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Cost-Effective Conservation Programs for Sustaining Environmental Quality

Roger Claassen and Marc Ribaudo

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The interface between agriculture and the environment is critical. Maintaining and increasing the productivity of agriculture depends on the quality of ecosystems that provide healthy soil, favorable climate, pollination, and water for irrigation. However, agricultural production can also damage ecosystems by contributing to climatic change through greenhouse gases emissions; by degrading the soil through erosion and loss of soil carbon; by polluting surface and groundwater with sediment, nutrients, and pesticides; and by contributing to the loss of wildlife habitat and biodiversity.

Evidence suggests that climate change and more intensive use of natural resources are increasing the risk of environmental damage. Although the exact effect of climate change on weather patterns is uncertain and will vary across the United States, climate change will increase the frequency and severity of extreme weather events, including intense rain storms, periods of extreme heat stress, and drought (Walthall et al., 2013; USCCSP, 2008). More intense rainfall, in particular, poses a significant challenge for conservation, especially intense storms that occur during the non-growing season or when the soil is bare. Rainfall rates that exceed the capacity of the soil to absorb and hold water will increase runoff that carries sediment, nutrients, pesticides, and other pollutants from fields to surface and ground water (SWCS, 2003; Nearing, Pruski, and O'Neill, 2004; Hatfield and Prueger, 2004).

In the Great Lakes basin, for example, evidence suggests that increased frequency of intense rain storms in the winter and spring are a key driver of elevated dissolved phosphorous loads into Lake Erie (Scavia et al., 2014; Daloglu, Cho, and Scavia, 2012; Michalak et al., 2013). Conservation practices or conservation systems—that is, groups of practices that work together—that are not designed for more frequent, higher intensity storms may not be fully effective in controlling nutrient runoff produced by them (Bosch et al. 2014). For example, filter strips may be inundated by the high-intensity storm events (Bosch et al., 2014). The application of other structural practices such as water and sediment basins or terraces may be needed to reduce or eliminate these negative impacts.

Climate change may also prompt farmers to change crops and production practices. These changes could have positive, negative, or mixed effects on the environment. Although there has not been extensive research in this area, some examples are instructive. Conservation tillage and no-till, for example, are often adopted as a soil moisture conservation strategy and are more often adopted in warmer regions (Ding, Schoengold, and Tadesse, 2009). To the extent that weather becomes warmer or drier in the future, conservation tillage and no-till adoption may increase. Changes in cropping patterns are also likely. O'Neill et al. (2005) argue that warmer, wetter weather in the Upper Midwest would make it profitable for farmers to switch acreage from wheat, a high residue crop, to soybeans, a low residue crop, potentially increasing soil erosion and nutrient runoff. Irrigation may also be used as an adaption strategy, putting further strain on water supplies. However, recent research suggests that U.S.

irrigated acreage could actually decline after 2020 due to limited water supplies and heat stress which reduces the relative profitability of irrigated production (Marshall et al., 2015). Although the exact mix of future climate change adaptations cannot be predicted and will vary, environmentally positive and negative adaptations are clearly possible.

While climate change is important in every part of United States and global agriculture, we focus on the U.S. crops sector.Conservation practices used in crop production can play important roles in mitigating the risks of climate change, limiting any increase in adverse environmental effects, and helping farmers increase resilience to increased production risks that may be associated with climate change. Climate mitigation efforts can include changes in land use, tillage, nutrient and manure management, and other practices that reduce greenhouse gas emissions or sequester carbon. Conservation practices can also help limit environmental damage—for example, sediment, nutrient, and pesticide runoff—that could be intensified due to climate change. On-going, periodic review of U. S. Department of Agriculture (USDA) conservation practice standards helps ensure that newly adopted or installed practices, if designed to USDA standards, will be effective even through weather patterns have changed.Some practices could provide multiple services. Practices that build soil health, for example, could provide climate mitigation (soil carbon sequestration), environmental protection (higher rainfall infiltration rates that reduce runoff and the loss of sediment and nutrients to the environment), and producer risk reduction (higher soil water holding capacity could reduce yield loss due to drought).

The increasing need for conservation practices could place greater demands on programs supporting conservation practice adoption.The USDA, through programs administered by the Natural Resources Conservation Service (NRCS) and the Farm Service Agency (FSA), has a long history of supporting conservation practice adoption through voluntary programs that provide both financial and technical assistance to producers. (See Box). Even as the need for conservation practices is rising, however, funding for USDA conservation programs has leveled off, at least for now. After substantial increases in conservation funding in the early years of the 2002 and 2008 Farm Acts, funding in the first years of 2014 Farm Act (2014 and 2015) were lower than levels in 2013—the last year when the 2008 farm bill was in force.

USDA Conservation Programs

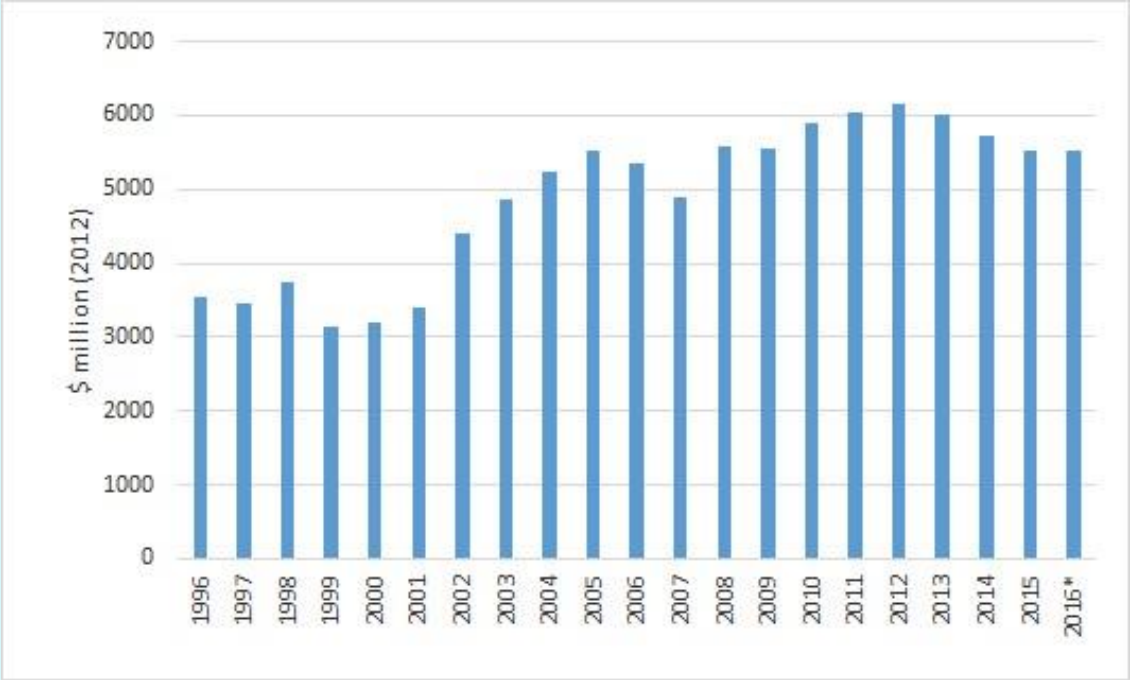
The U.S. Department of Agriculture administers a number of voluntary conservations programs. The Conservation Reserve Program (CRP), Environmental Quality Incentives Program (EQIP), the Conservation Security Program (CSP) and Conservation Technical Assistance (CTA) are the largest of these programs.

Program participation is voluntary. Producers receive financial and technical assistance in exchange for land retirement, through CRP, or adoption of conservation practices on working agricultural land, through EQIP and CSP. Payments are generally limited to participation costs, including direct costs of practice adoption and income foregone, or some portion of costs, although details vary across programs. Technical assistance can be provided without financial assistance (CTA).

Benefit-cost targeting is a feature of all major conservation programs and is generally implemented by ranking conservation program applications using a benefit-cost index. The best-known is the Environmental Benefits Index (EBI) used to rank applications in the general signup portion of the CRP (USDA-FSA, 2013). While most programs use some type ranking mechanism, details vary widely across programs.

Conservation effort is also targeted to specific regions and resources. The Regional Conservation Partners Program (RCPP) is designed to coordinate conservation program assistance with partners to solve problems on a regional or watershed scale. Financial assistance is coordinated through RCPP but provided to producers largely through other conservation programs. The Conservation Reserve Enhancement Program (CREP) forges Federal-state partnerships to focus conservation effort on specific resources—for example, water quality and wildlife habitat along a river corridor.

Figure 1: **USDA Conservation Program Funding, 1996-2016**



Source: USDA, Economic Research Service analysis of Office of Budget and Policy Analysis (OBPA) data on actual funding for 1996-2015 and OBPA estimates for 2016.
Notes: Includes the Conservation Reserve Program, Conservation Stewardship Program, Environmental Quality Incentives Program, Agricultural Conservation Easement program, Resource Conservation Partnerhsip Program, Conservation Technical Assistance and processor programs. Spending is adjusted to 2012 dollars.

Regardless of future conservation program budgets, cost-effectiveness will be an important determinant of how much conservation programs actually accomplish. As the increasing frequency of extreme weather events increases the need for conservation practices, the importance of cost-effectiveness will also increase. A program is cost-effective when payments go to farmers to support practices that deliver the largest environmental gain relative to adoption and maintenance cost. Given that USDA conservation programs are subject to budget constraints, the environmental gain that can be leveraged by a program is maximized when payments to individual program participants are just large enough to encourage adoption. Previous research suggests that the "devil is in the detail"—the cost-effectiveness of conservation programs can vary widely depending on how much is paid to which farmers for taking what actions (Shortle et al., 2012).

Cost-Effective Conservation is a Major Challenge

Achieving cost-effectiveness may be very difficult because the interface between agriculture and the environment is extensive and heterogeneous (Nowak, Bowen, and Cabot 2006). Thousands of farmers and ranchers, individual natural resources, including rivers and streams, wetlands, lakes, estuaries, groundwater, many types of wildlife habitat, and air quality can be affected by agricultural production. The benefits associated with increasing the supply of ecosystem services vary widely. Even when focusing on a specific resource, the environmental effect of individual farms—even individual fields—may vary widely depending on the mix of crop and livestock commodities produced, topography, soils, landscape position, and the specific production and conservation practices already in use. In many cases, the confluence of vulnerable resources and production practices that do not address these vulnerabilities produce situations where a large share of pollution originates on relatively small number of farms and fields (Nowak, Bowen, and Cabot, 2006). For example, consider a field with slopes that encourage rapid runoff of storm water, located near a river or lake, where granular fertilizer is applied to the soil surface without incorporating it into the soil. While nutrient loss to water is very likely, application of basic nutrient management techniques—for example, injecting fertilizer below the soil surface—could reduce nutrient runoff at a modest cost. For fields that are less prone to runoff or located at a greater distance from water, the environmental benefit of applying the same nutrient management practices is likely to be lower.

A large body of research suggests that program features like pay-for-performance (basing payment rates on the amount of ecosystem services produced) and benefit-cost targeting (targeting practices to landscapes or fields where they have the greatest effect per dollar of cost) can deliver environmental benefits at a lower cost than programs that do not account for heterogeneity across landscapes, farms, and fields (Babcock et al., 1997; Feather and Hellerstein, 1997; Cattaneo et al., 2005; Ribaudo, Savage, and Aillery, 2014). Some studies suggest that gains could be large. Feather et al. (1999) show that the likely increase in environmental benefits due to targeting introduced in the Conservation Reserve Program (CRP) in the early 1990s was equal to 25% of program costs without increasing program cost. In theory, more dramatic gains in cost-effectiveness could be obtained with extensive information on producer's willingness to adopt conservation practices and the relationship between conservation practice adoption and ecosystem services (Ribaudo, Savage, and Aillery, 2014).

When designing and implementing an actual conservation program, however, information needed to identify and enroll the farms and fields that would provide the most cost-effective environmental gain is difficult and costly to obtain. Because agricultural emissions—such as, nutrient runoff—cannot be directly observed, it can be very difficult to identify the farms and fields where large environmental gain, relative the cost of conservation practices, could be obtained.On-going research is expanding knowledge of the agriculture-environment interface. For example, the NRCS, through the Conservation Effects Assessment Program (CEAP), has made significant progress toward understanding the effect of conservation practices on soil erosion, nutrient runoff, and many other environmental effects. Nonetheless, our understanding is still far from complete. Incorporating new knowledge into program delivery can also be difficult because it requires the development of inexpensive and effective tools for measuring or estimating field level impacts on ecosystem services. That is, practical tools for program implementation must be effective without extensive and costly data collection and modeling efforts that are typical of research programs (for example, CEAP).

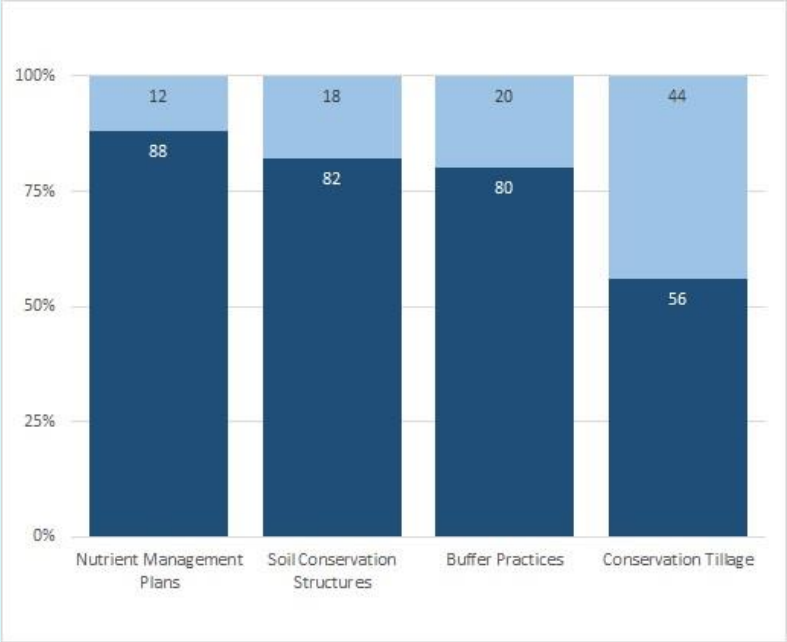
For voluntary conservation programs, producer participation is also critical. Cost-effectiveness may be limited when farmers don't participate in conservation programs (non-participation), when farmers receive payments for practices that they would have adopted without a payment (non-additionality), and when farmers stop using practices after a conservation program contract ends or the life of the practice ends (dis-adoption).

Producer willingness to adopt conservation practices and participate in conservation programs is difficult to anticipate. At any given point in time, some farmers adopt some conservation practices without financial assistance while others need substantial payments to adopt the same practices. In addition, technical assistance is often needed, even if financial assistance is not. A farmer will adopt conservation practices when the on-farm benefit from reduced input cost and preservation of soil productivity exceeds the cost of adoption within his or her planning horizon. Many conservation practices yield both on-farm and environmental, off-farm benefits. Individual farmers may be uncertain about the on-farm benefits and costs of implementing a given practice and may change their assessment of individual practices over time in response to successful application by neighbors, technical change that makes the practice easier to use, or a more complete understanding of on-farm benefits. Evidence also suggests that some farmers are willing to relinquish some return in exchange for protecting the environment (Chouinard et al., 2008). Because adoption cost, on-farm benefits, and environmental attitudes vary, the minimum level of payment needed to induce adoption—the farmer's "willingness to accept" or WTA—also varies in ways that are difficult to observe.

Non-participation by farmers who could produce large environmental gains relative to cost could limit cost-effectiveness. Farmers will participate in a voluntary conservation program only if the payment offered exceeds their WTA. Relatively high WTA could reflect high practice adoption costs or low on-farm benefits, but there are other issues. Data from the 2012 Agricultural Resources Management Survey (ARMS) shows a portion of conservation program non-participants believe that government conservation practice standards make practices more costly than necessary (34%) and that the cost of program application (29%) and documenting compliance (31%) are too high.Only 20% indicated that they believe practice-specific payments are too low (McCann and Claassen, 2016).

Non-additionality occurs when farmers participate in a conservation payment program even though they would have adopted conservation practices without receiving a payment. Payments may be made to these producers because program administrators do not know what level of payment they would be willing to accept. For conservation programs with fixed budgets, payments for practices that are non-additional—that would have been adopted even without the payment—use programs' resources but do not yield any environmental gain. Anecdotal evidence suggests that some farmers request financial assistance to access technical assistance that is provided by NRCS at no cost—any farmer may request technical assistance but priority is given to farmers who receive financial assistance.

Figure 2: **Additionality in Adoption of Common Conservation Practices, 2009-11**



Source: USDA, Economic Research Service, Economic Research Report, ERR-170

Existing estimates of additionality in voluntary conservation payment programs generally indicate that additionality is high for practices that have high initial costs or provide on-farm benefits that are small or realized only in the distant future. Using national data, Claassen et al., (2014) show that soil conservation structures (such as, terraces) and buffer practices (such as, grass waterways, filter strips) are additional about 80% of the time. Additionality is lower for practices that are more likely to be profitable in the short run. Conservation tillage practices—including no-till—are estimated to be additional roughly 50% of the time. High additionality on nutrient management plans means that farmers are unlikely to have a written plan without a payment. The result provides no information about plan application. Mezzatesta, Newburn, and Woodward (2013), using data from 25 Ohio counties, find additionality exceeding 80% for practices that have high costs or low on-farm benefits—for example, field-edge filter strips—but less than 25% for conservation tillage. Low additionality means that only a portion of benefits can be attributed to the program. If additionality in conservation tillage is actually 50%, for example, only half of the benefits from conservation tillage adopted with financial assistance can be attributed to the program.

Dis-adoption occurs when a producer participates in a conservation program but decides not to continue using the supported practice when the contract expires or life of conservation practices ends. Conservation payments provide a financial cushion to farmers for a limited time, helping them resolve uncertainty about practice costs and benefits or, perhaps, cover some one-time costs of transitioning to new practices. Beyond the end of the contract or the formal life of a practice, conservation practice use is likely to be sustained only when farmers believe that on-farm benefits exceed costs.

To date, there has been very little research on sustained adoption of conservation practices on working land. In a single watershed in Utah, Jackson-Smith et al. (2010) identified practices funded by USDA through the Little Bear River Watershed project between 1992 and 2006—mostly in the 1990s—and conducted follow-up interviews with producers to determine what proportion of practices had been maintained over time. Of practices actually implemented, they found that 78% were still in use, including 86% of structural practices (for example., more efficient irrigation systems) but only 66% of management practices (for example, conservation crop rotation). We note that roughly 30% of discontinued practices were dropped because individuals had quit farming or sold land for development While these data do not represent the entire United States, they suggest that follow up on practice use could provide valuable information on the effect of agricultural conservation programs.

Some Specifics (because the Devil Really is in the Detail)

Building soil health is increasingly viewed as a way to improve environmental quality and productivity because healthy soils have greater capacity to buffer extreme weather events. On the environmental side, for example, healthier soils with improved aggregate stability and more organic matter can increase rainfall infiltration rates and soil water holding capacity, thereby reducing sediment, nutrient, and pesticide runoff, and associated environmental damages. In terms of productivity, healthier soils can increase drought resilience by capturing and retaining moisture in the soil and making it available for plant growth.

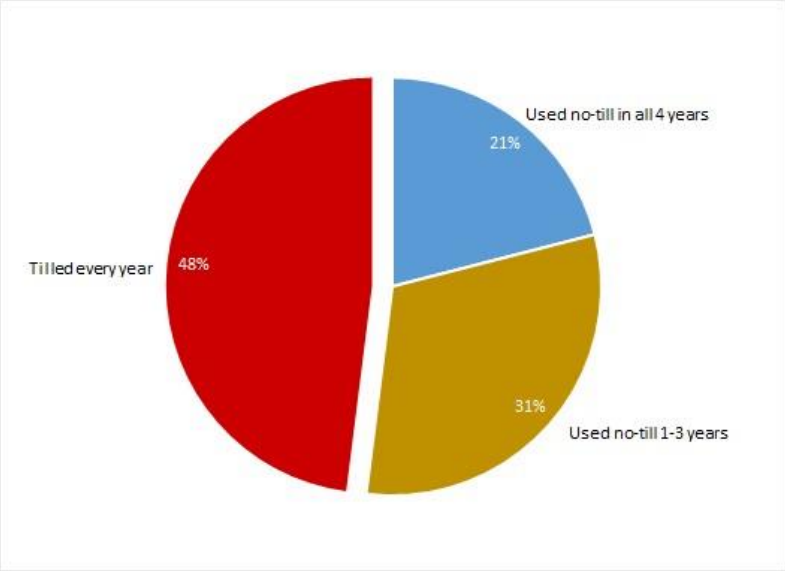
An extensive review of the agronomic literature (USDA-NRCS, 2014) suggests that soil health can be improved under a wide range of soil and climatic conditions, but only through the consistent application of a suite of practices over a period of years. Soil health can be built through long-term and continuous use of no-till, cover crops, double cropping, mulching, and rotation with permanent grass, such as pasture or hay. For example, continuous no-till used in conjunction with high residue/cover crops can have a positive effect on key soil properties including soil organic matter, soil aggregate size and stability, water infiltration, and water-holding capacity. Science-based nutrient management is needed

to maintain soil fertility for robust plant growth while minimizing the loss of nutrients to the environment.

According to the 2012 Census of Agriculture, cover crops were used on 10 million acres—about 3.2% of harvested cropland. Some farmers are concerned that cover crops will delay corn planting and about the cost of using cover crops (Reimer, Weinkauf, and Prokopy, 2012; Singer and Nusser, 2007). Preliminary results from an Indiana study indicate that on-farm benefits are less than the cost of cover crop adoption but that total social benefits including improved environmental quality are larger than adoption cost (Tyner, 2015). To the extent that annual costs of cover crops exceed on-farm benefits, concern about non-additionality is minimal. The potential for non-participation and dis-adoption, however, are high.

In Maryland, for example, it took annual, ongoing payments of $30-$55 per acre per year to effect a large increase in the use of cover crops as part of the effort to reduce nutrient losses to the Chesapeake Bay (Maryland Department of Agriculture, 2016a). For the 2015-16 cover crops season, Maryland farmers planted nearly 500,000 acres of cover crops (Maryland Department of Agriculture, 2016b), covering roughly 35% of the 1.4 million acres of cropland in Maryland (NASS, 2012). We do not know how many farmers would continue using cover crops if payments were ended.

Figure 3: **No-till Use Over a 4-Year Period for Corn, Soybean, and Wheat fields, 2009-2012**



Source: USDA, Economic Research Service and National Agricultural Statistices Service, field level data from Agricultural Resources Management Surveys, 2009, 2010, and 2012.
Notes: Surveyed fields grew wheat in 2009, corn in 2010, or soybeans in 2012, but could have been planted to other crops during any of the 3 years preceding the survey year

Unlike cover crops, no-till and strip-till are already widely adopted and largely without financial assistance, at least in some regions. Of farmers who reported some form of conservation tillage in the 2009, 2010, and 2011 field-level ARMS, only 10% reported ever receiving a payment for conservation tillage (Claassen et al., 2014). As already noted, the risk of non-additionality in conservation tillage practices is high. And, while the risk of complete dis-adoption is likely to be low, intermittent adoption may be limiting the soil health benefits of adoption no-till. Survey data also suggests that no-till and strip-till are used only intermittently on many farms. In 2010-11, for example, roughly 40% of four major crops—corn, soy, wheat, and cotton—were grown using no-till or strip-till but only about 23% of these crops were on farms that use no-till or strip-till on all crops (Wade, Claassen, and Wallander, 2015). Field-level ARMS survey data also show that farmers often rotate no-till with other tillage practices.

Farmers growing wheat in 2009, corn in 2010, and soybeans in 2012 were asked about no-till used in the survey year and the three previous years. No-till was used at least once on more than half of surveyed acres but was used continuously over the four-year period on only 21% of these acres (Claassen and

Wade, 2015). Evidence suggests that producers often rotate tillage practices along with crops. For example, no-till is more common on soybeans than corn (Wade, Claassen, and Wallander, 2015). These findings suggest that incentives may be needed to ensure continuous adoption of no-till/strip-till.

Understanding the Economics of Sustained Adoption is Major Challenge

Climate change is already intensifying the potential for environmental damage from agricultural production. Increasingly, extreme weather events threaten to overwhelm the capacity of existing conservation systems to absorb runoff from intense storms and sustain crop production through more severe periods of heat and drought stress. Conservation practices can help reduce risk to the environmental damage and limit the vulnerability of agricultural production to extreme weather events. Demand for financial and technical assistance from conservation programs is likely to increase. A higher level of program funding could help meet that demand. Working to improve program cost-effectiveness could also help increase the level of environmental protection derived from each dollar of conservation expenditure.

Increasing cost-effectiveness in conservation programs depends on identifying and engaging farmers who could deliver large environmental gains relative to the cost of achieving those gains. A key difficulty in achieving these gains is the complexity of the agriculture-environmental interface and the cost of obtaining information needed to identify these producers. The key question is whether greater cost-effectiveness—more environmental gain per dollar of cost—that could be achieved with more accurate targeting are large enough to justify the expense of identifying the producers that can deliver these gains. Even if these producers can be effectively identified, farmers and ranchers cannot be required to participate in voluntary conservation programs. Larger incentive payments could increase participation, but may not be the only issue limiting participation. Non-additionality and dis-adoption may also be issues. At this time, however, there have been only a handful of studies on these topics.

A more complete understanding of conservation practice adoption is needed. To date, most studies of conservation practice adoption have defined adoption within the scope of a single field and a single year. Understanding the economics of sustained adoption is a major challenge. Increasingly, producer surveys are eliciting information that could help improve adoption estimates. The CEAP survey, for example, asks producers for a wide range of information on a single field for a three-year period. The field-level portion of the ARMS asks for information on a limited set of practices, including crop history, cover crops, and no-till/strip-till, over a four-year period. At this time, however, there is very little data on how farmers use practices once conservation program contracts expire or conservation practice life ends. And, there is very little information on the frequency of dis-adoption or the frequency with which adoption is subsequently expanded to other parts of the farm. Developing data is a critical first step. For some practices, including no-till, remote sensing is likely to be a viable option. Increasing follow up on the effect of financial assistance for conservation management practices could also provide valuable information.

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Author Information

Roger Claassen (claassen@ers.usda.gov) is Senior Agricultural Economist, U.S. Department of Agriculture, Economic Research Service, Washington, D.C.

Marc Ribaudo (mribaudo@ers.usda.gov) is Chief, Conservation and Environment Branch, U.S. Department of Agriculture, Economic Research Service, Washington, D.C.

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