerial costs and risks of shifting to a new way of farming and limited knowledge of organic farming and marketing systems. According to Lynn Clarkson, a top organic grain broker, specific obstacles to adoption in organic grain production include the 3-year lag due to the organic transition period requirement, fewer organic marketing outlets, the need for onfarm storage, the lack of third-party contractors for organic pest and nutrient management, heavy managerial requirements, fear of criticism from neighbors, unknown risks, lack of government infrastructure support, and subsidies for ethanol that increase demand for conventional grain supplies (Clarkson, 2007).

Producers also face many challenges once they have shifted to organic production. Respondents to USDA's 2005 organic dairy producer survey indicated that certification paperwork and compliance costs were the most challenging aspect of organic milk production, followed by finding new organic sources of feed and dairy replacements, higher costs of production, and maintaining animal health (McBride and Greene, 2009). In the produce sector, a recent California study of small and mid-sized organic farmers, producing mostly fruit and vegetables, found that more than 80 percent reported marketing challenges—having too much or too little volume, obtaining organic price premiums, locating and accessing markets, handling competition, and accessing information on pricing (Cantor and Strochlic, 2009).

References

Cantor, Alida, and Ron Strochlic. 2009. *Breaking Down Market Barriers for Small and Mid-Sized Organic Growers*. California Institute for Rural Studies. Nov.

Clarkson, Lynn. 2007. "Review of economic impacts of production, processing, and marketing of organic agricultural products." Statement of the President of Clarkson Grain Co., Inc., Subcommittee on Horticulture and Organic Agriculture—Public Hearing. 110th Congress 2007-2008, Witness Opening Statements, House Committee on Agriculture, April 18.

Greene, C., C. Dimitri, B. Lin, W. McBride, L. Oberholtzer, and T. Smith. 2009. *Emerging Issues in the U.S. Organic Industry*. EIB-55. U.S. Department of Agriculture, Economic Research Service, June.

McBride, W.D., and C. Greene. 2009. *Characteristics, Costs, and Issues for Organic Dairy Farming*. ERR-82. Nov.

Nutrition Business Journal (NBJ). 2012. U.S. organic food sales – chart 22. Penton Media, Inc.

Ribaudo, M., L. Hansen, D Hellerstein, and C. Greene. 2008. *The Use of Markets To Increase Private Investment in Environmental Stewardship*. ERR-64. U.S. Department of Agriculture, Economic Research Service, Sept.

U.S. Department of Agriculture, Agricultural Marketing Service. 2000. "National Organic Program; Final Rule, 7 CFR Part 205," *Federal Register*, Dec. 21, www.usda.gov/nop

U.S. Department of Agriculture, Economic Research Service. 2009. Data sets: Organic Production. http://www.ers.usda.gov/data-products/organic-production.aspx

U.S. Department of Agriculture, Economic Research Service. 2011. Data sets: ARMS Farm Financial and Crop Production Practices. http://www.ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices.aspx

U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute. 2010. *Reducing Environmental Cancer Risk: What We Can Do Now, President's Cancer Panel, 2008-09 Annual Report*, April.

For more information, see...

U.S. Department of Agriculture, Economic Research Service. 2012. "Organic Agriculture." http://www.ers.usda.gov/topics/natural-resources-environment/organic-agriculture.aspx

Conservation Policies

Conservation Spending

Roger Claassen

Some farming practices can degrade natural resources and the environment. Runoff and leaching of sediment, nutrients, and pesticides, for example, can impair water quality. Other practices can preserve and enhance our natural heritage and provide substantial benefits through careful management of agricultural land. Enhancing wildlife habitat on agricultural land—for example, by providing nesting habitat for migratory birds—can help increase wildlife populations. USDA's conservation programs help agricultural producers improve their environmental performance in many ways, including soil quality, water quality, air quality, wildlife habitat, and greenhouse gas emissions.

A Portfolio of Incentives

The USDA conservation effort relies mainly on voluntary incentive programs to address natural resource issues. This approach can avoid the inherent difficulties in regulating nonpoint sources of pollution and can minimize economic harm to farmers by offering a range of incentives and assistance programs:

- Land retirement programs generally compensate contract holders for removing land from agricultural production for a period of 10 or more years and, in some cases, permanently. Retired land must be planted to buffers, grass or trees, or restored to wetland condition.
- Working-land programs provide technical and financial assistance to farmers who install or maintain conservation practices that support crop and livestock production. Common practices include nutrient management, conservation tillage, field-edge filter strips, and fences to exclude livestock from streams.
- Agricultural land preservation programs purchase rights to certain land uses, such as housing or other development, to maintain land in agricultural use.
- USDA provides, through Conservation Technical Assistance, ongoing technical assistance to agricultural producers who seek to improve the environmental performance of their farms.

Environmental compliance is a notable exception to the largely voluntary nature of U.S. agri-environmental programs. Under highly erodible land conservation provisions (often referred to as "Sodbuster" for land not cropped before 1985 and "Conservation Compliance" for land cropped before 1985), farmers who crop highly erodible land must apply an approved soil conservation system or risk losing nearly all agriculture-related farm program benefits, including commodity, conservation, and disaster payments. Under wetland conservation (often referred to as "Swampbuster"), producers must refrain from draining wetlands or face the loss of most agriculture-related program benefits.

Conservation Spending Has Been Rising

Through USDA, the Federal Government invested more than $5.5 billion in voluntary agricultural conservation incentives in fiscal year (FY) 2010 (table 4.1.1). Land retirement captured the largest share of conservation spending (46 percent in FY2010), although funding for working-land programs was substantial (35 percent). Most of the remaining expenditures were for Conservation Technical Assistance (14 percent) and agricultural land preservation (5 percent).

Since the mid-1980s, USDA conservation program spending has been on the rise (fig. 4.1.1). In 1986, with the beginning of the Conservation Reserve Program (CRP), USDA conservation spending was dramatically increased. For the next 17 years, until 2003, land retirement

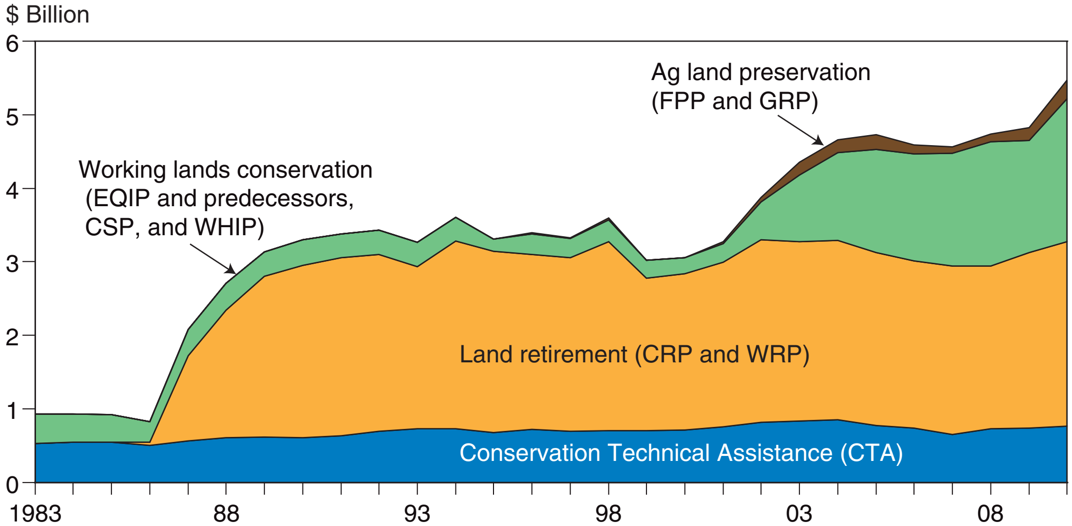
Table 4.1.1
Funding for major conservation programs, 2007-10

Program and program type	2007	2008	2009	2010
	Budget authority (*$ million*)			
Land retirement programs				
Conservation Reserve Program (CRP)	1,948	1,991	1,934	1,884
Emergency Forestry Conservation Reserve Program			10	8
Voluntary Public Access			0	12
Wetland Reserve Program (WRP)	248	183	436	630
Subtotal—land retirement	2,196	2,174	2,380	2,534
Working land programs				
Environmental Quality Incentives Program (EQIP)	993	1,200	1,067	1,174
Agricultural Water Enhancement Program	60	60	73	72
Conservation Security Program* (CSP)	382	317	276	222
Conservation Stewardship Program**	0	0	9	390
Wildlife Habitat Incentives Program (WHIP)	42	85	85	83
Subtotal—working land	1,477	1,662	1,510	1,941
Agricultural land preservation				
Farm and Ranch Land Protection Program (FPP)	73	96	121	150
Grassland Reserve Program (GRP)	13	3	48	100
Subtotal—land preservation	86	99	169	250
Other programs				
Healthy Forest Reserve Program	2	2	10	8
Chesapeake Bay Watershed	0	0	23	43
Agricultural Management Program	5	7	15	15
Subtotal—other programs	7	9	48	66
Conservation Technical Assistance	627	712	730	762
Total, major conservation programs	4,393	4,656	4,837	5,553

*Discontinued by the 2008 Farm Act, although some funding continues because multi-year contracts are still active.
**Created by the 2008 Farm Act.

Source: ERS analysis of USDA, Office of Budget and Program Analysis (OBPA) data.

Figure 4.1.1
Trends in USDA conservation expenditures, 1983-2010*



*Constant (2010) dollars.
See full names of programs (EQIP, etc.) in table 4.1.1, p. 42.
Source: ERS analysis of USDA Office of Budget and Policy Analysis (OBPA) data.

dominated USDA conservation spending. During this period, about 90 percent of USDA conservation payments made directly to farmers went for land retirement. Beginning in 2003, conservation spending took another leap, largely because of a dramatic increase in funding for working-land conservation programs. Most of the new money went to the Environmental Quality Incentives Program (EQIP) and the Conservation Security Program (CSP; superseded by the Conservation Stewardship Program). Between 2003 and 2010, working-land program funding grew nearly tenfold.

With the growth of conservation programs over the past 25 years, conservation spending for fiscal year 2010—expressed in constant dollars—was higher than at any time since 1960. In 1960 at the height of the Soil Bank program (a large land retirement program initiated in 1956), conservation program funding was almost $5.8 billion in 2010 dollars.

It is not clear that conservation spending will continue to rise in the future. The **Food, Conservation, and Energy Act of 2008** reduced the CRP acreage cap to 32 million acres, slowing spending in that program. If the demand for major commodities (e.g., corn, soybeans, and wheat) continues to be strong and market prices for these commodities continue to be well above historic levels, farmers may be unwilling to enroll land in CRP unless annual payments are increased to match the profits from crop production. Under such a scenario, CRP expenditures could jump or the program's acreage could shrink.

For more information, see...

U.S. Department of Agriculture, Economic Research Service. 2012. "Conservation Programs."
http://www.ers.usda.gov/topics/natural-resources-environment/conservation-programs.aspx

Conservation Policies

Conservation Reserve Program: Status and Trends

Daniel Hellerstein

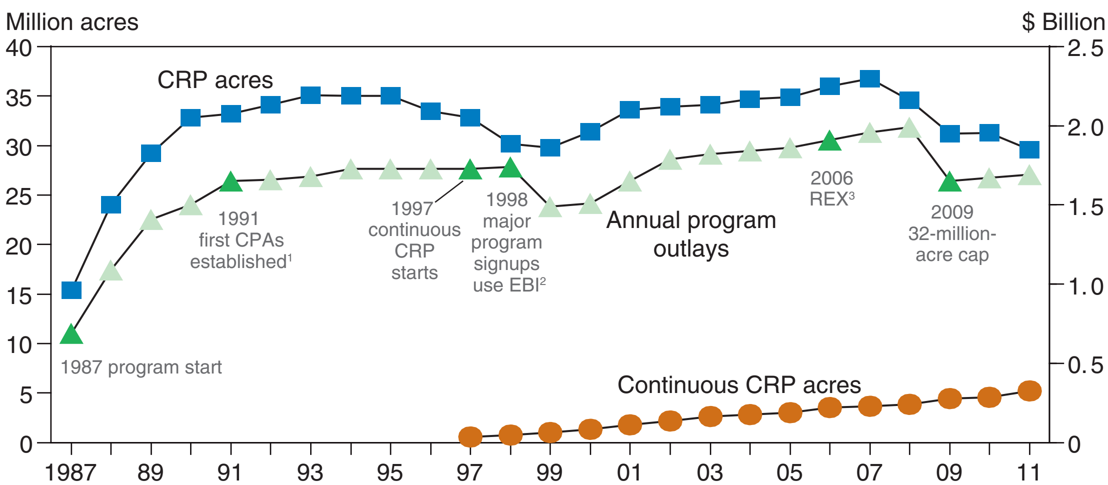
Now over 25 years old, as of June 2012 the Conservation Reserve Program (CRP) removes over 29 million acres of environmentally sensitive farmland from crop production under 10- to 15-year contracts. Over time, the program's size and goals have changed, from its early emphasis on limiting crop production and soil erosion to one that now considers a broad set of conservation goals including wildlife, soil, water, and air quality. Driven by improvements in conservation practices and changes in legislative mandates, commodity markets, and environmental concerns, the CRP continues to evolve.

The 2008 Farm Act capped the program at 32 million acres, down from a peak enrollment of 36.8 million acres in 2007. The required reduction was achieved by limiting 2009 contract extension offers to only 1.5 million of the 4.3 million expiring acres, yielding extensions on 1.1 million acres. High commodity prices also may be affecting program enrollment. CRP rental rates are based on county average cropland rental rates that, while updated periodically, may not reflect farmers' long-term expectations. For example, between 2006 and 2011, net farm income increased by about 80 percent while the cropland rental rates used by the program rose by about 40 percent.

As program acres shrank, in the 2010 and 2011 general signups a higher-than-usual proportion of offers were accepted into the CRP—75 percent and 86 percent of offers respectively

Figure 4.2.1

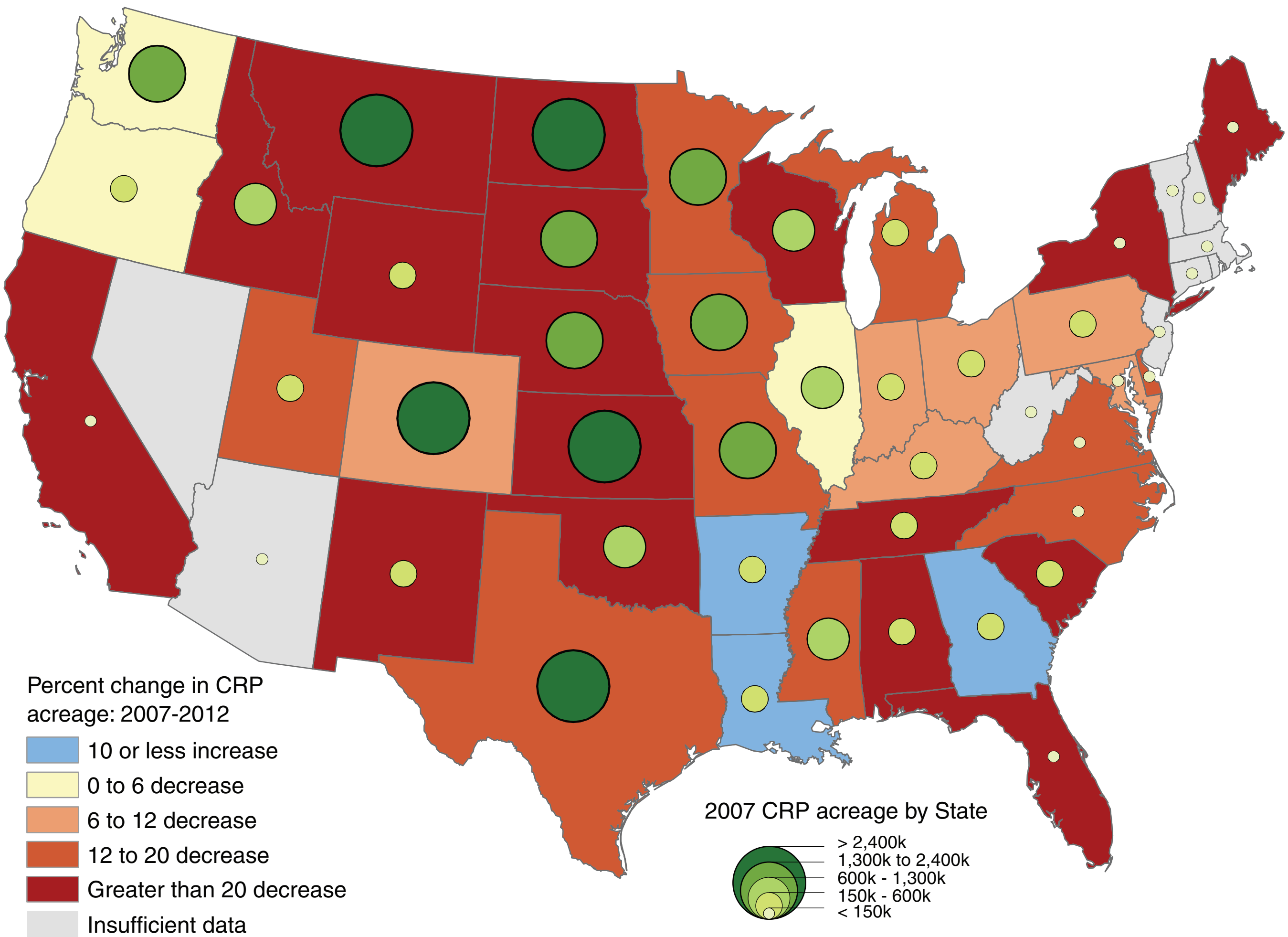
While total enrollment in the CRP has contracted since 2007, acreage addressing high-priority environmental concerns has expanded through continuous signups



[1]CPA = Conservation Priority Areas identified as being in need of protection.
[2]EBI = Environmental Benefits Index used to rank offers.
[3]REX = Re-enrollment and Extension Program allowed farmers with contracts expiring between 2007 and 2010 to either re-enroll their lands or extend their contracts for up to 5 years. About 82 percent, or 28 million acres, were approved for re-enrollment or extension.

Source: USDA, Economic Research Service.

Figure 4.2.2
CRP acres in 2007, and percent change 2007 to 2012



(compared with an acceptance rates ranging between 48 and 74 percent in the signups between 1997 and 2006). A high share of offered acres were re-enrollments (over 85 percent in 2011), suggesting that the pool of landowners interested in the CRP may be shrinking. Furthermore, enrollment seems to be shifting toward less productive land, with rental payments for newly accepted general signup acres basically constant between 2006 and 2011.

As the total acreage enrolled via CRP's general signups has declined, "continuous signups"—including land in one of the many State-Federal conservation partnerships under the Conservation Reserve Enhancement Program (CREP)—have increased. This acreage, which is targeted to address high-priority environmental concerns and is subject to more stringent eligibility requirements, grew from 3.7 million acres in 2007 to over 5.3 million acres in June 2012. Further growth in continuous signups is likely as targeted conservation practices and sites are identified. For example, about three-fourths of the 850,000 continuous signup acres allocated to the 2008 State Acres for Wildlife Enhancement initiative have been enrolled. New initiatives continue to emerge, such as the Louisiana Coastal Prairie CREP and expansion of Nebraska's Platte-Republican CREP, as high valued conservation opportunities are developed.

References

Hellerstein, Daniel, and Scott Malcolm. 2011. *The Influence of Rising Commodity Prices on the Conservation Reserve Program*. ERR-110, USDA, Economic Research Service, Feb. http://www.ers.usda.gov/publications/err-economic-research-report/err110.aspx.

U.S. Department of Agriculture, Farm Service Agency. 2011. Conservation Reserve Program Statistics, http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=rns

For more information, see…

Hellerstein, Daniel. 2012. "Recent Conservation Reserve Program Enhancements Signal Changing Priorities," *Amber Waves*, Vol. 10, Issue 1, (March).

Conservation Policies

Working-Lands Conservation Programs

Marc Ribaudo

With each of the last two Farm Acts, Congress has directed an increasing proportion of conservation funding toward programs that assist producers in implementing conservation activities on working lands (lands that are in active agricultural production). Much of the 17-percent increase in conservation funding authorized by the 2008 Farm Act goes toward two working-lands programs—the Environmental Quality Incentives Program and the Conservation Stewardship Program. These programs provide producers with financial and technical assistance for implementing and managing a wide range of conservation practices for crop, livestock, and forest production.

Two Different Program Designs Are Used

The Environmental Quality Incentives Program (EQIP) is the largest working-lands program in terms of funding and acreage. Established in 1996, EQIP's principal objective is to (1) promote production and environmental quality as compatible goals, (2) optimize environmental benefits, and (3) help farmers and ranchers meet Federal, State, and local regulatory requirements. Financial assistance is in the form of a cost share. Farmers seeking to participate in EQIP complete an application indicating which land on the farm will be enrolled, which resource concerns will be addressed, and what practices will be used. Contract selections are made at the State or local level. Total authorized funding for 2008-12 is $7.25 billion, 60 percent of which is targeted to natural resource concerns related to poultry and livestock production. The remainder is directed toward practices that address conservation priorities on working cropland. In 2010, EQIP obligated $839 million to treat 13 million acres of land.

The goal of the Conservation Stewardship Program (CSP) is to encourage producers to address resource concerns in a comprehensive manner by (1) undertaking additional conservation activities, and (2) improving, maintaining, and managing existing conservation activities. To participate in CSP, farmers and ranchers must, at minimum, have already addressed at least one resource concern throughout their farm, and agree to address at least one additional priority resource concern during the 5-year contract term. CSP pays participants for conservation performance—the higher the performance, the higher the payment. Performance is measured with the Conservation Measurement Tool. Using a point-based scoring system, the environmental benefits associated with each activity are assessed. Additional activities receive a higher payment rate than existing activities. This creates an incentive for landowners to provide more conservation than a simple cost-share might. The 2008 Farm Act directs the U.S. Secretary of Agriculture to enroll 12.77 million acres per year into CSP at an average cost of $18 per acre, or about $230 million per year. In 2010, CSP obligated $320 million to enroll 25 million acres of land.

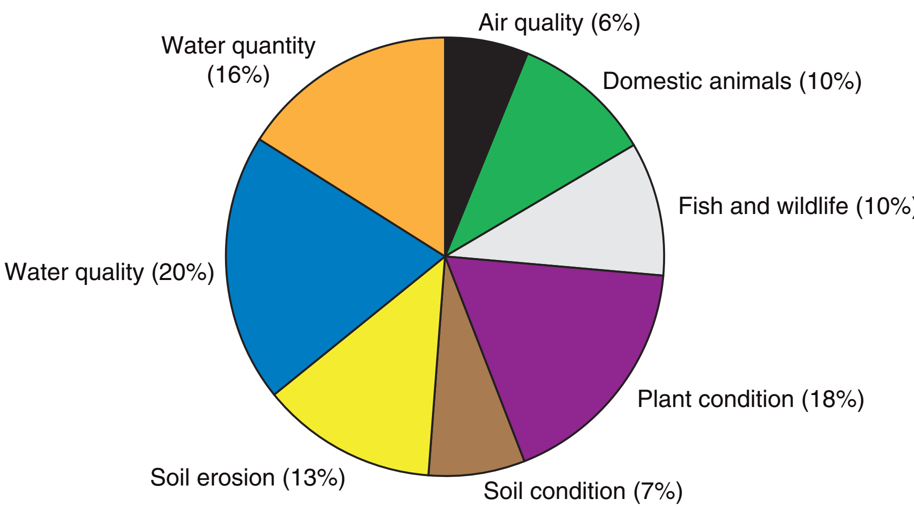
Multiple Resource Concerns Are Addressed

Working-lands programs address multiple resource concerns on farms, including air quality (odor, gaseous emissions), livestock and poultry (manure), fish and wildlife habitat, plant condition (forage quality, noxious and invasive plants), soil condition (organic matter, compaction, salinity), soil erosion, water quality, and water quantity (drainage, irrigation). Water quality, plant condition, and water quantity received the largest shares of financial assistance in the EQIP program (fig. 4.3.1). (Similar data are not available for CSP.)

Resource concerns addressed through EQIP vary widely across regions, driven largely by climate and predominant types of agriculture (fig. 4.3.2). Water quantity is a major issue in regions where irrigated crops are common: the Basin and Range, Mississippi Portal, Fruitful Rim, and Prairie Gateway regions. Water quality and soil erosion are major concerns in the Heartland, Mississippi Portal, Southern Seaboard, and Northern Crescent regions.

Figure 4.3.1

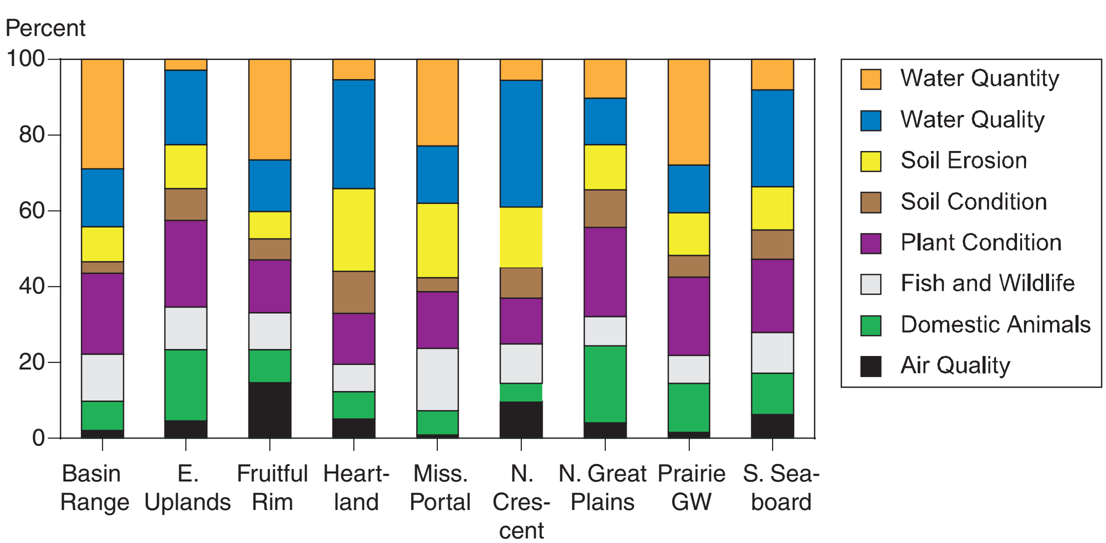
Distribution of EQIP contract obligations by resource concern, 2008-10



Source: USDA, Natural Resources Conservation Service contract data, 2008-10.

Figure 4.3.2

Distribution of EQIP contract obligations by resource concern and region, 2008-10



Source: USDA, Natural Resources Conservation Service contract data, 2008-10.