

Environmental Services From Agriculture

Environmental services from agriculture are a subset of ecosystem services from agriculture. Ecosystem services are defined by the United Nations' Millennium Ecosystem Assessment as the "benefits people obtain from ecosystems" (Millennium Ecosystem Assessment, 2003, p. 3). These include a wide range of provisioning, regulating, cultural, and supporting services. Both unmanaged and managed ecosystems (such as agricultural lands) can provide these services.

Farmers and ranchers constitute the largest group of natural resource managers in the world (Food and Agriculture Organization of the United Nations, 2007). Farms exist to produce food, fuel, and fiber and to sell them to consumers. However, farms also produce many other ecosystem services as externalities, in that they are unintended consequences of the primary production activities on the farm and those who are affected cannot influence their production. Farms can produce externalities as part of the production process (generally negative externalities, such as nutrient runoff or air pollution) or land use decisions (positive externalities, such as wildlife, wetland services, and water quality from farmland not planted to crops).

In this report, environmental services refer to positive externalities that result from stewardship on the farm (table 2.1). These externalities could include improved water quality from changes in crop management, carbon sequestration from converting cropland to forests, wetland services from preserving a wetland, and enhanced wildlife habitat by providing adequate food, cover, and nesting habitat.

Table 2.1

Some environmental services and farm management options

Environmental service	Farm-level management option
Carbon sequestration in soils	Manage soil organic matter
Carbon sequestration in perennial plants	Convert cropland to grassland or forest
Methane emission reduction	Capture and destroy methane from animal waste storage structures
Water quality maintenance	Reduce agrichemical use, establish vegetative buffers, improve nutrient management
Erosion and sediment control	Manage soil conservation and runoff, increase soil cover
Flood control	Create diversions, wetlands, storage ponds
Salinization and water table regulation	Grow trees, manage water
Wildlife	Protect breeding areas and wild food sources, improve timing of cultivation, increase crop species/varietal diversity, reduce use of toxic chemicals

Source: Food and Agriculture Organization of the United Nations, 2007.

Natural capital possesses the capacity of giving rise to the flow of environmental services (Boyd and Banzhaf, 2006; Costanza et al., 1997; Elkins, 2003). The natural capital that agricultural producers control is the land, water, air, and genetic resources on their farms. How these resources are managed affects the type and level of environmental services that can be produced.

Agriculture controls a large amount of natural capital in the United States. In 2002, private farms accounted for 41 percent of all U.S. land, including 434 million acres of cropland, 395 million acres of pasture and range, and 76 million acres of forest and woodland (USDA, National Agricultural Statistics Service, 2004). This capital can provide a host of environmental services, including water quality, air quality, flood control, wildlife, and carbon sequestration. These services can be consumed directly or combined by consumers with other goods to create final goods, such as sightseeing, fishing, wildlife viewing, or hunting. In this report, we focus on the provision of water quality, greenhouse gas reduction, wildlife, and wetland services. Markets have been developed for providing these services, and these are the ones specifically mentioned in the USDA policy on markets for environmental services (USDA, Natural Resources Conservation Service, 2006b).

Water Quality

The potential for agriculture to supply water quality improvement is defined largely by the significant *negative* impact that agriculture has historically had on water quality. Current production practices and inputs used by agriculture can result in a number of pollutants—including sediment, nutrients, pathogens, pesticides, and salts—entering water systems. Pollution from agriculture is generally exempt from regulations under the Clean Water Act, so agricultural producers have little incentive to address these largely offsite impacts.

Although no comprehensive national study of agriculture and water quality has been conducted, the magnitude of the impacts can be inferred from several water quality assessments. EPA's 2000 Water Quality Inventory reports that agriculture is the leading source of pollution in 48 percent of river miles, 41 percent of lake acres (excluding the Great Lakes), and 18 percent of estuarine waters that are impaired. The inventory shows these bodies of water to be water-quality impaired in that they do not support designated uses, such as swimming and aquatic life (U.S. EPA, 2002). The findings mean that agriculture is the leading source of impairment in the Nation's rivers and lakes and a major source of impairment in estuaries.

Agricultural producers can improve water quality by reducing the discharge of nutrients, pesticides, sediment, and other agricultural pollutants to water resources. The Natural Resources Conservation Service's (NRCS) technical field guide lists over 300 management practices that can improve water quality (USDA, NRCS, 2007b). These practices include conservation tillage, nutrient management, strip cropping, irrigation management, pesticide management, manure storage structures, vegetative buffer strips, fencing, and livestock watering facilities. Farmers can also retire cropland in sensitive areas and improve or restore wetlands to filter sediment and nutrients.

Air Quality

Agricultural production releases a wide variety of material into the air. Field operations produce windblown soil, nitrogen gases, and pesticides. Animal operations release hydrogen sulfide, ammonia, methane, volatile organic compounds, and odors. Internal combustion engines in field equipment and irrigation pumps and field burning produce fine particulates and nitrogen oxides. These pollutants may affect people's health, reduce visibility, and contribute to global warming or may simply be a nuisance. Agriculture can improve air quality by reducing the release of these materials through changes in soil, water, chemical, and manure management.

Greenhouse gases have been of particular recent interest due to their role in global climate change. Agriculture is both a source and a sink (storage in soil and in biomass) of greenhouse gases. It is a relatively small source of greenhouse gas emissions, accounting for about 8 percent of all U.S. greenhouse gas (GHG) emissions in 2005 (USDA, Office of the Chief Economist, 2007). The most important GHG emissions from agriculture are nitrous oxide (N₂O) and methane (CH₄). Agricultural soil management (60 percent), enteric fermentation (25 percent), manure management (13 percent), rice cultivation (2 percent), and agricultural residue burning (less than 1 percent) are the sources of agricultural GHG emissions.

Agriculture can sequester (store) carbon in soils and biomass, thus offsetting GHG emissions. Carbon entering the soil is stored primarily as soil organic matter. Agricultural soils sequestered an estimated 12.4 million metric tons carbon equivalent in 2004, less than 1 percent of U.S. emissions (U.S. EPA, Office of Atmospheric Program, 2006). Studies indicate that it may be *technically* possible to sequester an additional 89-318 million metric tons of carbon annually on U.S. croplands and grazing lands through various management practices, such as conservation tillage, crop rotations, and fertilizer management, or up to 16 percent of 2004 emissions (Lewandrowski et al., 2004). Shifting cropland to grasslands or forest could increase sequestration even more.

Wildlife

U.S. agriculture is in a unique position with respect to the Nation's wildlife resources. The historic development of U.S. agriculture required the development of large amounts of native grasslands, wetlands, and forests for agricultural purposes. Management of the Nation's farms and ranches can play a major role in protecting and enhancing its wildlife. Because of the dominance of private land ownership in the United States, Federal and State governments cannot exercise effective responsibility for wildlife management without productive collaboration with private land managers (Benson, 2001b; Conover, 1998).

The quality of wildlife resources is a function of the amount, quality, and diversity of habitat. Grasslands and wetlands are two common types of habitat that can be protected, restored, or improved through conservation on agricultural lands.

Grassland Habitat

Grasslands constitute the largest land cover on America's private lands. These lands provide biodiversity of plant and animal populations and play a key role in environmental quality. Grasslands also improve the aesthetic character of the landscape, provide scenic vistas, open spaces, and recreational opportunities, and protect soil from water and wind erosion.

Large expanses of grassland acreage are annually threatened by conversion to other land uses, such as cropland and urban development. About half of all U.S. grasslands have been lost since settlement, much due to conversion to agricultural uses (Conner et al., 2001).

Wetland Habitat

Wetlands are complex ecosystems that provide many ecological functions valued by society. They take many forms, including prairie potholes, bottomland hardwood swamps, coastal salt marshes, and playa wetlands. Wetlands are known to be the most biologically productive ecosystems in temperate regions. More than a third of threatened and endangered species in the United States live only in wetlands, and nearly half use wetlands at some point in their lives (U.S. EPA, Office of Water, 1995a). Most freshwater fish depend on wetlands at some stage of their lives. Many bird species depend on wetlands for either resting places during migration, nesting or feeding grounds, or cover from predators. Wetlands are also critical habitat for many amphibians and fur-bearing mammals. Besides supporting wildlife, wetlands also supply water pollution control, flood control, water supply protection, and recreation.

When the country was first settled, there were 221-224 million acres of wetlands in the continental United States (Heimlich et al., 1998). Since then, about half have been drained and converted to other uses, nearly 85 percent for agricultural uses. Currently, there are about 111 million acres of wetlands on non-Federal lands (USDA, NRCS, 2004b). About 15 percent are on agricultural lands (cropland, pastureland, and rangeland).

Demand for Environmental Services

The existence of a market for an environmental service requires that potential consumers are willing to pay a price for those services. Numerous studies have found that people are in fact willing to pay for environmental services from agriculture (Environmental Valuation Reference Inventory, 2007). These findings do not mean a market should exist, but they are a prerequisite for a market to exist.

Another indication that demand for environmental services exists is that State and Federal governments have developed many programs to supply them, implicitly reflecting public demand. Conservation programs, such as the Conservation Reserve Program, Wetland Reserve Program, Environmental Quality Incentives Program, and Farm and Ranch Protection Program, provide financial and technical incentives to agricultural producers to retire land, adopt management practices that protect and enhance environmental quality, or preserve farmland. In recent years,

USDA has spent over \$4.5 billion per year on such programs (USDA, Economic Research Service, 2007a).

Environmental regulations are also used to ensure that environmental services are provided. Regulations in the Clean Water Act; Clean Air Act; Federal Insecticide, Fungicide, and Rodenticide Act; and Endangered Species Act keep harmful chemicals from water and air, prevent wetland loss, and protect habitat for endangered species. These and other regulations have been created because the public demands that environmental services be protected. Agriculture, however, is often exempt from these regulations, which leaves other mechanisms, such as financial assistance, to provide incentives for agriculture to increase its production of environmental services.

Demand for environmental services can also be expressed through private actions, such as the purchase of conservation easements by land trusts. Land trusts are one alternative mechanism by which individuals can choose to act privately to address the failure of both governments and private markets to provide environmental services (Sundberg, 2006). They preserve and increase environmental services, based on the perception of their members' interests, by obtaining fee title or conservation easements of land they want to protect. The United States had over 1,600 land trusts, protecting open space and habitat on over 37 million acres of land, in 2005 (Land Trust Alliance, 2006). About 1.2 million acres per year are added to the rolls of privately conserved land.

Summary

Agriculture controls natural capital that can provide environmental services. There is much evidence that people value these services, yet there is longstanding concern over their continued loss. Government programs and nongovernment efforts have been developed to motivate agricultural producers to provide environmental services. These efforts raise the question of why landowners do not market and sell these services as they do agricultural commodities, thereby attaining an additional stream of income. The next chapter reviews the function of markets and the reasons that markets fail to develop.