ATTRA Sustainable Agriculture
A program of the National Center for Appropriate Technology • 800-346-9140 • www.attra.ncat.org

Payments for Ecosystem Services

By Colin Mitchell, NCAT Sustainable Agriculture Specialist and Dr. Barbara Bellows, Assistant Research Scientist, Texas Institute for Applied Environmental Research
Published June 2020

IP596

Texas Institute for Applied Environmental RESEARCH

Contents

SOUTHERN SARE Sustainable Agriculture Research & Education

This material is based upon work supported by the Southern Sustainable Agriculture Research and Education program through Research and Education grant award number LS14-264: Indicators and Soil Conservation Practices for Soil Health and Carbon Sequestration.

ATTRA *(www.attra.ncat.org)* is a program of the National Center for Appropriate Technology (NCAT). The program is funded through a cooperative agreement with the United States Department of Agriculture's Rural Business-Cooperative Service. Visit the NCAT website (*www.ncat.org*) for more information on our other sustainable agriculture and energy projects.

NCAT

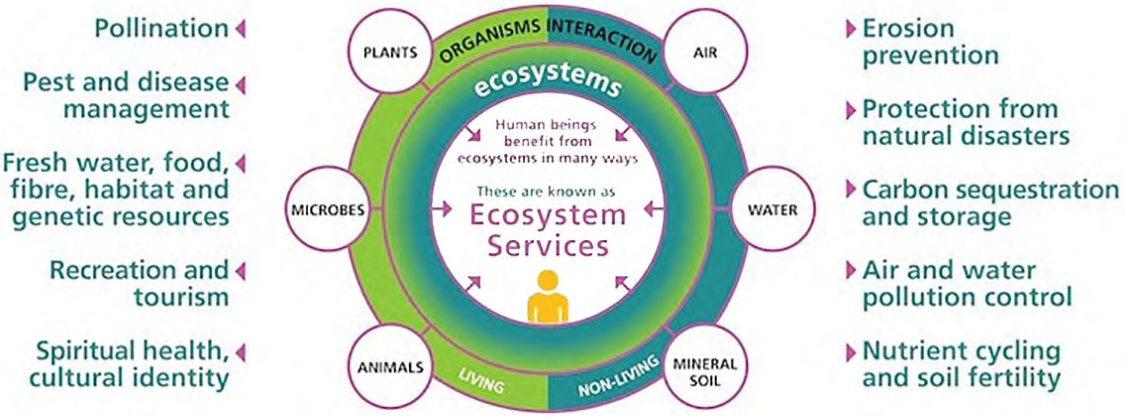
Since the 1960s, there has been discussion among academics about paying farmers for their contribution to a healthier environment. Today, programs make this concept a reality: payments reward farmers for improved and maintained ecosystem services, or the benefits that society receives from the environment, such as clean water, food, air quality, disease regulation, and more. There are four program types: direct payments, certifications, tax incentives, and ecosystem service markets. This publication explains each of these types in detail, with multiple case studies. Finally, it offers considerations that farmers can use to decide if enrolling in an ecosystem services market is a beneficial business decision.

Photo: USDA Natural Resources Conservation Service

Introduction

Farmers implementing conservation-based or sustainable agriculture practices such as cover cropping, minimum tillage, or rotational grazing don't just enhance soil health and long-term crop or forage production. They also provide numerous benefits to society. A healthy soil efficiently recycles nutrients and filters contaminants, thereby protecting ground and surface water quality. These practices can also remove greenhouse gases (GHG) from the atmosphere and thus mitigate global climate change. Increasingly, environmentalists and economists are acknowledging that promoting the health of the natural environment and its ecological systems can improve the health and well-being of individuals and communities. The ecological benefits that nature provides to society are called *ecosystem services.*

Just as society depends on these ecosystem services, so do farmers and ranchers. Sustainable crop production and ecosystem health are grounded in vital ecological interactions and provide economic resiliency (Cong et al., 2014). Unfortunately, start-up or transition costs often prohibit adoption of many agricultural conservation practices, thus preventing farmers from obtaining potential economic benefits, as well as preventing society from obtaining the benefits from ecosystem services. But, fortunately, there is increasing interest in paying farmers to adopt practices that provide these services.



Source: Consultative Group for International Agricultural Research
https://wle.cgiar.org/content/what-are-ecosystem-services

Related ATTRA Publications
www.attra.ncat.org

Agriculture, Climate Change, and Carbon Sequestration

Building Healthy Pasture Soils

Federal Conservation Resources for Sustainable Farming and Ranching

Managing Soils for Water: How Five Principles of Soil Health Support Water Infiltration and Storage

Planning for Profit in Sustainable Farming

Ecosystem Services Background

As awareness of environmental pollution and resource scarcity increased from the 1960s to the 1980s, ecologists began to recognize how the overuse of natural resources resulted in habitat degradation and vulnerability of ecosystems (Braat and De Groot, 2012; Costanza et al., 2017). Economists then started examining how these environmentally destructive practices affected the prices people paid for food, fiber, forest products, and other goods and services they obtain from nature (Schumacher, 1973). The term *ecosystem services* was used first in 1981 by Paul and Anne Ehrlich to describe the impact of ecosystem ecology on environmental and resource economics (Constanza et al., 2017).

By 1997, the concept of ecosystem services started to gain more widespread attention, aided by the release of Gretchen Daily's book, *Nature's Services: Societal Dependence on Natural Ecosystems* and the *Nature* article "The value of the world's ecosystem services and natural capital "(Costanza et al., 2017). This seminal article was the first time that the Earth's ecosystems and the services they provide were given economic values, which created considerable attention and controversy. The *Nature* article's minimum valuation of the world's ecosystems caused alarm because it was in the range of $16 trillion to $54 trillion per year, with an average of $33 trillion per year, which was larger than the global gross domestic product (GDP). Now, most economists accept that "ecosystem services analysis can help recognize the full costs and benefits of land management decisions" (Johnson et al., 2012).

However, there are those who oppose evaluating ecosystem services because of the risks of putting a price on the natural environment. Some have argued that the natural environment and all the species that inhabit it should be conserved and protected because they have a right to exist just as we do, not because of their economic value. Others are against attaching a price to ecosystem services, because by doing so we turn the environment into a service provider akin to a cable or chemical company that folds right into the global market, which neglects the cultural and psychological value of nature (Conniff, 2012).

Despite these arguments, placing an economic value on ecosystem services recognizes the extra costs people have to pay when ecosystems are degraded. For example, a soil that is eroded or depleted of organic matter has decreased capacity to hold water and nutrients for productive crop or forage growth. Valuing ecosystem services also recognizes that businesses, including mining, energy, farming, and transportation industries, often do not pay for the degradation they have caused (Tietenberg and Lewis, 2016). Generally, energy companies are not required to account for their release of carbon dioxide into the atmosphere in the same way that they need to account for their labor costs. Instead, society at large bears the economic burdens of climate change in the form of increased health and disaster-relief costs. As air and water quality degrade, people are increasingly paying for this degradation with their health or through environmental restoration and treatment costs. Payments for ecosystem services provide a way to pay for environmental protection and restoration that directly addresses the cost as an operating expense of the business.

What are Ecosystem Services?

According to the Millennium Ecosystem Assessment, "Ecosystem services (ES) are the ecological characteristics, functions, or processes that *directly or indirectly* contribute to human wellbeing: that is, the benefits that people derive from functioning ecosystems" (Costanza et al., 2017; Millennium Ecosystem Assessment, 2005). Ecosystem services are different than ecosystem processes and functions. Ecosystem processes and functions exist in an ecosystem whether or not humans benefit from them (Braat and De Groot, 2012). Ecosystem services, on the other hand, are a human-made economic tool that measures benefits people get from ecosystem processes and functions, whether people experience these benefits directly or indirectly and whether they are conscious of them or not. When the earth's ecosystems and their processes are functioning well, they provide benefits that are integral to humanity's well-being. Our health is tied to the health of our ecosystems. Ecosystem services have been broken down into four different categories by the UN Food and Agriculture Organization:

- *Provisioning Services:* Material or energy outputs from ecosystems and include food, raw materials, and more.
- *Regulating Services:* These come from the regulation of ecosystem process and include water purification, air quality, pollination, and more.
- *Cultural Services:* Non-material things that benefit society, such as recreation, cultural identity, and aesthetic value.
- *Supporting Services:* Having living spaces for plants and animals and the maintenance of biodiversity are supporting services, which are the foundation of all ecosystems and their services.

Images show erosion in an uncovered field versus a field that uses no-till methods and cover crops. Photos: USDA Natural Resources Conservation Service

How Can Farmers Provide Ecosystem Services?

Farmers provide and can improve ecosystem services in several ways (Adhikari and Hartemink, 2016; Abbott and Manning, 2015). First, farming is a provisioning service, as it produces food and fiber. Farmers can also provide supporting ecosystem services by creating wildlife habitats and increasing biodiversity with agroforestry buffers, wildlife corridors, pollinator strips, and riparian protection zones. Regulating services can be provided and improved in multiple ways by farmers practicing sustainable and regenerative methods. The most notable regulating services are water-quality protection, conservation of water quantity, and nutrient cycling. These are facilitated through enhanced water infiltration and water-holding capacity and through microbial processes that enhance soil tilth and nutrient holding.

Sustainable agricultural practices can also remove carbon dioxide from the atmosphere and store it in soils and trees through a process called *carbon sequestration.* Removing carbon dioxide from the air and storing it in soil and woody biomass mitigates climate change. Sequestered soil carbon increases the organic matter content of the soil, resulting in better soil aggregation and structure, and it allows more water to infiltrate into the subsoil and increase its water- and nutrient-holding

capacity. For more about this subject, read the ATTRA publication *Agriculture, Climate Change, and Carbon Sequestration.* Finally, soil is at the root of providing cultural services by supporting wildflowers, forests, and fields, along with the birds, butterflies, bees, and other wildlife that furnish a basis for vacations to natural areas, hunting and fishing, and the location of homes with "natural" viewscapes.

To learn more about the connection between soil organic matter and the water-holding capacity of soils, read the ATTRA publications *Building Healthy Pasture Soils* and *Managing Soils for Water: How Five Principles of Soil Health Support Water Infiltration and Storage.*

Carbon can be sequestered in soil by using cover crops, minimum or no-till methods, adaptive multi-paddock grazing, and other regenerative agriculture methods that build soil organic matter. Water quality can also be improved by keeping the soil covered, applying fertilizers and manure during times when rain is not expected, protecting riparian areas, and other methods of reducing runoff and erosion. And, farmers can improve air quality by planting windbreaks to reduce wind erosion or to act as odor barriers around manure lagoons, by not burning crops, and by timing fertilizer and manure application to reduce methane and nitrous oxide release.

Although many farmers are already using practices that provide ecosystem services beneficial to society, barriers may prevent them from expanding their efforts. Similarly, barriers may prevent other farmers from implementing agriculture practices that strengthen ecosystem services in the first place.

Agricultural Ecosystem Services

Agricultural Ecosystem Services are benefits provided to society from conservation agricultural practices, such as the following:

- Water-quality protection
- Conservation of water quantity
- Carbon sequestration
- Plant diversity for pollination
- Temperature moderation
- Nutrient cycling
- Aesthetic scenery
- Wildlife diversity conservation

Although many farmers are already using practices that provide ecosystem services beneficial to society, barriers may prevent them from expanding their efforts. Similarly, barriers may prevent other farmers from implementing agriculture practices that strengthen ecosystem services in the first place. A large factor is cost, whether that's represented as time, money, knowledge, or other resources. Transitioning to sustainable agriculture practices requires taking time for education, practice, and field testing, because the sustainable methods that provide ecosystem services may be outside of a farmer's experience. Often, sustainable agriculture practices that lead to beneficial ecosystem services require purchasing new equipment, such as a no-till drill, or cover crop seeds for cropping practices, or temporary fences and watering systems for rotational grazing. Sometimes landowners do not understand and are uncomfortable with tenant farmers using these practices on their land. Other times, landowners provide only short-term leases that prohibit farmers from implementing conservation practices because several years are needed for the adoption of a practice to make sufficient changes in the ecosystem for farmers to obtain economic benefits.

Barriers to implementing agricultural practices that protect ecosystem services:

- Limited financial resources
- Lack of proper equipment
- Rental land
- Time for education
- Market forces
- Government policies

The role farmers can play in improving the health of our society is becoming increasingly evident. However, farmers often do not have the ability to pass on the cost of transitioning to sustainable agriculture practices to the consumer and thus may need economic assistance to overcome these barriers. This has resulted in the emergence of public and private programs that pay farmers to implement sustainable practices that enhance ecosystem services.

Payments for Ecosystem Services

Paying farmers for improving ecosystem services is not really a new idea. The U.S. Department of Agriculture Natural Resources Conservation Service (USDA NRCS) and its former incarnation, the USDA Soil Conservation Service, have been providing farmers with technical and economic assistance to implement natural-resource conservation practices since the time of the Dust Bowl. But, as discussed above, in the second half of the 20th century, the idea of private-sector businesses paying farmers for maintaining or improving ecosystem services started to become more accepted among economists and policy makers as the "loss of ecosystem services became evident as natural capital (e.g., soil, water, and air quality) was depleted" (Costanaza et al., 2017). Since 1997, researchers and policymakers have ascribed free-market principles to ecosystem services by providing monetary reimbursement for individuals and groups that provide and enhance ecosystem services.

Policymakers, researchers, businesses, and farmers have moved toward this free-market approach to protecting or restoring ecosystem services for various reasons. Prior educational and technical approaches to halt ecosystem service losses have had limited impact on farmer decision making. Because point-source pollution, by definition, comes out of a pipe or smokestack, it is relatively easy to monitor, and thus regulate, these industrial, energy-production, and waste-treatment facilities by measuring amounts of contaminants released per unit of time. These entities can then pass on their pollution-reduction costs to the consumer. Farmers and ranchers were exempted from regulatory fines until the passage of regulations on concentrated animal feeding operations (CAFOs). This historical exemption is due to the difficulty associated with monitoring pollution from farms and the recognition that all society relies on farm products for survival.

Providing farmers and ranchers with economic incentives to implement ecosystem-service-enhancing practices recognizes the positive impacts of market-based approaches on farmer and rancher decision making while also recognizing the need for other sectors of society to demonstrate their support for protecting the environment. Incentives are viewed as a more acceptable method for influencing farmer decision making than fines. When farmers participate in incentive-based programs, they can voluntarily supply and improve ecosystem services on their property and be compensated through several options, including tax write-offs, easements, grants, direct payments, or ecosystem service market credits (Kemkes et al., 2010). The umbrella term to describe these incentive-based programs for improving ecosystem services is *Payments for Ecosystem Services.* These incentive-based programs also acknowledge that farmers and ranchers may need economic assistance to both initiate and continue to implement conservation agricultural practices, because most sell their products on a contract basis that does not allow them to pass on increased costs to the consumer.

Most programs that provide payments for agricultural ecosystem services offer compensation for one or more of the following accomplishments:

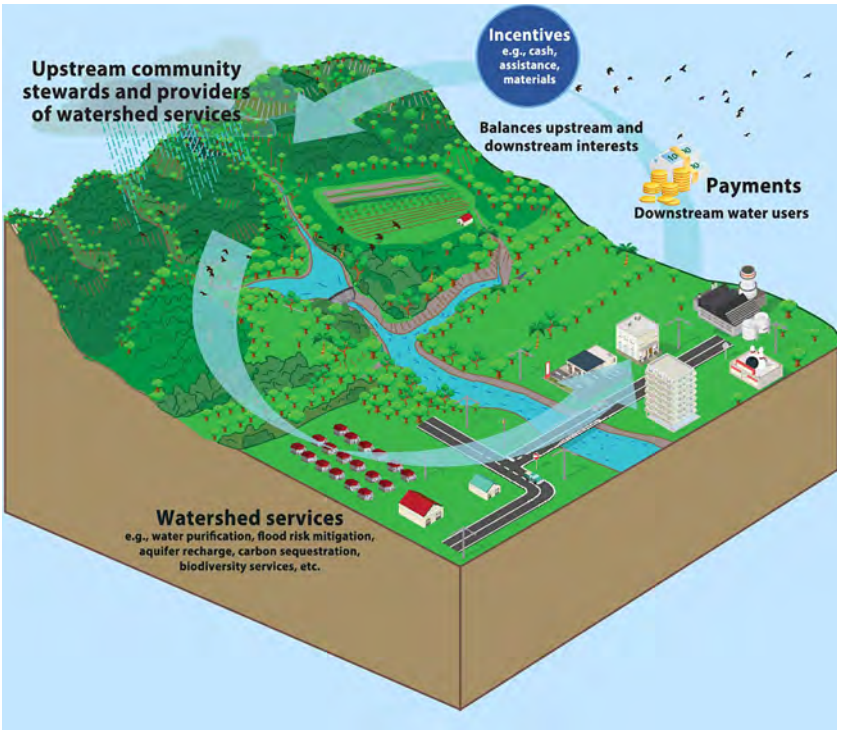
i) carbon sequestration in biomass or soils;

ii) provision of habitat for endangered species;

iii) protection of landscapes; or

iv) various hydrological functions related to the quality, quantity, or timing of freshwater flows from upstream areas to downstream users (Kemkes et al., 2010).

Farmers may also participate by reducing greenhouse gases, including methane and nitrous



Source: "Charting New Waters: State of Watershed Payments 2012," Bennett et al., 2013

oxide, through manure management or water-management practices, particularly in rice fields (Niles et al., 2019; Proville et al., 2018).

Free-market economic tools, such as ecosystem services markets, incentivize farmers and ranchers to implement practices that protect and conserve environmental resources. These approaches are more politically acceptable for private sector entities than levying fines against perceived pollution from their farms. Programs offering payment for ecosystem services often involve verification, coordination, and financing systems that minimize the benefits farmers obtain from these programs. Payments are an efficient mechanism for providing ecosystem services when these transaction and implementation costs are low and benefits can be captured by the group providing the money for the payments (Kemkes et al., 2010).

There are several free-market economic tools that are used to structure programs and deliver payments to farmers, ranchers, and others providing ecosystem services. These are the most common:

- Direct Payments
- Tax Incentives
- Certification Programs
- Cap and Trade Markets
- Voluntary Markets

Direct Public and Private Payments for Ecosystem Services

Direct payments for ecosystem services have been defined as voluntary transactions where an ecosystem service is being bought by one or more buyers from one or more sellers. In direct-payment programs, buyers of ecosystem services can be private or public, including government entities, nonprofit organizations, or private businesses. "Sellers," including farmers and ranchers, must be able to prove or have verified that they provide specific environmental benefits. Because changes in soil health and water quality are difficult and often expensive to monitor or verify, buyers pay farmers and ranchers for implementing designated conservation practices, rather than basing payments on assessments of water quality or soil health. For example, a Soil and Water Conservation District pays a farmer to plant trees in a riparian zone instead of paying a farmer based on water-quality improvements in the adjacent stream. Direct payments for ecosystem services, which often include technical assistance, help farmers overcome the cost of implementing conservation and sustainable agriculture practices.

NRCS Programs

NRCS provides farmers and ranchers with technical assistance and cost-share economic assistance to implement a broad range of conservation practices, often referred to as *best management practices* or *BMPs,* through several programs including the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP). The federal government provides farmers with this assistance in recognition that most agricultural conservation practices provide more benefits to society in terms of clean water and clean air than these practices provide to farmers in terms of enhanced yields, at least in the short term.

EQIP provides farmers and ranchers with financial resources and one-on-one technical assistance to plan and implement conservation practices. Popular practices implemented under EQIP include cover cropping, no-till planting, prescribed grazing, and water-conserving irrigation systems. Farmers wishing to enroll in EQIP need to contact their local NRCS office (www.nrcs.usda.gov/wps/portal/nrcs/sitenav/co/states/). Although EQIP funding is available, accessing funds can be competitive and not all projects receive funding. An NRCS conservationist, using computer maps and farm visits, will identify the farmer's interests and the potential resource concerns on the farm. Based on this information, NRCS conservationists work with farmers to identify conservation improvement options to install and then calculate cost-share payments to be provided through EQIP for practice implementation. For more information about federal opportunities for financial support for your sustainable operation, read the ATTRA publication *Federal Conservation Resources for Sustainable Farming and Ranching.*

The CSP is "the largest conservation program in the United States, with more than 70 million acres of productive agricultural and forest land enrolled" (USDA NRCS, no date). This program provides modest payments to farmers who implement sustainable woodland management, prairie restoration techniques, sustainable crop management and livestock methods, or wildlife

habitat practices that can provide important benefits to society. These practices can also improve cattle gains per acre, increase crop yields, decrease inputs, and create better resilience to weather extremes (USDA NRCS, no date).

There are both benefits and limitations of NRCS programs. EQIP and CSP help producers implement conservation practices on working agricultural lands that also benefit society and the broader ecosystem. However, funds from these federal programs are insufficient to assist all farmers and ranchers looking to implement such practices. In addition, NRCS assistance is provided on a short-term contractual basis. As such, this assistance is designed to help farmers and ranchers install or initiate use of conservation practices but does not provide assistance with the ongoing maintenance of these practices.

Photo: Noble Research Institute, Creative Commons License

New York City Watershed Agricultural Program

New York City obtains 90% of its drinking water from reservoirs in the Catskill/Delaware watershed, located more than 100 miles from the city. The remainder of the water comes from the Croton watershed, located just north of the metropolitan area. Together, these watersheds cover 2,000 square miles (Cornell Cooperative Extension, 2018). In 1992, the New York City Department of Environmental Protection, the department that manages the city's water supply, developed a partnership with the farming community in the Catskill/Delaware and Croton watersheds. The program's aim is to minimize agricultural runoff pollutants including sediment, nutrients, and pathogens. Reducing these pollutants will help the city avoid installing expensive water treatment facilities for New York City's drinking water. Runoff pollutants are reduced by farmers working with the Watershed Agricultural Program, facilitated by the nonprofit Watershed Agricultural Council, through creation and implementation of voluntary pollution reduction plans called Whole Farm Plans. "Each Whole Farm Plan is developed by an interdisciplinary team of professionals—including the farmer—based on a comprehensive environmental review of the farm's current and potential pollution problems" (NYC Environmental Protection, no date).

The plans recommend NRCS-developed BMPs specific to each farm's environment and operation that address current and future sources of pollution. To pay for implementation of these BMPs, the New York City Department of Environmental Protection provides the farmers with technical and financial assistance. In the Catskill/Delaware watershed, 100% of the cost to create and implement the plan is covered, while in the Croton watershed, farmers usually contribute half of the cost to create and implement the farm plans. In some cases, the NRCS covers some of these costs as part of the EQIP program. As of 2019, 90% of the farms on these watersheds are participating in the program, with approximately 400 Whole Farm Plans and more than 5,000 BMPs implemented on commercial large and small farms (Cornell Cooperative Extension, 2018). In addition to these direct payments, the Watershed Agricultural Council has bought forest and farmland easements on more than 25,000 acres to conserve and monitor working lands for the future.

How will Direct Payments for Ecosystem Services Benefit Farmers?

Right now, direct public and private payments for ecosystem services won't drastically, directly, or instantly affect a farmer's income. These programs are paying farmers to add conservation improvement practices to their farms, and farmers will likely spend all the direct payment they receive on this effort. In some cases, such as the NYC Watershed Agricultural Council program, 100% of the costs of developing and implementing conservation practices can be covered. In many cases,

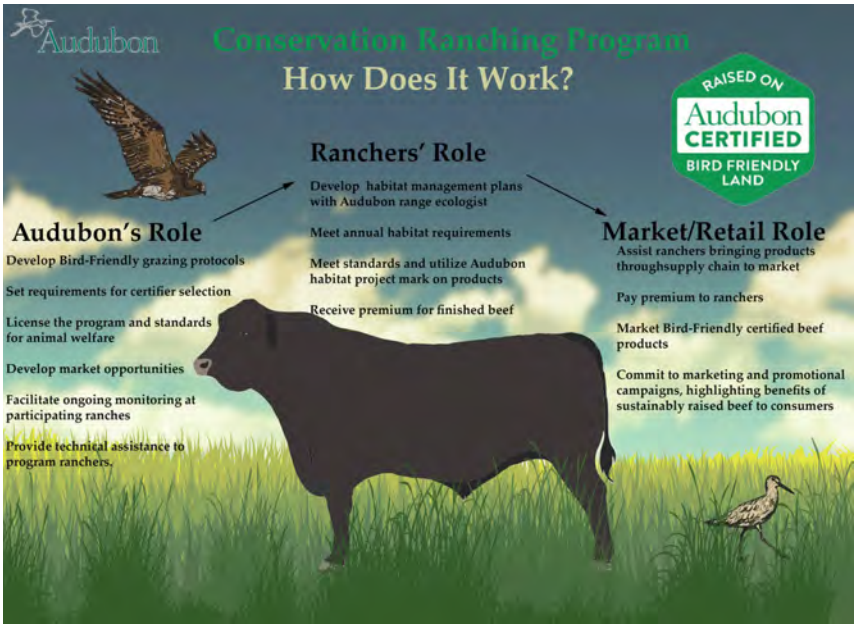
farmers will only receive a cost-share in which the payment provider splits the cost. Although instant and direct profit from these direct-payment programs cannot be expected, farmers can receive other economic benefits. For example, they can receive economic gains in the long term from having a farm or ranch that uses less resources, generally has higher yield (and thus a better higher net income), and is made more resilient due to the strengthened ecosystem functions. Direct-payment programs can help achieve conservation goals that fortify and increase yields while requiring a farmer to pay significantly less than they otherwise would. This can help farmers overcome barriers that would typically limit them from adopting conservation practices and create a healthier farm and community through the ecosystem services provided by these changes.

Tax Incentives

Another form of indirect government payment to farmers for protecting ecosystem services is tax incentives. "In exchange for committing resources to stewarding ecosystem services, individuals receive tax breaks from the government" (Ecosystem Marketplace, no date). A common form of tax incentives for producers is conservation easements. "An easement is either voluntarily donated or sold by the landowner and constitutes a legally binding agreement that limits certain types of uses or prevents development from taking place on the land…while it remains in private hands" (The Nature Conservancy, no date). Typically, a government agency or nonprofit organization, such as Land Trust Alliance or The Nature Conservancy, holds the easement rights and enforces the restriction on land use. Many easements are targeted to protect water quality, biodiversity, and wildlife migration routes. An example of a conservation easement would be one that protects a riparian area by banning development or agriculture production in the riparian zone. The owner of the land could potentially use this conservation easement as a way to receive a federal tax deduction for a charitable donation. "The amount of the donation is the difference between the land's value with the easement and its value without the easement" (Land Trust Alliance, 2014). However, having a conservation easement on your property doesn't necessarily guarantee property tax savings or any other tax incentives. For this, the land donation would have to meet several other federal tax code requirements.

Certification Programs

A common category of payments for ecosystem services is certification programs. These certifications signify that the producer is adhering to management practices that are beneficial to environmental and ecosystem-service health. The producer will typically have to go through an audit determined by the certifying group to be able to market their products with a certification label. In many cases, these audits cost money. Producers in turn can sell certified products for a premium in reward for caring for ecosystem services and



The National Audubon Society's Conservation Ranching Program is a market-based program that offers incentives for good grassland-management practices through a certification label on beef products. The label identifies that the product is "Audubon Certified" and that the cattle were grazed on bird-friendly land. Good grassland-management practices increase the biodiversity of rangelands and contribute to the health of the rangeland ecological system. By creating biodiverse rangelands through regenerative practices, ranchers can also create new, diverse market opportunities that include hunting, birding, and eco-tourism.

Source: The National Audubon Society

as a way to offset certification costs. Consumers who choose to buy certified products are paying for the protection of ecosystem services and the environment.

There are several certification programs available, for coffee, timber, paper, and food. One of the well-known certification programs that improves ecosystem services compared to conventional methods is the National Organic Program's USDA Organic certification. This program allows producers to use the USDA Organic label on their products when they grow food in a manner that meets the USDA's organic standards. Many of these standards concern the elimination of synthetic pesticides, herbicides, and other chemicals that are deemed to be harmful to the environment and related ecosystem services. The USDA Organic label allows producers of meat, cheese, produce, and value-added products to sell their goods to consumers for a premium.

Ecosystem Service Markets

Ecosystem service markets (ESMs) exhibit a variety of implementation and payment structures. Currently, however, these ecosystem service market programs have the following characteristics in common (Proville et al., 2018; Perez, 2017):

- Operated by a coordinating organization, either governmental or private sector
- Define detrimental environmental impacts
- Define beneficial environmental impacts
- Have developed criteria for assessing or verifying the amount of detrimental or beneficial impacts
- Are responsible for verification by conducting measurements and documenting the detrimental or beneficial impacts
- Have developed a process for determining the value of various detrimental or beneficial impacts.

Being market-based, ecosystem service programs require at least one buyer and one supplier or seller, and only work on the condition that the seller provides a verifiable improvement of the ecosystem services (Wunder, 2005). "Buyers" are usually producers of point-source pollution, or pollution that comes from a single, direct source, like out of a pipe from a water-quality treatment plant, a power plant, or a factory. "Sellers," including farmers and ranchers, provide environmentally beneficial impacts by reducing non-point source pollution, or pollution that comes from several sources over a larger area, such as erosion, runoff, or movement through ground water (Water Education Foundation, 2019).

In these programs, "buyers" buy pollution "credits" or payments for the right to pollute above a threshold that is usually set by regulations, but may be voluntarily determined by the industry. Buyers may be companies that produce point-source pollution or governmental agencies and non-governmental programs interested in improving environmental conditions. Payments that "sellers" obtain from these markets typically depend on the amount of environmental benefits provided and the value of the environmental benefits, minus the cost of the verification and coordination processes.

Various ecosystem service market programs have been developed. The three main types of ecosystem service markets that are currently operating are carbon trading programs, water-quality trading programs, and a comprehensive ecosystem service market program. These markets include a diversity of buyers. Each of these markets has a different implementation structure and affects farmers differently in terms of program involvement and payment methods.

Carbon Trading Programs

Policy makers and businesses are developing new methods for reducing greenhouse gas (GHG) emissions, from a national carbon tax to sustainable-product recognition for companies involved in GHG reductions and carbon markets. In 2017, more than 1,300 companies – including more than 100 Fortune Global 500 companies with a collective annual revenue of $7 trillion – were using internal carbon pricing to inform their decision making (World Bank, 2017). Companies not only use internal carbon pricing to manage "potential climate-related risks" but also to improve cohesion between finance and sustainability departments.

Carbon markets provide incentives to farmers for mitigating global climate change by either sequestering carbon or reducing the amount of carbon dioxide, methane, or nitrous oxide produced in agricultural or business operations. Companies that are point-sources for greenhouse gases, such as coal or oil-fired power plants, factories, or transportation businesses, are encouraged to implement practices to reduce their use of fossil

fuels and emissions of GHG. These "buyers" are charged a fee or credit for every megaton of carbon dioxide or other greenhouse gases, such as nitrous oxide and methane, produced over a specified baseline. Participation in carbon-trading programs by industrial businesses can be voluntary or required, depending on local laws and regulations.

Farmers and businesses are awarded credits for each megaton of carbon dioxide or other greenhouse gas that they sequester into the soil or prevent from being released into the atmosphere. Farmers and ranchers can obtain credits for sequestering carbon dioxide in soil organic matter, reducing methane emissions from ruminating cows, and mitigating nitrous oxide emissions from fertilized, flooded soil. Farmers and ranchers sell credits, representing the megatons of carbon they sequester or prevent from being emitted, to buyers who are industrial polluters. The cost of each credit represents the current "societal value" for each ton of GHG, which fluctuates according to supply and demand for these credits.

For more information about cap-and-trade programs, read the ATTRA publication *Agriculture, Climate Change, and Carbon Sequestration.*

Unfortunately, the economic value, or price paid, for greenhouse gases has historically been low (Gold Standard, 2019), resulting in carbon-credit programs having limited funds to pay farmers and ranchers for their practices after discounting for costs of practice verification and program management. The Chicago Climate Exchange founded the first voluntary GHG trading program in the United States in 2003. This exchange was discontinued in 2010 due to the low price being paid for each ton of carbon. The international price for carbon credits in 2018 was $12 per ton. Various economists have calculated that a value of at least $50 per ton is necessary to influence decision making by both carbon-credit buyers and sellers.

Currently, the largest seller or off-setter of carbon credits is forestry – either through protecting existing forests from deforestation or through reforestation projects (California Carbon Dashboard, 2019). Due to the relatively small amount of GHG reductions produced by each farm compared to the relatively large amount of GHG emissions produced by each energy or transportation company, credits from several farms need to be aggregated prior to being exchanged on the market. The cost of aggregation provides another layer of "middlemen," further decreasing the ecosystem service payments available to agricultural producers. Finally, for buyers to be willing to purchase carbon credits from farmers, both groups must be able to verify or prove that they made measurable changes in the amount of carbon or other GHGs they sequestered or prevented from being emitted. Because carbon-sequestration assessment methods can be time-consuming or require expensive equipment, this process can be cost-prohibitive for small and even medium-sized farmers.

The nonprofit organization National Resources Defense Council (NRDC) determined the following practices were effective in reducing GHG production:

- Regulating irrigation practices in rice production reduces methane emissions
- Applying the correct amount of nitrogen fertilizer at the right time reduces nitrous oxide emissions
- Returning compost to grasslands enhances soil carbon sequestration

Cap and Trade

Cap and trade is the term for regulated programs in which the government caps the amount of GHG that companies are permitted to produce each year. If businesses exceed this amount, they must purchase carbon credits for each additional ton of GHG they emit. Farmers and others who reduce the production of GHG are paid for these credits. There are two cap-and-trade programs in the United States. The Regional Greenhouse Gas Initiative encompasses 10 northeastern and mid-Atlantic states and only works with electricity generators. The Western Climate Initiative includes seven western states and four Canadian provinces. Of these, California has the most developed program and the only program that provides carbon credits to farmers through a carbon-offset market (Environmental Defense Fund, 2012). Companies purchase carbon credits from farmers to offset any amount of carbon emissions companies produce over the cap limit. Due to the

need for verification criteria, these offset-market programs currently are only available for rice farming, agroforestry, sustainable grassland management, and methane capture and destruction at dairy facilities.

Valuing carbon credit payments can be estimated with the following formula:

(Number of credits x Value of credits) – (Verification & Coordination Costs) = Payment Amount

Currently, the greatest barriers to the success of ecosystem service market programs are these:

- the price paid for environmental credits
- cost-effective, but accurate, verification methods and programs

The COMET Planner (http://comet-planner.com/) and the DNDC model (www.dndc.sr.unh.edu/model/GuideDNDC95.pdf) allow farmers and ranchers the ability to calculate their current and potential future levels of carbon sequestration and GHG emission reductions from farming practices.

Arkansas Rice Project

An innovative multi-agency program in Arkansas provides rice farmers with "carbon credit" payments for irrigation-management practices. Rice farming involves flooding fields, and the release of methane and nitrous oxide from flooded fields can be significant. Using irrigation practices that maintain low, but constant, levels of water in the fields decreases GHG emissions. The amount of downstream nutrient and sediment pollution is also reduced due to limited overflow of flood water into downstream fields or irrigation waterways. Due to the low economic value for the credits, and commissions charged by the program verifiers, the payments received by participating farmers were "about enough to buy a cup of coffee." However, numerous farmers were willing to adopt these practices anyway because their reduced irrigation expenses and the additional technical assistance they obtained were sufficient compensation.

Indigo Ag Terraton Initiative

New as of 2019, the Terraton Initiative is a carbon market and research project created by agriculture technology company Indigo Ag. The initiative's goal is to sequester one trillion metric tons of carbon dioxide through the new carbon market called "Indigo Carbon." Indigo Carbon differs from other carbon markets because Indigo Ag is setting a fixed price range of $15 to $20 per ton of CO2 sequestered. Indigo Carbon provisionally estimates that implementation of "regenerative" agricultural practices will result in an increase in soil carbon sequestration of two to three tons of carbon per acre per year for participants, equating to $30 to $60 per acre. In addition to this new carbon market, Indigo Ag is spearheading a decade-long research program in partnership with the Soil Health Institute and the Rodale Institute, called the Terraton Experiment. For more information about the Terraton Initiative, visit www.indigoag.com/the-terraton-initiative.

Photo: NCAT

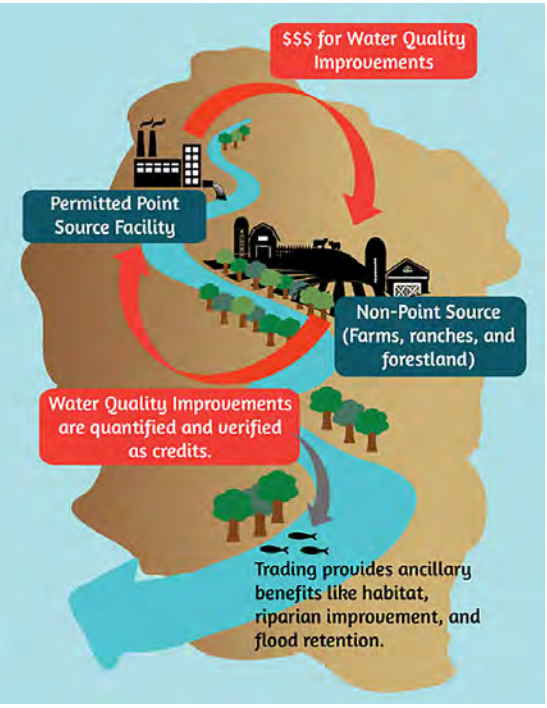
Water-Quality Trading Programs

Water-quality trading programs (WQT) typically involve wastewater treatment plants, energy companies that use hydropower, or various industries that release treated water into a lake, river, or reservoir from point-sources. These entities seek to reduce pollution through management practices or new technologies that reduce the amount of water pollution they produce. As they work towards these reductions, they pay fees or credits for the level of pollution they produce over a designated level. Farmers, ranchers, and other land managers can obtain credit payments for reducing water-quality impacts by implementing land use

practices that reduce non-point-source water pollution due to runoff, erosion, or movement of contaminants to streams.

As of 2015, at least 15 states had enacted legislative authority to establish water-quality trading programs. Within these states, several successful watershed-based WQT programs have been implemented. Some of these programs are local and focused on a specific industry, such as the Southern Minnesota Beet Sugar Cooperative permit. Other programs are multistate and multi-agency, such as the Ohio River Basin Water Quality Trading Project. These programs collaborate and share information through the National Network on Water Quality Trading, a partnership of public agencies, private-sector businesses, and nonprofit organizations (http://willamettepartnership.org/water-quality-trading/national-network).

Although regulatory structures for WQT programs vary from state to state, most programs are implemented as environmental cap-and-trade markets that put a water pollution cap on various forms of pollutants: primarily temperature, phosphorus, and nitrogen. Pollution caps are typically calculated on a particle measurement standard known as the "total maximum daily load" (TMDL), or the chemical content of the water measured in a lake, stream, or river. Some water programs focus on one pollutant type, while others cover multiple pollutants.



Source: Willamette Partnership

In Washington State and Oregon, regulating the temperature of water being released from water treatment and energy-production plants is critical because salmon—and other aquatic life—are sensitive to high temperatures. In areas with high concentrations of crop or animal-production operations, phosphorus and nitrogen from fertilizers and manure can cause water eutrophication, or the excessive growth of algae in water. When these algae die, their decomposition by heterotrophic microorganisms reduces the availability of oxygen to fish and other aquatic organisms, resulting in reduced fish numbers and reduced diversity of fish species. The downstream movement of nutrient-rich stream and river water results in the formation of similar "dead zones" in the ocean, where lack of oxygen eliminates the growth of most aquatic species. In areas where surface water is used as the source of drinking water for cities or municipalities, treatment costs for removing sediments, nutrients, and pathogens from the water can be substantial. In addition, this pollution causes health risks to people using these lakes and reservoirs for contact recreation.

In most WQT programs, sellers operate within a regulatory structure, needing to either meet TMDLs or pay for TMDL overages. Thus, water-quality trading programs can act as a quasi-cap-and-trade program because, in many cases, polluters aren't voluntarily participating. Farmers and ranchers are primarily voluntary participants unless subject to concentrated animal feeding operation (CAFO) or other state or local regulations. In many cases, payments and technical assistance are provided through county Soil and Water Conservation Districts or nonprofit organizations.

Currently, only a limited number of water-quality trading programs involve the agricultural sector. The lack of inclusion of the agricultural sector results from the perceived difficulty of verifying water-quality impacts of agricultural conservation programs and choices made by point-source polluters to make improvements in their practices rather than pay for pollution credits. Two successful water-quality trading programs that provide financial benefits to farmers are the Great Miami Watershed Water Quality Credit Trading Program (GMWWQCTP) and the multistate effort to use water quality trading to improve the health of the Chesapeake Bay.

Sustainable agriculture practices protect water quality by controlling soil erosion, reducing or eliminating pesticide use, applying fertilizers and manure in the correct amount and at the right time, and protecting riparian buffers.

Chesapeake Bay Regional Water Quality Trading

The Chesapeake Bay, a major tourist and shellfishing location, has a large watershed that covers 64,000 square miles in parts of Maryland, Virginia, Pennsylvania, Delaware, New York, West Virginia, and the District of Columbia. "When the six states and the District asked EPA to establish a multi-state Total Maximum Daily Load under the Clean Water Act in 2010 and assign each state its fair share, they took on the job of reducing discharges of nitrogen from all sources by 25%, phosphorus by 24%, and sediment by 10%" (Hall, 2018). Each state was allocated different TMDLs. The states with the largest share of Chesapeake Bay pollution and the greatest need to meet TMDL reductions, Maryland, Pennsylvania, and Virginia, implemented water-quality trading programs. Each state is in charge of the creation and regulation of its own public water-quality trading market. Also, each state's water-quality trading program is semi-regulatory in its interaction with farmers because it requires regulated facilities, including farms, wastewater treatment facilities, and city stormwater runoff, in the watershed to reduce pollutants a certain amount so that each state can meet its TMDL requirement. Farmers and ranchers have the ability in some cases to reduce pollution more than is legally required through conservation practices. Any reductions met through the implementation of management practices that exceed farmers' and ranchers' TMDL baseline requirement are sold as credits to other businesses, facilities, and local municipalities, so that overall reduction requirements are met (Chesapeake Bay Foundation, 2019). "Trading allows regulated polluters to meet their legal requirements and defray the costs of compliance—through purchased credits—while still reducing the amount of pollution entering the watershed overall" (Chesapeake Bay Foundation 2019). For many regulated polluters, it is cheaper to buy these credits from farmers and ranchers to meet their TMDL than to pay outright for technology and upgrades to meet TMDLs.

Corporations and government bodies in the Chesapeake Bay region also support the adoption of farm and best management practices by supporting the Chesapeake Bay Foundation. These groups include The Hershey Company, Lockheed Martin, Northrop Grumman, and the Port of Virginia, and they support the Chesapeake Bay water quality trading efforts through Chesapeake Bay Foundation's advocacy, outreach, education, and technical assistance. The Chesapeake Bay Foundation provides support to farmers and ranchers looking to adopt conservation practices and enroll in their state's water quality trading. Two such programs are the Mountains-to-Bay Grazing Alliance and the Headwaters Agricultural Stewardship Project.

The Mountains-to-Bay Grazing Alliance "brings together private and public partners to promote the implementation of rotational grazing and related conservation practices and to increase the number of pasture-based livestock operations in the Bay watershed portions of Virginia, Maryland, and Pennsylvania. The program connects current and new grazing farmers, providing outreach and technical assistance in the form of farmer-to-farmer mentoring, on-farm demonstrations…and other peer to peer experiences" (Chesapeake Bay Foundation, no date). The Headwaters Agricultural Stewardship Project works with farmers and ranchers in Virginia's Shenandoah Valley to install conservation measures and best management practices that improve water quality, including fencing cattle out of streams, planting native riparian buffers, and adopting rotational grazing.

Farmer success stories from the Chesapeake Bay can be found at

www.cbf.org/blogs/save-the-bay/farmer-success-stories.html

Great Miami River Watershed Water Quality Credit Trading Program

The GMRWWQCTP, developed in 2005, serves the Great Miami Watershed in southwestern Ohio. This program involves both point-source wastewater treatment facilities and non-point-source farms and ranches as potential sources of water pollution. Agricultural operations installing conservation practices to reduce water pollution obtain funding through local Soil and

Water Conservation Districts. District personnel then work with farmers to implement conservation practices on farms. The American Farmland Trust, a national nonprofit organization, helps to coordinate farmer involvement in this project and facilitate farmer ability to implement appropriate conservation practices (AFT, 2019). In its 2019 annual report, the Miami Conservation District described the cost-effectiveness of this program by estimating that, on average, point-sources would pay $23.37 per pound to reduce phosphorus with biological nutrient removal, compared to $1.08 per pound for agriculture with conservation practices. For nitrogen, point-source unit costs were $4.72 per pound, compared to $0.45 per pound for agriculture.

Comprehensive Ecosystem Service Trading Markets

Comprehensive ecosystem services markets differ from carbon and water-quality trading programs by covering more than a single ecosystem service. The Ecosystem Services Market Consortium (ESMC) is an innovative, private-sector program that was officially launched in February 2019. Working in conjunction with the Soil Health Institute, this consortium is focused primarily on cooperating with farmers and ranchers as they implement conservation practices on their land. Although the program was initially supported by the Noble Research Institute LLC, 11 private-sector companies and nonprofit organizations are now members of ESMC's Founding Circle. These entities include ADM, Cargill, General Mills, Mars, McDonald's USA, and the Nature Conservancy, among others. Initially, the ESMC will primarily promote conservation-management practices to improve soil health, reduce GHG emissions, improve related water quality, and reduce water use. In the future, it plans to also promote practices that enhance biodiversity and pollinator habitat. In 2019, program activities were pilot tested on 50,000 acres of rangeland and farmland in Texas and Oklahoma. By 2022, the program intends to encompass all major agricultural production systems and geographies in the United States (Knight and Reed, 2019).

The implementation structure used by this consortium evolved through a series of discussions among farmers, academics, government and non-government agency personnel, and business managers. Throughout the development process, collaborators sought to overcome critical barriers to implementation associated with prior carbon-trading or water-quality-marketing programs. Specifically, they sought to develop a program that was not associated with either state or federal governments, and thus was non-regulatory, not impacted by changes in political priorities over time, and had the potential to be implemented throughout the United States and even beyond. They also wanted to reduce costs associated with verifying environmental benefits provided by participating farmers and ranchers. This will reduce "middleman" costs and increase the amount of the environmental payments received by farmers. Also, program coordinators are examining methods for making this program more accessible to small-scale farmers. In many current ecosystem service trading programs, small-scale farmers have limited ability to participate because the assessed value of their impacts is small.

Are Ecosystem Service Markets Right for You?

Currently, ecosystem service market programs may not be available in your area. However, changes in local, state, or federal policies or environmental stewardship interests of private companies may result in the creation or expansion of these programs in the future. Before enrolling in ecosystem service market programs, farmers and ranchers should consider the following:

- **Stability of the program and the prices paid for incentives**: How long has the program been in effect? How often does the price fluctuate? Is the price for each carbon or water credit going to pay some bills or buy me a cup of coffee?
- **Clarity of required practices and verification processes**: Does the market have a list of best management practices and a clear, written process for verifying if you are actually sequestering carbon or contributing to improved water quality? Without this information, the contractual relationship between the farmer or rancher and the coordinating organization is unclear.
- **Transparency of all costs for participation**: Most ecosystem service markets involve various fees for impact verification, aggregation of sellers, and program coordination. There should be a set, itemized list and cost for each step of the implementation process.

As with any contract, be wary of fine print, surcharges, or other hidden fees.

- **Payment for practice implementation or for environmental impact**: Although each of these programs has its benefits and downsides, the most important aspect, from the perspective of the farmer or rancher, is when payments are made. In general, payment for practice implementation occurs at the time it happens, in contrast with payments for environmental impacts, which are made based on environmental improvements over time. The main benefit of payment for environmental impacts is that farmers who have implemented agricultural environmental practices on their own can be paid for their prior work.
- **Return on investment**: These markets must be worth your time and money. It may be worth it if you have been wanting to adopt some sustainable agriculture practices but have not been able to obtain assistance from NRCS for a specific type of practice, or for expanding your involvement beyond what is covered by NRCS. Unfortunately, many ecosystem service markets are not currently profitable for small farms because their impact on the environment is viewed as being small.
- **Bundling and stacking payments**: A possible way to increase the likelihood that payments for ecosystem service programs work for you as a farmer is to enroll in multiple programs at once, if the programs allow for it. Bundling multiple programs together can take the risk out of some more-volatile programs or programs that can take a while to pay the producer back. Bundling programs together also has the possibility of increasing return on a farmer's efforts for implementing conservation practices. If you are adopting and practicing conservation agriculture, why not try to get paid as much as possible from as many sources as possible? Some ecosystem services markets allow you to "stack credits" by receiving credits for each of the multiple ecosystem services that conservation agriculture practices can produce.

A Scenario that Demonstrates Bundled Payments for Ecosystem Services

You are a farmer with property adjacent to a river, are USDA Organic certified, and are interested in enrolling in USDA NRCS EQIP or CSP programs. Working with all of these programs, you could create a riparian buffer and place it into an easement while implementing other agricultural conservation practices on your other land. From these integrated actions, you could receive a tax incentive for your easement land, a higher price for your USDA Organic certified produce or livestock, and cost-share funding and technical assistance from the NRCS to implement conservation practices. Finally, an ecosystem services market program could provide you with additional cash or cost-share incentives.

For farmers who are transitioning into the use of agricultural conservation practices, the ability to stack programs and obtain multiple sources of financial and technical assistance can assist in covering the sometimes-expensive transition costs.

Examples of Stacked Programs

- The Willamette Partnership allows producers to receive ecosystem service credits simultaneously for fish and wildlife, as well as for water quality.
- The Soil Health Institute Ecosystem Service Market Consortium will allow farmers to receive payments on both carbon and water-quality trading markets. In addition, farmers can simultaneously receive conservation planning cost-share through NRCS.

For many ecosystem service program payments—outside the NRCS programs—payments are primarily available at a regional level. As indicated, most of these ecosystem service markets are coordinated by Soil and Water Conservation Districts and Watershed Authorities. If you are a farmer and are interested in these regional ecosystem service markets, contact your regional Soil and Water Conservation District or Watershed Authority to see if a payment program is available in your area or encourage them to start one. To find your nearest Soil and Water Conservation District, visit the National Association of Conservation Districts conservation district directory at www.nacdnet.org/general-resources/conservation-district-directory.

For farmers or ranchers in areas where ecosystem service market or water-quality market programs are evolving or expanding, examine the Further Resource section of this publication for farmer-friendly Web-based tools and monitoring practices that you can use to determine the environmental impact of your farm or ranch and what you might do to enhance the level of environmental services it provides.

References

Abbot, L., and D. Manning. 2015. Soil Health and Related Ecosystem Services in Organic Agriculture. Sustainable Agriculture Research. Vol. 4, No. 3. p. 116-125.

Adhikari, K., and A. Hartemink. 2016. Linking soils to ecosystem services-A global review. Geoderma. Vol. 262. p. 101-111.

AFT. 2019. Water Initiatives. American Farmland Trust. https://farmland.org/project/water-initiative

Bennet, G., N. Carroll, K. Hamilton. 2013. Charting New Waters: State of Watershed Payments 2012. Ecosystem Service Marketplace. www.forest-trends.org/wp-content/uploads/imported/state-of-watershed-payments-2012_exec-summary_1-22-13-pdf.pdf

Braat, L., and R. De Groot. 2012. The ecosystem services agenda: Bridging the worlds of natural science and economics, conservation and development, and public and private policy. Ecosystem Services. Vol. 1, No. 1. p. 4-15.

California Carbon Dashboard. 2019. Cap and Trade. http://calcarbondash.org

Chesapeake Bay Foundation. 2019. Nutrient Trading. www.cbf.org/issues/nutrient-trading.html

Chesapeake Bay Foundation. No date. Mountains to Bay Grazing Alliance. www.cbf.org/how-we-save-the-bay/programs-initiatives/multi-state-grazers-alliance.html

Cong, Rong-Gang, Henrik G. Smith, Ola Olsson, and Mark Vincent Brady. 2014. Managing ecosystem services for agriculture: Will landscape-scale management pay? Ecological Economics. March. p. 53-62.

Conniff, Richard. 2012. What's wrong with putting a price on nature? Yale Environment 360. https://e360.yale.edu/features/ecosystem_services_whats_wrong_with_putting_a_price_on_nature

Cornell Cooperative Extension. 2018. Watershed Agricultural Program. CCE Delaware County. www.ccedelaware.org/agriculture-natural-resources/watershed-agricultural-program

Costanza, R., R. De Groot, L. Braat, I. Kubiszewski, L. Fioramonti, P. Sutton, S. Farber, and M. Grasso. 2017. Twenty years of ecosystem services: How far have we come and how far do we still need to go? Ecosystem Services. Vol. 28. p. 1-16.

Ecosystem Marketplace. No date. Payments for Ecosystem Services. Ecosystem Marketplace, www.ecosystemmarketplace.com/payments-ecosystem-services

Environmental Defense Fund. 2012. The Role of Offsets in California's Cap-and-Trade Regulation. www.edf.org/sites/default/files/OffsetsPercentagesFAQFinal 041612.pdf

Food and Agriculture Organization of the United Nations. Supporting Services. Ecosystem Services & Biodiversity (ESB) www.fao.org/ecosystem-services-biodiversity/background/supporting-services/en

Gold Standard. 2019. Carbon Pricing: What is a carbon credit worth? www.goldstandard.org/blog-item/carbon-pricing-what-carbon-credit-worth

Gómez-Baggethun, E., R. Groot, P. Lomas, and C. Montes. 2010. The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. Ecological Economics. Vol. 69, No. 6. p. 1209-1218.

Hall, Ridgway. 2018. Strong Headwinds Face Water Quality Trading in the Chesapeake. American College of Environmental Lawyers. www.acoel.org/post/2018/08/02/acoel.org/file.axd?file=2018%2f8%2fACOEL+Blog+on+Bay+State+Trading+Programs.pdf

Johnson, K., S. Polasky, E. Nelson, and D. Pennington. 2012. Uncertainty in ecosystem services valuation and implications for assessing land use tradeoffs: An agricultural case study in the Minnesota River Basin. Ecological Economics. Vol. 79. p. 71-79.

Kemkes, R., J. Farley, and C. Koliba. 2010. Determining when payments are an effective policy approach to ecosystem service provision. Ecological Economics. Vol. 69, No. 11. p. 2069-2074.

Knight, B., and D. Reed. 2019. Ecosystem Services Market Consortium: Growing resilience in our nation's soil. Ecosystem Services Market Consortium. www.c-agg.org/wp-content/uploads/ESMC-Sacto_2019.pdf

Land Trust Alliance. 2014. Benefits for Landowners. www.landtrustalliance.org/what-you-can-do/conserve-your-land/benefits-landowners.

Miami Conservation District. 2019. Water Quality Trading Program: A common sense approach to reducing nutrients. www.mcdwater.org/wp-content/uploads/2017/05/WQCTP-fact-sheet-2017-FINAL.pdf

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-Being. World Resources Institute. www.millenniumassessment.org/documents/document.356.aspx.pdf

Niles, M., H. Waterhouse, R. Parkhurst, E. McLellan, S. Kroopf. 2019. Policy Options to Streamline the Carbon Market for Agricultural Nitrous Oxide Emissions. Climate Policy. Vol. 19, No.7. p. 893-907. www.tandfonline.com/doi/full/10.1080/14693062.2019.1599802

Nutrient Tracking Tool. 2018. http://ntt.tiaer.tarleton.edu/welcomes/new?locale=en

NYC Environmental Protection. No date. Agriculture on Private Lands. www1.nyc.gov/html/dep/html/watershed_protection/agriculture.shtml

Perez, Michelle. 2017. Water Quality Targeting Success Stories. World Resources Institute. www.wri.org/publication/water-quality-targeting-success-stories

Proville, J., R. Parkhurst, S. Koller, S. Kroopf, J. Baker, W. Salas. 2018. Agricultural Offset Potential in the United States: Economic and Geospatial Insights. ResearchGate. www.researchgate.net/publication/327272176_Agricultural_Offset_Potential_in_the_United_States_Economic_and_Geospatial_Insights

Rong-Gang, G., H. Smith, O. Olsson, and M. Brady. 2014. Managing ecosystem services for agriculture: Will land-scape-scale management pay? Ecological Economics. Vol. 99. p. 53-62. www.researchgate.net/publication/327272176_Agricultural_Offset_Potential_in_the_United_States_Economic_and_Geospatial_Insights

Schumacher, E.F. 1973. Small is Beautiful: Economics as if people mattered. New York: Harper & Row

The Nature Conservancy. No date. Private Lands Conservation. www.nature.org/en-us/about-us/who-we-are/how-we-work/private-lands-conservation

Tietenberg, T., and L. Lewis. 2016. Environmental and Natural Resource Economics. 10th Edition. Routledge, Taylor, and Francis Group. London and New York.

USDA, No date. Conservation Stewardship Program. www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp

Water Education Foundation. 2019. Point source vs. nonpoint source pollution. www.watereducation.org/aquapedia-background/point-source-vs-nonpoint-source-pollution

World Bank. 2017. Carbon Pricing. www.worldbank.org/en/results/2017/12/01/carbon-pricing

Wunder, S. 2005. Payments for environmental services: some nuts and bolts. CIFOR Occasional Paper. No. 42. p. 24.

Further Resources

Online Resources

Building a Water Quality Trading Program: Options and Consideration
www.wri.org/publication/building-water-quality-trading-program-options-and-considerations

The Water Quality Trading Network is a consortium of 19 governmental, non-governmental, and business organizations representing agriculture, wastewater, and stormwater utilities, environmental groups, regulatory agencies, and practitioners delivering water-quality trading programs. This document describes how water-quality trading programs can be formed, managed, and provided with oversight. It addresses the development of water-quality markets, developing credits, and performing project review and compliance.

Climate Action Reserve. Offset Marketplace
www.climateactionreserve.org/how/offsets-marketplace

This website furnishes a comprehensive list of agencies and organizations providing carbon credits or acting as brokers or managers in the carbon market. Most programs address non-agricultural sectors. Components of the agricultural sector addressed by these markets presently are livestock, rice, composting, and forestry.

Environmental Markets and Conservation Finance
www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/emkts

The NRCS Conservation Innovations Team was established in 2016 in response to growing interest in environmental markets and conservation finance. Their vision is to develop new revenue streams and sources of private capital for agricultural producers and rural economies by attracting non-Federal funding to private lands conservation.This Web page includes links to resources, success stories, and an Environmental Markets 101 webinar.

Involving Agriculture in Water Quality Trading Markets
https://4aa2dc132bb150caf1aa-7bb737f4349b47aa42dce777a72d5264.ssl.cf5.rackcdn.com/Involving-Agriculture-in-Water-Quality-Trading-Markets.pdf

This document describes how an American Farmland Trust program in Illinois developed a water-quality trading program with farmers, based on the implementation of NRCS Best Management Practices.

National Network on Water Quality Trading
http://willamettepartnership.org/water-quality-trading/national-network

A partnership of public agencies and private-sector businesses and nonprofit organizations.

Rice Cultivation Project Protocol
www.climateactionreserve.org/how/protocols/rice-cultivation

Developed by the Climate Action Reserve, this document describes how greenhouse gas reductions from rice management practices were calculated, reported, verified, and used within the California and Arkansas carbon trading programs for rice producers.

Water Quality Trading Success Stories
www.wri.org/publication/water-quality-targeting-success-stories

This document from American Farmland Trust and World Resources Institute describes six agriculture-based water-quality trading programs from across the United States. Based on assessments of these programs, lessons learned and recommendations for future programs are provided.

Assessment Tools

COMET-Farm
http://cometfarm.nrel.colostate.edu

Developed by researchers at Colorado State University with support from the USDA NRCS, COMET-Farm is a whole-farm and ranch carbon and greenhouse-gas accounting system. This interactive, Web-based tool allows users to locate their farms on a map to provide access to soil, terrain, and climate information and then enter detailed information about past and future cropping, tillage, and nutrient management practices. Based on this information, this program can calculate potential carbon sequestration as well as carbon dioxide, methane, and nitrous oxide emissions. In addition to assessing these factors for crop and pasture production, this tool is also able to estimate GHG emissions from livestock manure and rumination, as well as emissions from the use of tractors, trucks, and other vehicles or equipment used in the farming operations. By adjusting inputs provided for future management practices, agricultural producers can determine how they could modify their operations to reduce their carbon footprints.

DeNitrification and DeComposition (DNDC)
www.dndc.sr.unh.edu

Developed by researchers at the University of New Hampshire, the DNDC model is a computer simulation model of carbon and nitrogen biogeochemistry in agroecosystems. It consists of two components. The first component focuses on the carbon cycle as affected by soil characteristics, climate, crop growth, and residue decomposition. The second component, consisting of the nitrification, denitrification, and fermentation sub-models, predicts emissions of carbon dioxide (CO2), methane (CH4), ammonia (NH3), nitric oxide (NO), nitrous oxide (N2O), and dinitrogen (N2) from the plant-soil systems. The entire model is driven by four primary ecological drivers, namely climate, soil, vegetation, and management practices.

Although this model can be downloaded from the Web, some inputs into the program, such as meteorological and soil information, require access to detailed data, rather than this information having been programed into the model. Other inputs into this model include cropping systems, tillage, nutrient management, irrigation, mulching, and grazing. Unlike COMET-Farm, DNDC does not account for GHG emissions from vehicles and equipment.

Nutrient Trading Tool (NTT)
http://ntt-re.tiaer.tarleton.edu/welcomes/new?locale=en

NTT is a Web-based model that assists farmers and watershed managers in determining cost-effective land-management practices for enhancing water-quality protection. Developed by the Texas Institute for Applied Environmental Research (TIAER) at Tarleton State University in Texas, this model incorporates detailed hydrology and agricultural land-use parameters to assess water quality at the field and small-watershed level. This program is combined with the Farm-level Economic Model that allows users to assess the economic costs and returns as affected by alternative agricultural policy and practice scenarios.

As with COMET-Farm, users identify their farms on a map to access embedded soil and climate information. They then enter cropping, nutrient management, tillage, irrigation, and other land-management information to determine the current impact of their farming operations on water quality. They can then enter alternative management scenarios to identify additional BMPs to enhance their impact on water-quality protection.

Researchers with Colorado State University and TIAER are currently working to integrate the GHG information in COMET-Farm with the water-quality information in NTT to provide a comprehensive, user-friendly tool for ecosystem assessment. The Ecosystem Services Marketing Program will use a combination of NTT for water-quality assessments and DNDC for greenhouse-gas emissions and captures, as part of its validation process.

Acknowledgements

A special thank you to Lisa Akinyemi, Environmental Studies M.S. Student, Tarleton State University, and Chad Ellis, Industry Relations and Stewardship Manager, Noble Foundation, for their technical review of the document and Lee Rinehart, NCAT, for his editorial review of the document.

Notes

.

Payments for Ecosystem Services

By Colin Mitchell, NCAT Sustainable Agriculture Specialist, and Dr. Barbara Bellows, Assistant Research Scientist, Texas Institute for Applied Environmental Research

Published June 2020

Tracy Mumma, Editor • Amy Smith, Production

This publication is available on the Web at:
www.attra.ncat.org

IP596
Slot 621
Version 060120