Agri-Environmental Policy at the Crossroads: Guideposts on a Changing Landscape

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Abstract

Agri-environmental policy is at a crossroads. Over the past 20 years, a wide range of policies addressing the environmental implications of agricultural production have been implemented at the Federal level. Those policies have played an important role in reducing soil erosion, protecting and restoring wetlands, and creating wildlife habitat. However, emerging agri-environmental issues, evolution of farm income support policies, and limits imposed by trade agreements may point toward a rethinking of agri-environmental policy. This report identifies the types of policy tools available and the design features that have improved the effectiveness of current programs. It provides an indepth analysis of one policy tool that may be an important component of a future policy package—agri-environmental payments. The analysis focuses on issues and tradeoffs that policymakers would face in designing a program of agri-environmental payments.

Keywords: conservation programs, environmental policy, agricultural policy, policy instruments, agricultural program design, soil erosion, and nitrogen runoff

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Contents

Summary

In the upcoming farm bill debate, decisionmakers considering policies that address the environmental implications of agricultural production may find themselves at a crossroads. Significant progress has been made in addressing traditional environmental concerns over the past 15 years; soil erosion is down, wetland restoration and protection have increased, and more wildlife habitat exists on farmlands. But the array of policy-relevant agri-environmental problems has also grown, as farm practices have changed and public concern has increased. In addition, world trade agreements may limit farm program options, perhaps increasing the practicality of "green-box" agri-environmental programs as vehicles for income support. This changing landscape presents decisionmakers with tremendous challenges as well as new opportunities.

This report provides policymakers with a guide to some of the choices they may face in formulating new agri-environmental policies. This guide looks back at past policies and the lessons that can be gleaned from their implementation, and it looks forward at the range of options available, providing conceptual insights and estimates of future policy tradeoffs. The potential benefits and costs of each policy option depend on the specifics of the program's design, so significant detail on design features is provided.

A glimpse into the policy toolbox reveals a wide variety of policy options: information dissemination programs such as education and technical assistance, government labeling standards, economic incentives, compliance mechanisms, and regulatory requirements. These tools range from voluntary to mandatory. Some are better suited for addressing problems or creating benefits flowing from the amount of land in crop production, while others are best suited for addressing issues arising from the choice of which crops to produce and how to produce them. The role of government varies as well. Government participation may be indirect or direct; for example, government agents may make information available to farmers or they might disburse (or collect) payments to (from) farmers. This variation in features among policy tools implies potential variation in the environmental effectiveness, economic efficiency, and distributional consequences of each. Tradeoffs—among environmental goals and in who gains and who loses and where in the country those gains and losses occur—are inherent in any policy choice.

Experiences with past agri-environmental programs provide lessons on effective design options.

- *Environmental targeting* channels funding to those areas where the environmental benefits are greatest relative to costs. Targeting can, however, result in an uneven distribution of program funding. One approach to environmental targeting—the Environmental Benefits Index—has been successfully applied in the Conservation Reserve Program (CRP).
- *Producer flexibility* allows farmers to devise a least-cost approach to meeting environmental improvements rather than imposing a specific approach devised at county, State, or Federal offices. This flexibility has been successfully applied in implementation of conservation compliance provisions.
- *Program coordination* ensures that programs do not duplicate or offset each other. Coordination is complicated because of the wide range of existing farm

programs and environmental regulations. Implementation of conservation compliance provisions with the 1985 farm bill demonstrated successful coordination.

Maintaining the environmental gains achieved to date and addressing an expanded range of problems (nitrate leaching, manure management, etc.) in an increasingly complex policy landscape may require a mix of policy tools, some relatively new. One such tool is an agri-environmental payments program—payments to farmers who use or adopt practices that enhance the environment. While agri-environmental payments have tremendous potential to meet multiple environmental and farm income goals, how well they perform will depend on numerous design decisions, such as:

- The objective of the program—which environmental goal(s) is the program designed to achieve? Is support of farm income a program goal?
- The program base—what actions will trigger payments? Will we pay only for improvements in environmental quality, or will payments be made to all "good actors?" Will payments be based on the use or adoption of specific management practices thought to improve the environment, or will they be based on a measure of whether environmental quality actually improves? Will constraints be imposed on which lands are eligible for payments?
- The payment rate—How much will farmers be paid? Will payments exceed farmers' costs? Will payments be targeted, that is, will they vary spatially with the level of potential benefits from improving environmental quality? Will total program size be limited?

An agricultural sector simulation model measures many of the tradeoffs inherent in selecting among environmental goals or across program design features. Because not all market and nonmarket impacts are measured, results are instructive but not definitive. The environmental quality measures featured in the analysis are benefits from reduced soil erosion and nitrogen runoff. Soil erosion, at 1.9 billion tons per year, remains significant even though farm programs and changes in farming practices have reduced erosion 40 percent between 1982 and 1997. Nitrogen's adverse impact on water quality in coastal areas is a significant and growing concern. Nitrogen loadings (from fertilizer) are a leading cause of eutrophication in coastal estuaries and a large hypoxic zone in the Gulf of Mexico, though the full scope of these problems is still unknown.

Given the multiple objectives of agricultural policy, the analysis suggests that some tradeoffs can be avoided by addressing each objective separately. Objectives may be complementary or conflicting, but even where overlap exists, the ability to achieve two or more goals with a single instrument may be limited. For example, a program targeted to reduce nitrogen runoff damage could increase soil erosion damage. However, reductions in soil erosion may reduce damages from phosphorus. In other examples, the analysis shows that targeting payments to support the incomes of any specific group of farmers is unlikely to solve any given agri-environmental problem. Conversely, targeting any specific agri-environmental problem may exclude many producers that policymakers would otherwise include in an income support program.

Simulation results indicate that subsidizing only environmental improvement (if such a program can be implemented) would be the most cost-effective way to achieve environmental gains. However, environmental improvement implies that payments would apply only for changes in environmental performance made after enactment of an agri-environmental payment program. Lack of a pre-program, farm-specific environmental baseline may prevent policymakers from implementing such a program. Moreover, payments based on environmental improvement would not recognize the past contribution of “good actors”—producers who have already achieved a high level of environmental performance.

Alternatives include payments based on “good” environmental performance (e.g., “low” rates of soil erosion as estimated by the Universal Soil Loss Equation) or the use of environmentally “good” practices (e.g., conservation tillage), regardless of when or why “good” performance was achieved or “good” practices were adopted. These approaches are practical and equitable to good actors. However, they are likely to be less cost effective in achieving environmental gains and, unless carefully crafted, may create an incentive to expand production onto previously uncropped land. This could lead to a worsening of environmental quality.

Payments for “good” environmental performance would focus on management or conservation practices that are environmentally effective. When there is more than one way to achieve an environmental gain, a performance-based payment would allow producers to select the lowest cost alternative for their own resource conditions and farming operation. However, performance-based payments may entail substantial public investment in planning and enforcement. Farm- or field-specific conservation plans would be required.

Payments for “good” practices would limit producer flexibility and may result in the use of practices that are ineffective under some resource conditions. However, planning and enforcement costs may be quite low. Thus, practice-based payments may be more or less cost effective than performance-based payments depending on the environmental problem to be addressed and the resource conditions, crops, and farming practices at hand.

Agri-environmental issues come in all shapes and sizes and a one-size-fits-all policy tool does not exist. Hence, harmonizing agricultural production with preferences for improved environmental quality may require a menu of policy options. But choosing one, or many, policy tools is just the beginning. How well a policy instrument performs and the distribution of benefits and costs—among and between farmers, consumers, and taxpayers—will depend as much on how a policy is designed as on which policy is selected.

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Introduction

Agricultural production can both enhance the environment and degrade it. Agriculture provides rural landscape amenities and wildlife habitat, but has also resulted in soil erosion, nutrient and pesticide runoff, and the loss of wetlands (see box "Environmental Impacts of Agriculture"). Agricultural producers have limited market incentives to maintain beneficial practices or reduce environmental damages. Environmental outcomes typically follow from production on many farms over a large area. Benefits and damages often occur at some distance (i.e., downstream or downwind) from the farms that create them and may be realized only after a period of months or even years. The contributions of an individual farmer to environmental benefits and damages are neither directly observable nor easily monitored.

Agri-environmental programs seek to increase environmental benefits and decrease environmental damages associated with agricultural production. For example, soil conservation can reduce sediment in water, enhancing water-based recreations such as boating. Land retirement or wetland restoration can provide habitat that increases wildlife populations, enhancing wildlife viewing, fishing, and hunting. Agri-environmental programs may also support farm income. For example, a subsidy program might pay farmers who use environmentally sound production practices such as conservation tillage or nutrient management. These payments, even if designed to improve environmental quality, could provide another source of farm income.

Agri-environmental policy generally refers to a group of programs that encourage farmers to adopt environmentally sound production practices. Policy instruments or "tools" range from involuntary approaches, such as regulation or environmental taxes, to voluntary approaches such as technical assistance and subsidy programs. Some programs—like land retirement—discourage the use of environmentally sensitive land in crop production. Other programs focus on crop production practices (which tillage systems or chemicals are used) or on livestock waste management. Education and technical assistance help producers improve environmental performance, with or without financial incentives.

Producer participation in agri-environmental programs has mostly been voluntary; participants receive cost-share or incentive payments. To be eligible for these and other farm program payments, however, producers must meet minimum standards of soil conservation on highly erodible land and refrain from converting wetlands for crop production.

How well an agri-environmental policy instrument performs (e.g., the extent of environmental gains, cost of achieving gains, and distribution of these costs) depends largely on program design and implementation. In other words, the "devil is in the detail." Performance can vary widely depending on *how* a policy tool is used as well as *which* policy tool is used. Program features that can improve the effectiveness of an agri-environmental policy instrument, recognizing changes in the policy environment, are the subject of this report.

Agri-Environmental Policy At a Crossroads

Changes in the slate of agri-environmental problems and changes in agricultural and trade policy have transformed the agri-environmental policy landscape over the last two decades. A number of factors may point toward a rethinking and restructuring of agri-environmental policy.

First, the number of widely recognized agri-environmental problems is expanding. Before 1990, agri-environmental policy focused largely on conserving soil to

Environmental Impacts of Agriculture

Seventy-one percent of all U.S. cropland (nearly 300 million acres) is located in watersheds where the concentration of either dissolved nitrate, phosphorus, fecal coliform bacteria, or suspended sediment exceeds criteria for supporting water-based recreation (Smith et al., 1994).

National water quality assessments strongly suggest that agriculture is a leading source of remaining water quality problems (Ribaudo and Smith, 2000). Sediment is the largest contaminant of surface water by weight and volume (Koltun et al., 1997), and is identified by States as the leading pollution problem in rivers and streams (U.S. EPA, 1998). High concentrations of nitrogen in agricultural streams were correlated with nitrogen inputs from fertilizers and manure used for crops and from livestock wastes (USGS, 1999).

The level of agricultural nitrogen use, as with nitrogen concentrations in surface waters, rose sharply during the 1970's, peaked in 1981, and then stabilized (Smith et al., 1993; Smith et al., 1987).

Eutrophication and hypoxia in the northern Gulf of Mexico are due to nitrogen loadings from the Mississippi River (Rabalais et al., 1997). Agricultural sources (fertilizer, soil inorganic nitrogen pool, and manure) are estimated to contribute about 65 percent of the nitrogen loads entering the gulf from the Mississippi Basin (Goolsby et al., 1999). As much as 15 percent of the nitrogen fertilizer and up to 3 percent of pesticides applied to cropland in the Mississippi River Basin make their way to the Gulf of Mexico (Goolsby and Battaglin, 1993).

Recent research found that 44 estuaries (40 percent of major U.S. estuaries) exhibited highly eutrophic conditions, caused by nutrient enrichment (Bricker et al., 1999). These conditions occurred in estuaries along all coasts, but are most prevalent in estuaries along the Gulf of Mexico and Middle Atlantic coasts.

The most frequently detected herbicides in surface waters include several triazines (atrazine, cyanazine, and simazine), acetanilides (metolachlor and alachlor), and 2,4-D. These are among the most commonly used agricultural herbicides (USGS, 1999).

At least one of seven important herbicides (atrazine, cyanazine, simazine, alachlor, metolachlor, prometon, and acetochlor) was found in 37 percent of the groundwater sites examined by USGS but all at low concentrations (Barbash et al., 1999).

From its 1988-90 survey of drinking water wells, the EPA found nitrate in more than half of the 94,600 community water system wells and in almost 60 percent of the 10.5 million rural domestic wells. Levels exceeded minimum recommendations in 1.2 percent and 2.4 percent of the community and rural wells (U.S. EPA, 1992).

Groundwater levels are declining anywhere from 6 inches to 5 feet annually beneath more than 14 million acres of irrigated land (Sloggett and Dickason, 1986). Groundwater overdrafts tend to permanently increase pumping costs; can lead to land subsidence, which compacts the aquifer's structure; and can induce saltwater intrusion (USDA/ERS, 1997a).

Soil particulate, farm chemicals, and odor from livestock are carried in the air we breathe.

Habitat loss associated with modern farming methods on over 400 million acres of cropland brought about dramatic reductions in many wildlife species in North America, including cottontail rabbits and ringneck pheasants (Wildlife Management Institute, 1995; Risley et al., 1995).

Agriculture has been a factor in the decline of 380 of the 663 species federally listed as threatened or endangered in the United States (USDA/ERS, 1997a).

Agricultural wetland conversions averaged 31,000 acres per year between 1982 and 1992 (Heimlich et al., 1998). Wetland losses often reduce biodiversity because many organisms depend on wetlands and riparian zones for feeding, breeding, and shelter (NRC, 1995).

Success of Agri-Environmental Protection, 1985-2000

Agriculture-induced erosion fell from 3.08 to 1.89 billion tons/year from 1982 to 1997.[1]

Nonmarket benefits of erosion reduction due to compliance are estimated to exceed $1.4 billion/year (Hyberg, 1997).

Nonmarket benefits of erosion reduction due to the CRP land-use changes are estimated to exceed $692 million/year (see table 3).

Wetland losses fell from 593,000 acres/year in 1954-74 (Frayer et al., 1983) to 31,000 acres/year in 1982-92 (Heimlich and Melanson, 1995) as conversions became less cost-effective and Federal regulations became more constraining.

Swampbuster now discourages conversion of 1.5 to 3.3 million (estimated range) wetland acres (Claassen et al., 2000).

The WRP and EWRP have restored over 990,000 acres of wetlands (Heimlich et al., 1998; USDA, NRCS, 2000c).

The permanent cover of the CRP and WRP has improved wildlife habitat. The nonmarket benefits from the habitat provided by the CRP are estimated at over $704 million/year (see table 3).

Conservation tillage, which reduces soil erosion, was used on over 37 percent of all acres planted in 1998, up from 26 percent in 1989 (Magleby et al., 2000).

Land in retirement programs is increasing the amount of carbon sequestered in the soil, mitigating greenhouse gas buildup. A CRP acre in the Great Plains is estimated to sink approximately 0.85 metric ton of carbon each year (Lewandrowski et al., 2000).

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[1] Estimates of changes in erosion from 1982 to 1997 are from ERS analysis of National Resources Inventory (NRI) data of the USDA/NRCS.

preserve agricultural productivity. The 1990 farm bill expanded agri-environmental objectives to include water quality, air quality (dust), and wildlife habitat. More recently, nutrient runoff from agricultural sources has been identified as a key source of remaining U.S. surface water quality problems (USEPA and USDA, 1998). Nutrient runoff from commercial fertilizer, animal waste, and non-farm sources is polluting estuaries throughout the United States (Bricker et al., 1999). Nutrient inflows into the Gulf of Mexico are the suspected cause of a large zone of hypoxic (oxygen-depleted) waters (Goolsby, 1999), creating a “dead zone” largely devoid of marine life. Nutrient runoff from livestock farms may be responsible for outbreaks of waterborne pathogens, including *pfiesteria piscicida* (Mlot, 1997), *Cryptosporidium* (USDA, NRCS, 2000a), and deadly strains of *E. coli* (USDA, NRCS, 2000b). Other emerging or ongoing issues include the use of genetically engineered organisms in agricultural production, carbon emissions and the potential for sequestration in agriculture, and food safety concerns ranging from pesticide residues to new strains of antibiotic-resistant bacteria.

Second, environmental issues are increasingly important in agricultural policy. While farm income support has always been an implicit objective of agri-environmental programs (Luzar, 1988; Reichelderfer, 1991; Batie, 1984), environmental performance is now explicitly recognized as a policy objective in farm income support programs. Coordination between income support and agri-environmental policy was increased significantly in the 1985 and 1990 farm bills, helping to create significant agri-environmental gains. Since 1985, eligibility for farm income support programs has been tied to soil conservation on highly erodible land and preservation of wetlands. Between 1982 and 1997, soil erosion was reduced by nearly 40 percent on U.S. cropland.[1] The rate of wetland conversion for crop production in 1982-92 was a fraction of that in the 1950’s and 1960’s (Heimlich and Melanson, 1995; Frayer et al., 1983). Policy coordination may have played an important role in slowing wetland con-

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[1] Source is 1997 National Resources Inventory, U.S. Department of Agriculture, Natural Resources Conservation Service: www.nhq.nrcs.usda.gov/NRI/1997/.

version for agricultural production (Heimlich et al., 1998). Land retirement and other traditional agri-environmental policies, which focused largely on soil conservation before 1990, have been broadened to include water quality, air quality, and wildlife habitat.

Third, recent developments indicate that the future of farm price and income support policy is uncertain (Browne et al., 1997; Orden et al., 1996). In some respects, the 1996 FAIR Act was designed to reduce the role of the Federal Government in agriculture. Some farm income support was decoupled from market prices and production decisions. Annual acreage reduction programs, designed to reduce commodity production in times of excess supply, were ended (Young and Westcott, 1996). On the other hand, loan deficiency payments (LDP's), which have accounted for a significant share of income support in recent years, are closely tied to production and market prices. Moreover, in 1998 and 1999, policymakers approved emergency farm legislation to partially offset low market prices and other disasters and up total direct producer payments to $14.4 billion in 1999 and $20.8 billion in 2000.[2] This strongly affirms Congress' commitment to farm income support, but the cost and ad hoc nature of emergency legislation also raises questions about the underlying rationale for farm support and the sustainability of current farm programs.

Moreover, global trade agreements have further complicated the farm policy debate, possibly restricting farm program options. Under the Uruguay Round Agreement on Agriculture, countries agreed to reduce domestic commodity price support and export subsidies. The United States met its commitment to limit farm commodity support to no more than $23.1 billion in 1995, and is to meet a ceiling of $19.1 billion[3] in 2000 (USDA, ERS, 1997b). Many U.S. programs—including "decoupled" payments, the Conservation Reserve Program (CRP), and the Environmental Quality Incentives Program (EQIP)—appear to qualify as "green box" programs that do not count against support ceilings. (USDA/ERS, 1998a and 1998b). However, countercyclical payment mechanisms (such as loan deficiency payments under the 1996 Act and deficiency payments under past farm bills) would count against support payment ceilings.

These changes hint at new roles for agri-environmental programs in the tableau of U.S. agricultural policy. Some have suggested that the limits imposed by trade agreements will give greater prominence to "green box" agri-environmental programs as vehicles for farm income support. Others see a need to replace conservation compliance—the quid pro quo arrangement under which commodity and commodity loan payment recipients must provide minimum land stewardship—with programs that independently encourage good practices (or discourage bad ones). Questionable environmental implications of subsidized crop insurance—an increasingly popular farm program mechanism suspected of inducing farmers to overplant—are leading some to look for new agri-environmental program resolutions to the ever-present problem of program consistency across agricultural objectives. And producers who face the prospect of increasing regulation, particularly of animal waste management for water quality, seek a lower-cost, voluntary alternative through new or expanded agri-environmental program opportunities.

A new farm bill will be debated in 2001 and 2002 (which also ends the period of payments under the 1996 FAIR Act). This presents a grand opportunity to rethink the focus of agri-environmental policy and its relationship to overall farm policy. In looking ahead, only one thing is certain. Agricultural policymakers in the legislative and executive branches, and their constituents in agricultural and environmental interest arenas, will witness adoption of some portfolio of policies that will influence (if not induce) particular levels of agri-environmental protection and farm and farm household income. Exactly what those levels are, and how they relate to one another, is a direct function of the specific features—bells, whistles, and more pedestrian details—of the agri-environmental programs in place at the time. Because the features of agri-environmental programs end up resonating in the political arena, a prospective examination of how outcomes appear to be linked with program characteristics is clearly a useful exercise. And because history informs the future, some retrospective reflection can be equally useful.

This report seeks to arm those considering the future of agri-environmental programs with lessons gleaned from the past and conceptual insights about future

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[2] Program payments include: Production Flexibility Contracts, Loan Deficiency Payments, Market Loss Assistance Payments, Noninsured Assistance Payments, Disaster Assistance, Cotton User Market Payments, Supplementary Income Assistance Payments, Farm Storage Facility Loans, and other direct payments. Dollar figures are based on data from Office of Budget and Program Analysis, USDA.

[3] Not all of the direct payments to farmers mentioned above are subject to limitations, so the support ceiling is unlikely to be violated.

farm and agri-environmental policy interactions. We begin with a review of the general types of policy "tools" available and utilized to gain agri-environmental benefits. We then catalog the environmental gains achieved and limitations encountered under the policies and programs in place between 1985 and 2000. From this, we extract a series of lessons about the design of cost-effective conservation and agri-environmental policies.

Finally, we turn to analysis of a specific agri-environmental policy option: an agri-environmental payments program. Agri-environmental payments are based on actions taken to improve environmental performance. As we use the term, agri-environmental payments are extended to producers primarily for changes in farming practices and are designed to address issues that may not be effectively addressed with more traditional cost-share or land retirement programs. For example, changes in crop rotations, input use, and tillage systems could be subsidized under an agri-environmental payments program. Although not principally a land retirement program, producers could retire land in response to an agri-environmental payments program as a method of reducing input use, soil erosion, etc.

The term "green payment" refers to a subset of agri-environmental payment programs that have both environmental and farm income objectives.

Green payments are frequently discussed as an alternative for, or supplement to, current farm income and environmental programs (Lynch, 1994; Lynch and Smith, 1994; Batie, 1999; Horan, 1999; Claassen and Horan, 2000). For example, the Conservation Security Program (CSP), proposed as part of the Clinton Administration's FY 2001 budget proposal, would provide payments to support farm income but only to farmers who implement or maintain certain conservation practices such as conservation tillage or nutrient management (Glickman, 2000).

We address a number of questions that policymakers will face in designing any agri-environmental payments program:

- How will producers be prioritized for the receipt of payments? On the basis of potential environmental gain, need of farm income support, or both?
- Will payments be based on a measure or estimate of environmental performance or on the use of practices deemed to be environmentally sound?
- Will "good actors"—producers who have already adopted good conservation practices and/or achieved good environmental performance—receive payments on the basis of past actions?
- Will payments exceed the cost of making changes required for program participation? In other words, will producers derive significant benefits—over and above their costs—from participation in an agri-environmental program?

These program design details will largely determine the environmental and farm income effects of an agri-environmental payment program. To illustrate this, we define some hypothetical program scenarios. Using a computer simulation model designed to predict producer response to policy incentives, we analyze these scenarios to illustrate some of the more important tradeoffs policymakers will face in designing an agri-environmental payment program.

In analyzing program options, we pay special attention to the prospects for unintended consequences that may arise from extensive use of a subsidy mechanism.

Various Policy Instruments For Various Ends

Agricultural production affects the environment in myriad ways, and so begets multiple policy instruments to mitigate those effects. This section provides an overview of policy instrument types, highlighting generic properties and illustrating those properties with actual policies, where applicable.

The wide variety of specific policy tools available to policy decisionmakers can be categorized broadly as (1) information dissemination tools, (2) economic incentive tools, and (3) regulatory requirements. One important difference among the three groups is the degree to which producer participation would be voluntary (table 1). Fully voluntary approaches include technical assistance and government cost sharing. Instruments become increasingly prescriptive as economic incentives are tied to performance, ending with regulatory requirements as under the Clean Water Act.

A second major difference among policy tools is the role of government. Public personnel may simply assist farmers by collecting and disseminating information (e.g., educational and technical assistance programs). They might also, in a more direct role, define recommended procedures for achieving certain goals—a set of recommended best-management practices or requirements for third-party organic produce certification. Finally and most directly, public agencies could pay farmers who change their behavior (or levy taxes on those who do not) or simply require that best-management practices be implemented.

The third principal difference among policy tools is the nature of the land management decision targeted. A policy can be designed to influence/change farmers' choices about *how much* (and *which*) land to farm (land retirement). Or it can target decisions about *how cropland* is *used*, which crops are produced and under which practices and inputs (management and conservation practices).

Each policy tool has advantages and disadvantages; their differences will manifest as different impacts on farmers' profits, taxpayer costs, consumer prices, and environmental gains. The actual economic and environmental effectiveness will depend on a range of detailed design issues discussed later in the report ("Analysis of Alternative Program Designs," p. 36).

Here, we briefly describe each type of policy tool and its advantages and disadvantages.

Education and Technical Assistance

Education and technical assistance provide information to farmers to facilitate the adoption or use of more environmentally benign practices. Assistance can range from providing data, for example on soil quality, or disseminating information about new technologies or practices—including which are best under a given set of circumstances or how to operate them to achieve the greatest gain—to helping farmers prepare conservation plans.

Participation decision: Voluntary.

Government role: Provide information.

Land management target: Traditionally applied to management and conservation practices.

Advantages: Public information gathering and distribution may increase the use of conservation practices by farmers unaware of their effectiveness or unsure about how to adopt them. Private benefits to producers may include lowering production costs, preserving soil productivity, or reducing damage to their own resources such as ground water.

Disadvantages: These programs are completely voluntary, with effectiveness largely dependent on whether a given practice creates benefits for farmers that offset the costs of adoption (Ribaudo, 1997).

Application: U.S. agri-environmental policy has long relied on education and technical assistance. The oldest, and largest, education and technical assistance program is the Conservation Technical Assistance program (CTA), founded in 1936. Real expenditures (in constant dollar terms) for technical assistance followed a slight upward trend to about 1970, and then leveled off (or declined slightly) (Heimlich et al., 2000b). In terms of Federal program expenditures, the importance of technical assistance relative to land retirement has declined precipitously since 1986 (fig. 1).

Government Labeling Standards for Private Goods

Government labeling standards for private goods help create efficient private markets for goods produced with environmentally sound practices. National certifi-

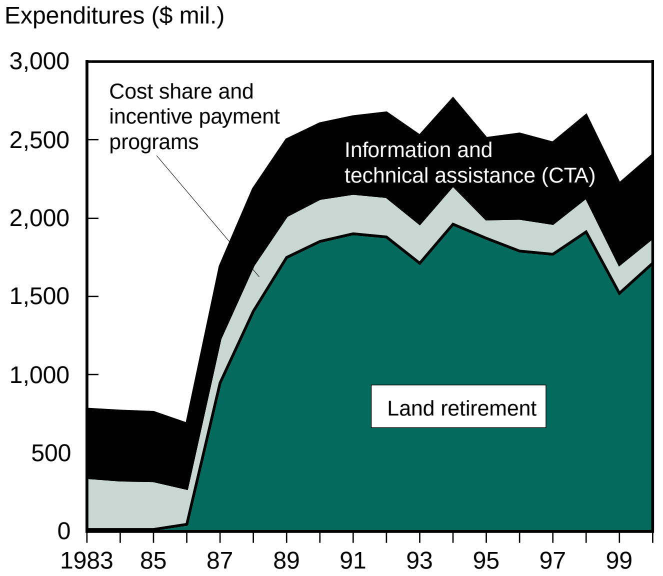
Table 1—A survey of public policy tools for addressing environmental effects of agriculture

Policy tool	Participation	Government Role	Selected U.S. Programs	
			Program title	Acronym
Educational/ Technical assistance	Voluntary	Provide farmers with information and training to plan and implement practices	Conservation Technical Assistance	CTA
Government labeling standards for private goods	Voluntary, but standard must be met for certification	Government sets standards, which must be met for certification typically involving voluntary "eco-labeling" guidelines	Organic certification	None
Incentive policies: Land retirement payments	Voluntary	Annual payments for retiring land from crop production for contract duration; contracts generally long term (10 years - permanent)	Conservation Reserve Program Wetland Reserve Program and Emergency Wetland Reserve Program	CRP WRP EWRP
Incentive policies: Land use payments	Voluntary	Payments to offset the cost of adopting specified best management practices; contracts intermediate run (5-10 years)	Agricultural Conservation Program[1] Water Quality Improvement Program[1] Environmental Quality Incentives Program Wildlife Habitat Incentives Program	ACP WQIP EQIP WHIP
Incentive policies: Environmental taxes	Involuntary, but payment amount depends on behavior	Per-unit charges for failure to meet environmental goals	None at the Federal level	None
Compliance mechanisms	Involuntary, after opt-in to Farm Program	Sets standards for environmental performance and determines whether requirements are met before releasing payments	Conservation Compliance Sodbuster Swampbuster	None None None
Regulatory requirements	Involuntary	Producers subject to regulations if voluntary measures do not achieve environmental goals	Coastal Zone Management Act Reauthorization Amendments	CZARA
		Operations may be subject to effluent discharge permits	Clean Water Act	CWA
		Use restrictions and bans on certain pesticides	Federal Insecticide, Fungicide and Rodenticide Act	FIFRA
		Farmers may not "take" a member of a listed species; Agencies must protect and restore species and their habitats	Endangered Species Act	ESA

[1] Programs are no longer in effect; they were replaced in 1996 by EQIP.

Figure 1

Conservation expenditures, 1983-2000



cation standards increase the informational value associated with specialized labels.

Participation decision: Voluntary.

Government role: Identify approved practices or guidelines for certification, enforcement.

Land management target: Traditionally applied to management practices.

Advantages: Certification standards assure consumers of the meaning and value of specialized labels, and make it easier for producers to capture price premiums for products produced under environmentally friendly practices. National certification standards can eliminate confusion created by standards that vary by State, facilitating interstate commerce in such products.

Disadvantages: Certification standards will generally be effective only where private gains from participation can be captured in a market setting. In some cases, it will be difficult to link program participation to measurable environmental benefits.

Application: USDA recently set uniform national standards defining the term “organic” for both bulk and processed products and at all stages of production and marketing in an effort to encourage wider adoption of low-input, organic crop production. To the extent that organic farming increases production costs per unit of output, relative to commercial farming, farmers will be more likely to adopt such practices if they can capture price premiums. Without clear standards for organic production practices, the line between organic farming and traditional commercial farming could blur and farmers adopting practices best for the environment might be less competitive than others. Standards can protect such farmers by requiring that everyone marketing their output as organic adopt at least a minimum set of required practices.

Economic Incentive-Based Policies

Economic incentive-based policies can provide positive incentives (payments to farmers) designed to encourage environmentally beneficial activities, or negative incentives (taxes farmers pay) designed to discourage environmentally harmful activities. In practice, only positive incentives have been implemented at the Federal level in regard to agriculture.

Economic-incentive instruments allow producers greater flexibility of response than do regulatory approaches (discussed below). Producers are free to weigh the incentive (subsidy or tax) against the costs they will encounter in making land use, management, or conservation practice changes that could increase a total subsidy payment or decrease a tax bill. Some producers may find it advantageous to forgo subsidies or pay a tax because the cost of making changes is high. Other producers may make large changes in response to the incentive. In this way, incentives can direct agri-environmental activity toward producers who can makes changes (achieve gains) at the lowest cost. Hence, economists frequently hail incentive-based policies as efficient tools for environmental goals. Whether they are, in fact, efficient will depend on the agri-environmental setting and the details of the program design.[4]

Taxes and subsidies differ, of course, in their effect on net farm income and on taxpayer burdens (both farm income and taxpayer burden rise with subsidies and fall with taxes). They also differ in the incentive they create for expanding or contracting crop production. Subsidies can encourage producers to expand crop production while taxes can encourage producers to contract production. A more detailed description of three economic incentive options follows.

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[4] Later is this report, we show that the efficiency of a subsidy incentive depends signficantly on the details of program design.

Cost-Share/Incentive Payment Policies

Cost-share/incentive payment policies pay farmers for adopting or using environmentally desirable practices. Cost-share policies typically pay 50 to 75 percent of farmers' adoption costs, while incentive payments more broadly defined could include payments exceeding farmers' costs.

Participation decision: Voluntary.

Government role: Determine targeted practices, provide direct payments.

Land management target: Traditionally applied to management practices.

Advantages: Cost-share and incentive payment programs increase the likelihood that farmers will adopt environmentally desirable practices by reducing the net cost of doing so. The larger the payment, the greater the range of practices likely to be adopted and the higher the number of likely participants. Payments that exceed the cost of adoption can provide income support to farmers who adopt or use environmental practices, compensating them for providing public amenities such as clean water or wildlife habitat (although landowners who are not farmers may capture some of the value of these payments (see box, "Supporting Farm Incomes and Protecting the Environment: The Case Where Farmers Are Not Landowners"). Also, if farmers are required to improve their environmental performance as a result of a separate regulatory requirement, public subsidies for adopting required practices would reduce (or eliminate) the impact of that requirement on farm income. Finally, incentive payment policies are conducive to voluntary contracts spanning a number of years, ensuring continuity of practices over time.

Disadvantages: Participation in such programs is voluntary. Policies providing for less than 100 percent of adoption costs will be effective only to the extent that targeted practices provide private economic benefits (in addition to the environmental benefits). Because participation will increase as payment rates rise (also increasing total program expenditures), it may be expensive for taxpayers to fund and exact substantial environmental change. In addition, without specific controls, payments for targeted practices can induce producers to expand crop acreage and thus exacerbate environmental damages, even if average damages per acre fall. These unintended consequences are addressed at length later in this report.

Application: A number of incentive payment programs have dealt largely with how land is farmed, including the Agricultural Conservation Program (ACP) and its successor the Environmental Quality Incentives Program (EQIP), and the Wildlife Habitat Incentives Program (WHIP) (see appendix 1, "Major Conservation Programs"). Traditionally, these programs focused on soil erosion but have expanded to incorporate other environmental attributes. While they have long been a mainstay of agri-environmental policy, total expenditures on these programs are small relative to expenditures on land retirement (fig. 1).

EQIP was enacted in 1996 to combine and refocus a number of longstanding conservation cost share/incentive payment programs (Ribaudo, 1997). Unlike the programs it replaced (the ACP, Great Plains Conservation Program, Colorado River Salinity Program, and Water Quality Incentives Program) 50 percent of EQIP funds are earmarked for practices or systems relating to livestock production. Moreover, EQIP funds are to be targeted to achieve the greatest possible environmental benefit per dollar of program expenditure. The programs preceding EQIP were generally available to producers on a first-come, first-served basis, and funds were divided more or less evenly among political jurisdictions.

EQIP has, in fact, focused a substantial share of program resources (58 percent of EQIP funds) on livestock operations (see box, "Environmental Quality Incentives Program"), especially management of livestock waste nutrients.[5] Under EQIP, 20 percent of program funds are allocated to livestock waste management,[6] a 50-percent increase in total funding for livestock waste management relative to ACP allocations in 1995. This increase is doubly significant since funding for cost-share and income incentive programs like EQIP has declined (in real dollars) over the past 15 years (fig. 2).

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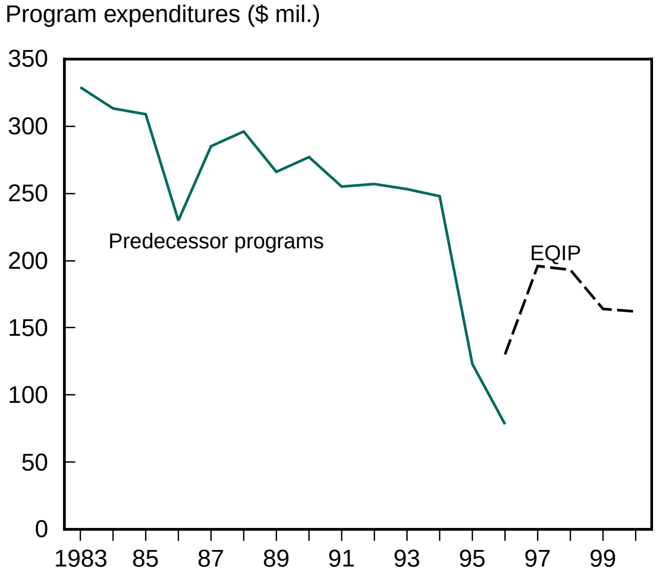
[5] Local USDA-NRCS staff determine whether an activity is "livestock-related." While there is no specific definition of a livestock-related activity, the term encompasses more than animal waste management.

[6] Source: ERS analysis of EQIP program data.

Figure 2

Funding for EQIP and predecessor programs



Land Retirement Programs

Land retirement programs provide annual payments to farmers for retiring land from crop production. Payments compensate farmers for forgone net revenues (net benefits they would have received had they produced crops on that land).

Participation decision: Voluntary.

Government role: Provide direct payments, select lands to be retired.

Land management target: Land retirement.

Advantages: Land retirement programs are particularly well suited for securing environmental benefits that increase with the length of time land is removed from crop production. For example, many wetland services and other wildlife habitat arise only when the ecosystem is fully established, a process that might take years. Retirement programs are also useful for protecting lands that cannot be sustainably farmed, such as those with very steep slopes. As such, land retirement programs tend to run longer than other policies. By removing land from crop production, land retirement also controls commodity supply, whether intentionally or as a byproduct. Finally, land retired can be easily confirmed and, therefore, easily enforced.

Disadvantages: Land retirement policies cannot address environmental damages from the vast majority of cropland that remains in production. Also, because program payments must cover the full value of the land in crop production (rather than a cost for modifying practices on land remaining in production), land retirement programs may be more expensive, per acre, than other policies discussed.

Application: Land retirement was used sporadically, most notably under the ACP in the 1930's and in the Soil Bank program of the 1950's, until the Conservation Reserve Program (CRP) began in 1985. Since the mid-1980's, land retirement has dominated Federal spending on agri-environmental programs (fig. 1). The CRP initially continued a tradition of land retirement for soil conservation and commodity supply management. Unlike previous programs, however, CRP eligibility was restricted to highly erodible land to enhance environmental performance. More than 36 million acres—about 10 percent of U.S. cropland—were eventually enrolled in CRP (Osborn et al., 1995). (See appendix 1, "Major Conservation Programs," for a program description.)

In 1990, the resource concerns of agri-environmental policy were broadened, largely to address many offsite problems (Zinn, 1991). An Environmental Benefits Index (EBI) was adopted to target land for retirement in the CRP based on environmental benefits and government costs. Wetland restoration on agricultural land also accelerated after 1990 with enactment of the Wetland Reserve Program (WRP), which purchases long-term, often permanent, easements.

Using the EBI, CRP contracts are allocated among bids based on generic environmental objectives like water quality or wildlife habitat. In recent years, policymakers have created the Conservation Reserve Enhancement Program (CREP) to focus a portion of CRP resources on local environmental problems. In Maryland, for example, the CREP is targeted to protect water quality in the Chesapeake Bay. In New York, specific watersheds are targeted to protect the drinking water supply for New York City. In Washington and Oregon, CREP programs focus on endangered species habitat (Smith, 2000).

Environmental Taxes

Environmental taxes are per-unit charges for actions contributing to environmental degradation. Charges may be associated with emissions (such as a fixed dollar value per pound of soil lost) or with input use (such as a fertilizer). They can be assessed on all units, or just on the

Supporting Farm Incomes and Protecting the Environment: The Case Where Farmers Are Not Landowners

It may be difficult to support farm incomes—through agri-environmental payments or otherwise—when farmers are not landowners. About 40 percent of agricultural land is rented from retired farmers, family members of deceased farmers, or somebody else. Payments intended to support farm income may instead be used to increase bids in the competition for rental land. In recent years, cropland rental rates have not declined, despite historically low commodity prices, indicating that some portion of large Federal farm income support payments (more than $20 billion in 2000) has supported land rental rates instead.

Whether payments can, in fact, support the incomes of tenant farmers depends on the nature of land rental agreements and the type of management or conservation practices being subsidized. Two types of tenure agreements predominate in agriculture: cash rental agreements (about 30 percent of cropland) and share rental agreements (10 percent of cropland). Moreover, the level of tenant and landowner responsibility and cost may depend significantly on the type of management or conservation practice involved. Environmentally motivated changes in management or conservation practices may involve (1) changes in crop production practices or (2) permanent improvements on land itself, e.g., terraces, waterways, manure handling facilities, etc. Permanent improvements imply a higher level of landowner responsibility and cost.

Under cash rental, tenants pay a fixed fee for use of the land, pay all costs of production, retain the commodities produced, and generally are paid all commodity program benefits. When land rental markets are competitive, commodity program benefits generally accrue to landowners in the form of high rental rates. Likewise, if agri-environmental subsidies paid to farmers exceed the costs of practice adoption, a portion of this income support payment may also accrue to landowners.

Even if landowners have no stake in annual production, they may receive a share of—or even all of—an agri-environmental payment. Under the Environmental Quality Incentives Program (EQIP, see box), for example, landowners are ultimately responsible for completion of contract terms. USDA allows EQIP contracts to specify any mutually agreed distribution of payments. Many contracts, particularly those involving structures such as manure management facilities for confined animals, reportedly go entirely to the landlord.

Under share rental agreements, tenants and landowners typically share in crop revenues, costs of production, and farm income support benefits. Agri-environmental subsidy payments, as well as any change in revenues or costs resulting from changes in management or conservation practices, would be split according to the general terms of the rental agreement. Because tenants generally provide machinery, they may receive a larger share of payments for changes involving machinery investment, such as conservation tillage. On the other hand, landowners are generally responsible for improvements to the land and may receive a relatively large share when changes involve land-related investment (e.g., terraces). To the extent that landowners are able to negotiate a relatively favorable division of the agri-environmental payment, they can capture some of the payment intended for farm income support.

number of units emitted or used above a given threshold. Total tax payments would depend on the farmer's behavior; the further from the environmental goal, the higher the payment. Farmers who meet those goals might incur no additional costs from a tax program.

Participation decision: Involuntary.

Government role: Monitoring, enforcement, and collection of tax.

Land management target: Primarily management practices, but could be designed to address land retirement.

Advantages: Environmental tax policies are consistent with the "polluter pays" principle, and they do not promote expansion of environmentally damaging activities.

Disadvantages: Taxes have a negative impact on farm income.

Application: Environmental taxes have not been used as an agri-environmental policy mechanism at the Federal level, though a few State tax programs do exist. For example, both Minnesota and Iowa tax agricultural pesticides and fertilizer (Morris, 1994). However, tax rates are too low to have a significant effect on the use of pesticides or fertilizer. Tax revenues fund research on environmentally sustainable agriculture (Iowa) and cleanup of agricultural chemical spills (Minnesota).

Compliance Mechanisms

Compliance mechanisms require a basic level of environmental compliance as a condition of eligibility for other programs. This tool shares characteristics with both government standards for private goods/actions and economic incentives. It is similar to the former in that the government establishes a set of approved practices, except that here compliance is linked to a direct economic payment. Because existing programs are used for leverage, compliance mechanisms require no budget outlay for producer payments, although considerable technical assistance is needed to develop conservation compliance plans.

Participation decision: Involuntary.[7]

Government role: Establish and determine whether compliance standards are met.

Land management target: Land use, management, and conservation practices.

Advantages: Compliance mechanisms are well suited to certain agri-environmental problems that may be more difficult to address with voluntary subsidy programs. For example, draining a wetland can trigger the loss of Federal program benefits. In contrast, to protect wetlands with a voluntary subsidy program, policymakers might find themselves having to pay for maintenance of all wetlands—a potentially expensive proposition—or needing to decide which wetlands have sufficient agricultural conversion potential to warrant protection—a potentially difficult and divisive task (Heimlich and Claassen, 1998b).

Disadvantages: The distribution of agri-environmental incentives depends on the distribution of Federal farm program payments. Many agri-environmental issues, particularly emerging issues such as livestock waste management, do not occur on farms that are the traditional clients of these programs. Also, if farm program payments are countercyclical, program payments will be low when prices, and therefore incentives for plowing highly erodible land (HEL) or draining wetland, are high (Heimlich et al., 1989).

Application: In 1985, the Food Security Act ushered in a new era of agri-environmental policy. Perhaps the most fundamental change in policy was the adoption of compliance mechanisms to protect highly erodible soils and wetlands. These mechanisms require certain resource conservation activities in return for benefits from selected Federal agricultural programs, most notably price support loans and income support payments.

- Under the **sodbuster** provision, producers who bring HEL into crop production must apply strict soil conservation systems(USDA/NRCS, 1996).
- **Conservation compliance** requires conservation systems on previously cropped HEL, albeit less stringent systems than required by sodbuster.
- Under **swampbuster**, producers who convert wetland for agricultural production can lose Federal farm program payments.

The adoption of compliance mechanisms was a significant step toward coordination in agricultural and agri-environmental policy. The sodbuster and conservation compliance provisions were enacted in conjunction with the Conservation Reserve Program as part of an overall strategy to reduce soil erosion. Producers who choose not to meet conservation compliance requirements (because of cost, for example) could enroll land in the CRP. Compliance mechanisms also redressed a longstanding inconsistency between farm price and income support programs—which encouraged farmers to expand production, sometimes on environmentally sensitive land—and conservation programs that sought to mitigate the adverse effects of agricultural production (Miranowski and Reichelderfer, 1985).

Regulatory Requirements

Regulatory requirements lie at the far end of the policy spectrum in terms of the degree to which participation is voluntary. Rather than attempting to facilitate or encourage improved environmental performance, policymakers can simply require it. In the name of public health and safety, a number of practices are banned and safe application methods are required. The ban on the production and application of the chemical DDT is one such example.

Participation decision: Involuntary.

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[7] Participation is technically voluntary. However, payments in these programs are widely viewed as entitlements by producers, are largely capitalized into the value of land (Barnard et al., 1997; Duffy et al., 1994), and are generally built into producers' financial calculations. Consequently, we categorize this policy instrument as an involuntary one, albeit with a qualification.

Government role: Establishing standards, monitoring, and enforcement.

Land management target: Management practices and land retirement.

Advantages: Regulatory requirements can be the most effective of all policy tools in effecting changes to improve environmental quality, assuming that regulations are adequately enforced. Unlike policy choices in which farmer participation is uncertain, regulations simply require that all farmers participate. This feature is particularly important if the consequences of not changing are drastic or irreversible.

Disadvantages: Regulatory requirements can be the least flexible of all policy instruments, requiring that producers reach a specific environmental goal or adopt specific practices. Producers are not free to determine their own level of participation, based on their costs. Unless regulators know farm-specific costs and can use this information to establish farm-specific regulations, agri-environmental effort is not necessarily directed toward producers who can make changes (achieve gains) at the lowest cost. Consequently, regulation can be less flexible and less efficient that economic incentives.

Application: Regulatory requirements are rare within traditional agri-environmental policy. However, farmers operate within an increasingly complex regulatory environment. Federal laws most likely to impact farm operations include the Coastal Zone Act Reauthorization Amendments (CZARA), which targets agricultural nonpoint-source runoff affecting coastal waters; the Clean Water Act (CWA), which regulates the deposit of dredge and fill materials in wetlands; the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), which regulates the use of farm chemicals; and the Endangered Species Act (ESA), which aims to protect species in danger of going extinct (see appendix 1, "Major Conservation Programs"). The Environmental Protection Agency (EPA) is currently developing regulations regarding the management of animal waste from large confined animal operations under authority provided by the CWA.

In sum, a wide variety of tools are available to policy decisionmakers. Tools range from direct to indirect and voluntary to involuntary, from information provision and technical assistance to policies that dictate farmers' practices or performance levels. Some tools provide a direct economic incentive to encourage participation. Some policies are better suited for influencing decisions regarding cropping and management practices on land in production; others are better suited for addressing environmental implications of decisions on whether to retire land.

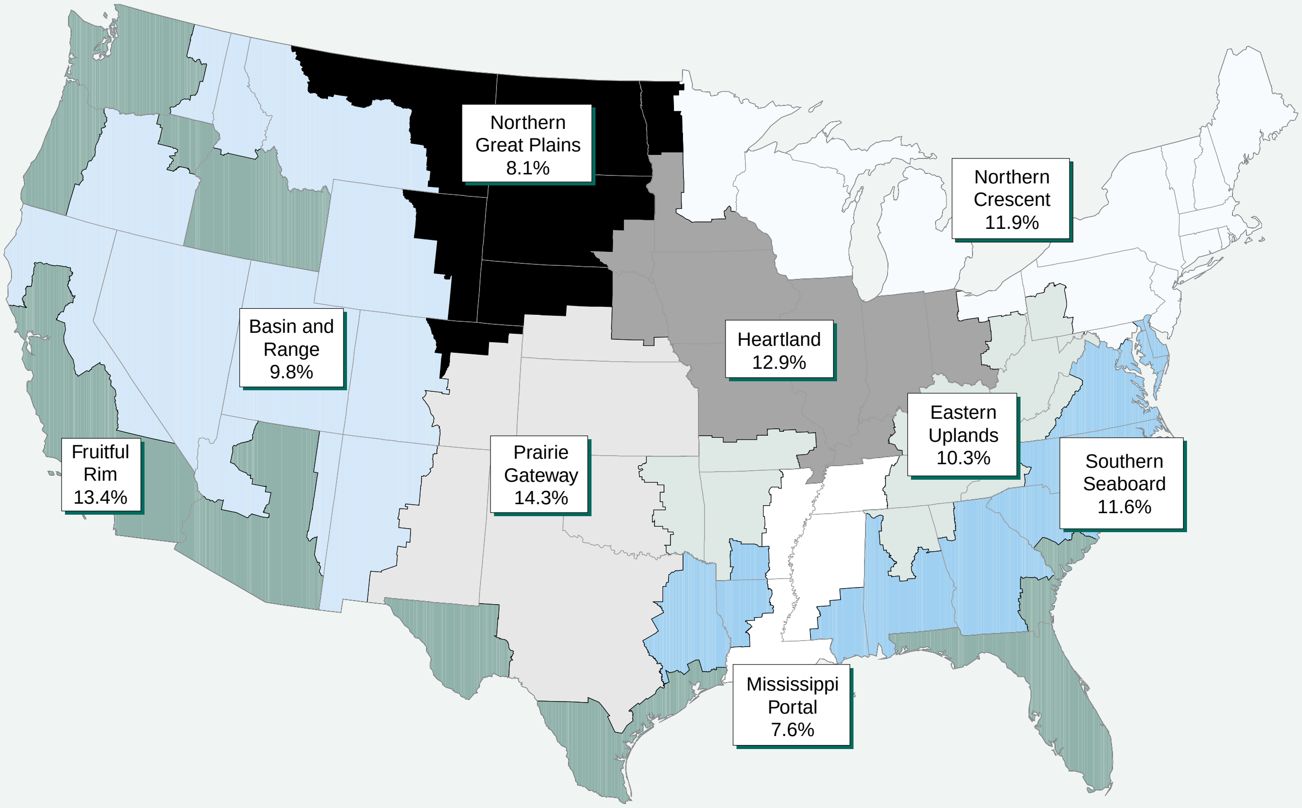
Despite this wide range of options, USDA agri-environmental policy in the past two decades has relied primarily on two tools: economic incentives for long-term land retirement and compliance mechanisms for soil conservation on land remaining in production and to discourage conservation of wetlands to crop production. Cost sharing and technical assistance programs exist as well, but are significantly smaller than land retirement in terms of total expenditures and than compliance mechanisms in terms of acreage affected. In the following section, we discuss the environmental gains that can be associated with past programs, and highlight policy design features that contributed to their relative successes and failures.

The Environmental Quality Incentives Program (EQIP)

The Environmental Quality Incentives Program (EQIP) provides technical, financial, and educational assistance for a wide range of agri-environmental activities. Through 1999, $466 million was obligated in 64,361 contracts covering 26.8 million acres of agricultural land, including nearly 7 million acres of cropland. Payments are proportional to the number of farms across resource regions, except in the Basin and Range where payments relative to the number of farms tend to be greater (see appendix 6, “ERS Farm Resource Regions”).

Five categories of conservation practices are being funded: crop-related nutrient management, livestock-related nutrient management, soil erosion and land protection, water resources management, and other resource concerns. Thirty-nine percent of EQIP funds are being allocated toward water resources management practices, ranging from more efficient irrigation systems to livestock drinking troughs. Soil erosion and land protection practices account for 30 percent of all funding. While 58 percent of EQIP funds are devoted to livestock-related activities, 20 percent of funds have been designated specifically for livestock waste nutrient management.

Regional distribution of EQIP payments



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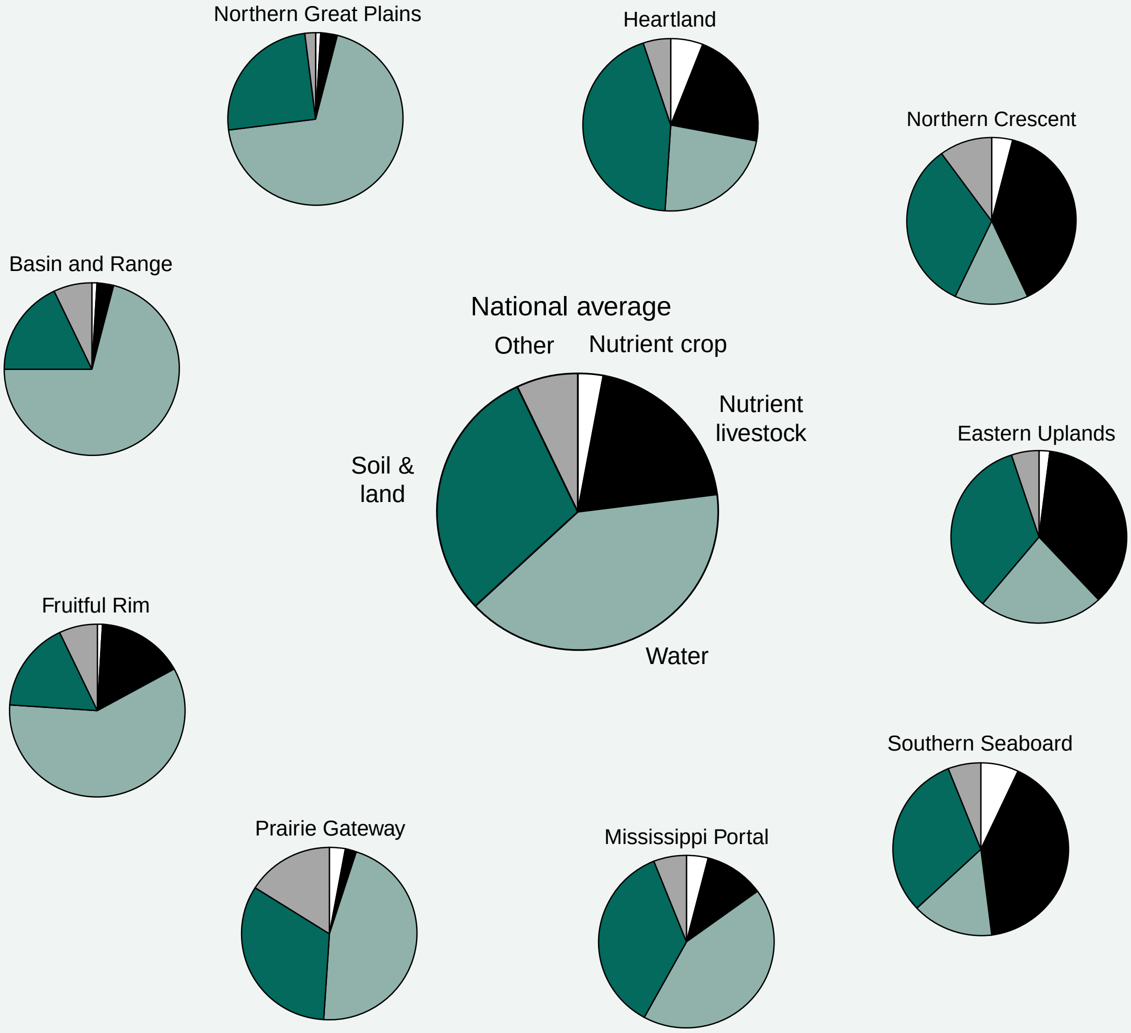
Distribution of EQIP funding



EQIP's targeting, in environmental terms, varies significantly across the ERS Farm Regions. Practices associated with management of livestock waste obtain the lion's share of funds in the Northern Crescent, Eastern Uplands, and Southern Seaboard where there is, in fact, an overriding concern surrounding these issues. In the Western United States (e.g., Northern Great Plains, Basin and Range, Fruitful Rim, and Prairie Gateway regions), where water scarcity is high profile, the majority of EQIP funds are allocated to improve water management practices. In the Heartland and the Prairie Gateway regions, which include 44 percent of the Nation's cropland, a large share of the funds are used to prevent soil erosion (the Heartland has the highest share of its expenditures allocated for soil erosion control). The Mississippi Portal is the one region where water resource and soil erosion practices are assigned approximately equal shares of the budget.

A Conservation Program Retrospective: Gains Made And Lessons Learned, 1980-2000

A look at recent agri-environmental programs reveals significant environmental gains. A closer look at the agri-environmental gains, in turn, provides some lessons on the merits of past program features.

Agri-Environmental Gains

To date, measurements of physical and economic gains have been attempted only for major agri-environmental programs: conservation compliance and the Conservation Reserve Program. Data on the impacts of smaller programs are scarce, which means it is difficult to measure their environmental effectiveness relative to costs. However, since the excluded agri-environmental programs are small, their environmental gains relative to those of the major programs can be expected to be small.[8]

Soil Erosion Has Been Significantly Reduced

Between 1982 and 1997, total erosion on U.S. cropland fell from 3.08 to 1.89 billion tons/year, a decline of roughly 1.2 billion tons/year or nearly 40 percent. Of this, just over half, 641 million tons/year, was due to reductions in sheet and rill (water) erosion, while 552 million tons/year was due to reductions in wind erosion (table 2). Farm conservation programs—especially conservation compliance and the Conservation Reserve Program—have helped bring about reductions in soil erosion (Magleby et al., 1995).

Conservation compliance has helped reduce erosion on land that remains in crop production. Conservation compliance required farmers to file and implement an approved conservation plan on nearly 91 million acres of cropped HEL to remain eligible for many farm programs (Hyberg, 1997). In 1997, approved conservation systems were in operation on more than 95 percent of all land subject to compliance (Claassen et al., 2000). Furthermore, once farmers have adopted conservation or reduced tillage practices on their HEL, they may be more likely to use these same practices on their non-HEL.

Total erosion on cropped HEL was 323 million tons/year lower in 1997 than in 1982; erosion on non-HEL cropland decreased by 319 million tons/year (table 2).[9] The nearly equal decline in erosion on HEL and non-HEL cropland, despite the lower erosion rate on non-HEL, is explained, in part, by the 3-to-1 ratio of non-HEL to HEL acres nationwide.

Government programs may not be the only factor reducing erosion. Erosion reductions may also be the result of technological advances in the production and design of conservation-related inputs. For example, a recent improvement in corn planters ensures even spacing of the seed despite the level of crop residue. Technological advances increase the profitability, and thus the adoption, of some conservation practices.

The Conservation Reserve Program reduced erosion by taking cropland out of production and requiring that a permanent cover be established. The Conservation Reserve Program selected HEL when the program began in 1985 and was expanded to include HEL and non-HEL after 1991. Total CRP acreage has ranged from 30 to 36 million acres since the late 1980's. Approximately 31.5 million acres were enrolled as of June 15, 2000, at an average per-acre rental rate of $45 (USDA, FSA, 2000b).

On land enrolled in the CRP in 1997, total erosion was 406 million tons/year in 1982 (table 2). However, this number does not represent the CRP's total impact on soil erosion for several reasons. First, the CRP reduces erosion to very low levels, but not to zero. Second, with conservation compliance, erosion on many of these acres would have fallen without the CRP. Third, the CRP helped raise commodity prices, which brought more land into production (USDA, FSA, 1997). This "slippage" comes from converting hayland or pastureland to cropland, thus increasing erosion.

The erosion due to slippage is difficult to assess because other factors also affected farmland conversions. First, the sodbuster provision of conservation compliance discouraged farmers from converting HEL to cropland. Second, compliance was encouraging

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[8] Expenditures on conservation practices through EQIP, which tends to be significant among remaining programs, averaged $155 million/year from 1997 through 1999 (see box, "EQIP")—approximately one-tenth those of the CRP.

[9] Estimates of changes in erosion between 1982 to 1997 are based on ERS analysis of National Resources Inventory (NRI) data of the USDA/NRCS.

Table 2—Soil erosion reduction in the United States 1982-97

Item	Soil erosion reduction, 1982-97 *(million tons/year)*
Net reduction in **total** erosion on cropland from 1982 to 1997 (percent change)	1,192.7 (38.9)
Net reduction in sheet and rill erosion on cropland from 1982 to 1997	640.7
Net reduction in wind erosion on cropland from 1982 to 1997	552.0
Erosion on HEL cropped in 1982 and 1997[1]	322.9
Erosion on non-HEL cropped in 1982 and 1997[2]	319.4
Erosion in 1982 on cropland enrolled in CRP in 1997[3]	406.0
Net change due to non-CRP land use change[4]	144.4

[1] The erosion change on HEL cropped in 1982 and 1997. Therefore, it does not account for the erosion reduction associated with any HEL that was cropped in 1982 but in pasture, hay, or the CRP in 1997. It does not include the erosion increase on the non-HEL that was pasture or hay land in 1982 and cropped in 1997.

[2] The erosion change on non-HEL cropped in 1982 and 1997. Therefore, it does not account for the erosion increase on non-HEL that was pasture or hay land in 1982 and cropped in 1997. It does not account for the erosion decrease on non-HEL that was cropped in 1982 but in pasture, hay, or the CRP in 1997.

[3] Erosion on CRP land is very low but not zero. Thus this figure would be slightly larger than the actual reduction in erosion.

[4] The net change in erosion on land that was cropped in 1982 but not cropped or in the CRP in 1997 and of land that was not cropped in 1982 but cropped in 1997. In other words, this is net change in erosion on land cropped in either 1982 or 1997 but not in the CRP. This category includes the cropland excluded from the three previous categories.

Source: ERS analysis of 1997 National Resource Inventory (NRI) Data.

farmers to take HEL out of crop production. And third, changes in world commodity markets affected domestic prices and also affected crop acreage. Thus, the effects of slippage, sodbuster, and conservation compliance on land conversions and on erosion are not separated.[10]

The public gains when soil erosion is decreased. Reductions in sheet and rill erosion have improved surface-water quality, which increases the public's enjoyment of water-based recreation and decreases costs to municipalities, industry, and other public and private sectors. Reductions in wind erosion reduce airborne dust, which betters human health, reduces household chores (sweeping windblown dirt from sidewalks, cleaning within homes, etc.), lowers some costs to industries, and increases the visibility of scenic vistas. Reduced soil erosion also helps maintain soil productivity, which increases food security. Because the farmer is not able to market and to be paid for these benefits of reduced soil erosion, they are referred to as "nonmarket" goods or impacts.

Conservation compliance is estimated to provide nonmarket benefits of $1.4 billion/year. Erosion reductions by the CRP are estimated to provide $694 million/year in nonmarket benefits (table 3).[11] These values include impacts to water-based recreation, soil productivity, municipal and industrial uses, and household chores. This likely understates the true value of the reduced soil erosion because benefits associated with increases in waterfowl populations, improvements in coastal and estuarine recreation areas, increased likelihood of survival of endangered species, increases in marine fisheries' populations, and decreases in the cost that airborne soil imposes on industries, scenic views, and others have not been included.

Wetland Restoration Has Exceeded Losses

Perhaps the most dramatic change in agri-environmental performance has been with respect to wetlands. Trends in wetland conversion and conservation programs have helped agriculture become a net restorer of wetlands. The rate of wetland conversion in agriculture has dropped sharply in recent decades, reducing the overall rate of net wetland loss (Heimlich et al., 2000a; Heimlich et al., 1997). Through the Wetland Reserve Program (WRP), agriculture has become the single largest source of U.S. wetland restoration (Heimlich et al., 2000a; Heimlich et al., 1998).

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[10] The total effect of these factors and of slippage reduced annual erosion by 144 million tons from 1982 to 1997 (table 2).

[11] Each benefit estimate assumes typical agricultural production with current programs in place.

Table 3—Environmental performance of conservation programs

Environmental performance measure	Program	Nonmarket benefits *($million/year)*
Soil erosion reduced		
	Conservation compliance	1,400[1]
	CRP	694[2]
Wildlife habitat improvement		
	CRP	704[3]

[1] Based on per-acre conservation compliance benefit measures and the 91 million acres meeting compliance in 1997 (Hyberg, 1997).

[2] Includes freshwater-based recreation benefits of $129 mil/yr (Feather et al., 1999), increases to soil productivity of $145 mil/year (Young and Osborn, 1990), impacts to costs of municipal water cleaning, dredging, etc. of $366 mil./yr (Ribaudo, 1989), and health impacts $50 mil/yr (Ribaudo et al., 1990). To be consistent with recreation estimates, all other reported values were adjusted to represent annual values on 35 million acres, a common approximate level of program enrollment.

[3] Benefits of wildlife viewing and pheasant hunting on CRP from Feather et al. (1999). Program acreage selected with an EBI.

Wetlands provide myriad ecological, biological, and hydrological functions (e.g., wildlife habitat, water quality, and floodwater retention) (Novitski et al., 1996). For example, filtering sediment and nutrients improves water quality, enhancing the value of downstream and underground waters (Carter, 1996; Williams, 1996).

The adequacy of wetland protection and restoration programs is currently assessed in relation to the goal of "no net loss" of wetland functions and values (Heimlich et al., 1998; Conservation Foundation, 1988). Because wetland functions and values are difficult to assess, no net loss of wetland area has often been used as a proxy for no net loss of wetland functions and values.

On the wetland conversion side of the ledger, conversions for agricultural production have decreased steadily in recent decades (fig. 3). Conversion of wetlands for crop production averaged 593,000 acres per year in 1954-74 (Frayer et al., 1983), but dropped to 235,000 acres for 1974-84 (Dahl and Johnson, 1991). Between 1982 and 1992 (the latest year data are available), gross agricultural wetland conversion fell to roughly 31,000 acres per year (Heimlich and Melanson, 1995).

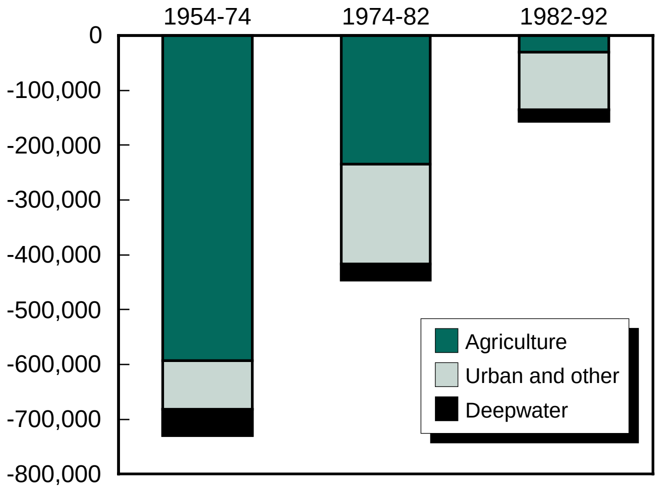
The decline in the rate of agricultural wetland conversion has been attributed to several factors. First, roughly half of all wetlands in the conterminous United States in 1780 have been drained, including larger proportions in some heavily agricultural States such as Iowa, Illinois, Indiana, Ohio, and California (Dahl, 1990). Remaining wetlands may be more difficult or expensive to convert or may be less productive once converted. Second, the long-term decline in the real price of agricultural commodities has reduced the potential benefit of wetland conversion (Tolman, 1997; Kramer and Shabman, 1993). Finally, policy change has been a factor. Section 404 of the Clean Water Act of 1972 regulates discharge of dredge and fill material into wetlands, and the Tax Reform Act of 1986 eliminated tax preferences that encouraged wetland drainage. Under the swampbuster provisions of the 1985, 1990, and 1996 farm bills, producers who convert wetlands for crop production can be denied a wide range of farm program benefits.

Evidence on the role of policy change in reducing wetland conversion for agriculture is mixed (see Heimlich et al., 1998, for a full survey). Some analysts have concluded that wetland conversion for agricultural production has simply become unprofitable, with or without swampbuster sanctions (Tolman, 1997; Kramer and Shabman, 1993). Using more detailed data on the

Figure 3

Wetland losses, 1954-92

Average annual conversion



potential productivity of wetland soils, other work has estimated that, without swampbuster, 5.8 to 13.2 million acres of wetlands would be converted to cropland (Heimlich et al., 1998). Claassen and others (2000) estimate that between 1.5 and 3.3 million acres of wetlands are being preserved with swampbuster compliance, depending on producer price expectations.

On the wetland restoration side of the ledger, agriculture is a leading sector in wetland restoration. USDA's Wetland Reserve Program (WRP) and Emergency Wetland Reserve Program (EWRP) have restored more than 990,000 acres of agricultural land to wetland status (USDA, NRCS, 2000c), an average rate of nearly 110,000 acres per year—between three and four times the rate of gross wetland conversion to agriculture calculated for 1982-92 (Heimlich et al., 2000a). Cropped wetlands also account for 1.6 million acres enrolled in CRP; roughly one-third of these acres are actual wetlands, the rest is upland buffer acreage. A number of smaller programs also restore wetlands on agricultural land, but at a combined rate of less than 12,000 acres per year (Heimlich et al., 1998).

Wildlife Habitat on Agricultural Land Is Enhanced

The availability of permanent cover, in some parts of the country, has grown significantly, primarily through the CRP. The CRP has provided 30 to 36 million acres of cover since the late 1980's, although slippage (the conversion of land to cropland) again reduces the program's net contribution. Wetland protection and restoration, through swampbuster and the WRP, have also contributed significantly to enhancing wildlife habitat.

Permanent cover greatly improves the health of wildlife ecosystems. The permanent cover of the CRP and the habitat diversity it adds to intensely cropped landscapes provide nesting cover, wintering habitat, and plant and insect feeds for most wildlife species not indigenous to forestland. This includes the large class of upland species.

The WRP has increased the availability of a unique habitat used by the greatest diversity of wildlife species. Wetlands are the most biologically productive ecosystems in the temperate regions, rivaling tropical rain forests (Mitsch and Gosselink, 1993). A wide variety of fish, birds, mammals, reptiles, insects, and plants take advantage of the wetlands' various functions. Over a third of all bird species in North America rely on wetlands for migratory resting stops, breeding or feeding grounds, or cover from predation (Kroodsma, 1979).

Increases in fish and wildlife populations provide the public better wildlife viewing, fishing, and hunting. These are nonmarket goods or benefits that the conserving farmer is unable to sell.[12]

The value of the CRP's improvements to wildlife viewing and to pheasant hunting has been estimated at $704 million/year (table 3). This represents a lower-bound estimate of wildlife benefits because it does not include improved hunting for many other species and the increased protection of threatened and endangered species. Note too that some impacts can be unexpected. For example, the added CRP acres in the Northern Plains have significantly increased duck populations, which require dense vegetative cover within 3 miles of the wetland for successful nesting (Reynolds et al., 1994).

The impacts of farm programs, as measured here, are lower-bound estimates because only major agri-environmental programs are included and because numerous wildlife, wetland, and soil erosion impacts have not been assessed. Furthermore, impacts on other agri-environmental resources—many of significant public concern—are not included. These include impacts on:

- Chemical loadings in water and the environment—Land retirement programs will decrease nutrient and pesticide use, although slippage offsets some reductions. Conservation tillage slightly increases herbicide use but leads to little change in nutrient and insecticide use (Padgitt et al., 1997). Any decrease in agri-chemical use can help decrease loadings in ground and surface water and in wildlife food sources.
- Climate change—Land in retirement programs increases the soil's carbon sequestration, which

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[12] Farmers do sell fishing or hunting access to pond-raised or pen-raised species. Because farmers hold property rights on these species and they are not dependent on wild ecosystems, the hunting and fishing of pond- and pen-raised species are not considered here. In limited cases, farmers sell access to species dependent on wild ecosystems. However, unless the farmer owns full access to affected water bodies and the essential parts of wildlife ecosystems, environmental impacts will not be privatized. For example, the farmer who provides the essential nesting and winter habitat may see many of the pheasant raised on his/her land hunted in the corn stubble of neighbors' land.

reduces atmospheric carbon loads. For example, a CRP acre in the Great Plains is estimated to sink approximately 0.85 metric ton of carbon per year (Lewandrowski et al., 2000). These benefits are temporary, however; should the acreage move back into crop production, the sequestered carbon will be released. Soil conservation practices associated with conservation compliance, including reduced tillage systems and use of winter cover crops, are also credited with reducing atmospheric carbon loads (Kern and Johnson, 1993; Lal et al., 1998).

- Groundwater quality and availability—Land retirement, through both the CRP and the WRP, helps improve the quantity and quality of groundwater recharge. The CRP is designed to account for potential groundwater quality impacts of fields offered for enrollment when a field is located in a groundwater protection area (table 4). The WRP restores wetlands, which not only improve groundwater resources by filtering chemicals from recharge but increase the rate or quantity of groundwater recharge (USDA/NRCS, 1997).

Lessons Learned

Factors That Sustain Environmental Gains

Only one program—the Wetlands Reserve Program—ensures permanent environmental gains through the purchase of permanent easements. For other programs, environmental gains are not sustained unless the programs themselves are sustained and the program incentives remain adequate. Failing that, farmers must find it profitable to maintain the land use or conservation practices.

If the CRP were eliminated, some portion of land would continue in the program until all contracts expire (no more than 15 years). When a contract expires, landowners are free to return land to crop production, although conservation compliance requirements must be met if the farmer is to remain eligible for many USDA programs (see box, “Conservation Compliance Requirements”). Whether land is returned to crop production depends on whether the landowner believes crop production will be more profitable than economic use of the existing land cover (e.g., the farmer may maintain tree cover). Profitability will depend on commodity prices relative to production costs (Osborn et al., 1993) and the productivity of land under the expiring CRP contract (Johnson et al., 1997; Johnson and Segarra, 1995).

Enterprise mix and related investments also appear to influence the likelihood of post-CRP conversions. Farmers who produce both crops and cattle are less likely than crop producers to say they will return CRP land to crop production (Johnson et al., 1997; Cooper and Osborn, 1997). Land irrigated prior to CRP enrollment may be more likely to return to crop production (Skaggs et al., 1994). Larger tracts of CRP land may be more likely than smaller tracts to be returned to crop production because small acreages are less likely to be productive or add significantly to farm revenue (Skaggs et al., 1994).

Socio-economic factors may also determine post-CRP land use. Producers who were motivated by conservation concerns to enroll land (Johnson et al., 1997), have obtained off-farm employment (Skaggs et al., 1994), or who are retired (Cooper and Osborn, 1997) are less likely to return land to crop production. Contract holders who are older but not retired (Skaggs et al., 1994) and those who are more risk-averse (Johnson and Segarra, 1995) are more likely to return land to crop production.

Sustaining gains achieved from conservation compliance, sodbuster, and swampbuster provisions depends on: (1) the size of Federal farm program payments that can be withheld relative to the costs of complying with HEL and wetland conservation requirements; and (2) the extent to which producers with highly erodible land (HEL) or wetlands on their farms participate in Federal farm programs. It is difficult to predict future farm programs or producer participation. Although evidence suggests that farm support programs will continue into the foreseeable future, it is reasonable to ask whether gains in soil conservation and wetland protection could be sustained without the incentive provided by these programs through compliance mechanisms.

Conservation compliance requires application of approved conservation systems (see box “Conservation Compliance Requirements”). Once established, the cost of maintaining conservation systems may be quite low, especially in cases where a significant capital investment is required. Conservation tillage—used on 33 percent of the HEL acres subject to compliance (table 5)—may have reduced per-unit production costs in many cases, although studies of the production efficiency of conservation tillage suggest that conservation tillage is not equally well adapted in all soil and climate conditions (Sandretto, 1997; McBride, 1999). However, once the investment in conservation tillage

Table 4—Factors generating points for the Conservation Reserve Program's environmental benefit index[1]

EBI factor	Definition	Features that increase points	Maximum points
Wildlife	Evaluates the expected wildlife benefits of the offer.	• Diversity of grass/legumes • Use of native grasses • Tree planting • Wetlands restoration • Beneficial to threatened/endangered species • Complements wetland habitat	100
Water quality	Evaluates the potential surface and ground water impacts	• Located in ground or surface water protection area • Potential for percolation of chemicals and the local population using groundwater • Potential for runoff to reach surface water and the county population	100
Erosion	Evaluates soil erodibility of field	• Larger field-average rate of estimated soil erosion	100
Enduring benefits	Evaluates the likelihood of CRP cover to remain	• Tree cover • More points for hardwoods	50
Air quality	Evaluates gains from reduced dust	• Potential for dust to affect people • Potential for wind erosion	35
Conservation Priority Area (CPA)	Evaluates potential to improve a CPA	• Located within a CPA	25
Cost	Evaluates cost of parcel	• Lower CRP rent • No government cost share • Payment is below program's maximum acceptable for area and soil type	Varies

[1]This table includes the most common and highest scoring practices. For more information, see USDA, FSA, 1999.

machinery is made, its continued and extended use may prove practical. Terraces—used in 13 percent of conservation systems—also require a significant capital investment (table 5). Once in place, terraces are relatively inexpensive to maintain.

Other practices are less likely to be maintained in the absence of an effective compliance incentive. Conservation cropping sequences—included in 81 percent of the conservation compliance systems—may be abandoned if less profitable than other sequences. However, because available data do not fully describe the conservation cropping sequences, an assessment has not been possible. Producers may also choose to remove grassed waterways and field borders—included in plans covering 9.2 and 3 percent of HEL cropland (table 5)—because they take land out of production.

Producers may also drain some wetlands or plow some previously uncropped HEL in the absence of effective swampbuster[13] and sodbuster[14] provisions. However, some authors have suggested that wetland conversion for crop production is no longer profitable, with or without swampbuster sanctions (Kramer and Shabman, 1993; Tolman, 1997). Similar arguments could be made with respect to conversion of HEL, but little formal research has been carried out on HEL conversion in recent years. New research, based on more detailed data than used in past efforts, indicates that 7.1 million to 14.1 million acres of wetland and HEL could be

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[13] The discharge of dredged and fill materials in wetlands is regulated under the Clean Water Act. These provisions have been used to regulate wetland drainage. However, this authority has not been effective in regulating wetland conversion for agricultural production. See Heimlich and others (1998) for a full discussion.

[14] HEL can be converted to crop production without sodbuster violation if a stringent and potentially expensive conservation system is applied. See Claassen and others (2000) for a discussion.

profitably converted to crop production without swampbuster and sodbuster, depending on producers' commodity price expectations (Claassen et al., 2000).

Similar issues apply to voluntary agri-environmental programs such as EQIP. To the extent that these programs leverage conservation investments with low maintenance costs or promote practices that reduce costs or provide other ongoing benefits to producers, e.g., protection of their own ground water, these investments or practices are more likely to be retained over the long term. Because technical assistance and cost-share programs require producers to pay part of the cost of conservation practices, producers who participate in EQIP or other cost-share programs are likely to adopt only those practices that reduce costs or provide other ongoing benefits.

Features That Provide Greater Environmental Gains Relative to Costs

Features of recent agri-environmental programs now allow these programs to provide more environmental quality relative to costs. Gains can be measured in physical or economic terms, with economic measures capturing the nonmarket value of the improvements in environmental amenities. Costs are represented by the net decrease in incomes of taxpayers, consumers, and farmers. (Although incomes of some groups may rise, they can be more than offset by losses in other groups.)

Consistency among farm and environmental programs improves agri-environmental protection. It was recognized in the mid-1980's that Federal commodity, loan, and crop insurance programs often induce production patterns that are inconsistent with soil conservation and water quality goals (Reichelderfer, 1985). This effect was unintentional, and arose from a complicated and unanticipated set of policy interactions. A history of land set-asides to achieve production controls for particular commodities led to an artificial scarcity of land, consequential hikes in farmland values, induced development of land-saving technologies, and a more intensive set of production systems, especially in times of high prices (Miranowski and Reichelderfer, 1985). Before 1985, a land owner/operator might be receiving commodity program payments that encouraged expansion of input-intensive production on additional land, while also receiving conservation cost-share payments to reduce the agri-environmental damages from that same production. The 1985 farm bill explicitly recognized this inconsistency, and attempted to reconcile it with conservation compliance

Conservation Compliance Requirements

Conservation compliance requires all farmers who produce crops on highly erodible land (HEL) and who receive or request certain USDA benefits to have an approved conservation system applied on those lands. Violations may result in disqualification from USDA programs or reduction of benefits. Conservation compliance was enacted in the 1985 farm bill. Producers were required to devise USDA-approved conservation plans by 1990 and to actively apply the conservation systems called for in the plans by 1995.

An approved conservation system is a set of field-specific cropping and managerial soil conservation practices designed in cooperation with local NRCS agents to reduce soil erosion. Basic conservation systems reduce erosion to the soil tolerance level. The soil tolerance level, or T, is the rate of soil erosion that can continually occur on specific soil without reducing its productivity. Soil erosion rates are estimated using the Universal Soil Loss Equation (Wischmeier and Smith, 1978) and the Wind Erosion Equation (Skidmore and Woodruff, 1968). Alternative conservation systems are allowed where basic conservation systems would place an excessive economic burden on producers. These systems must provide "significant" erosion reduction, but producers are not required to reduce erosion to the T level. The 1996 farm act requires that plans developed after July 3, 1996, reduce erosion by at least 75 percent of potential erodibility, not to exceed 2T. On land returning to crop production from the Conservation Reserve Program (CRP), however, conservation compliance requirements cannot exceed the requirement existing when the land entered the CRP.

Based on the FSA 1997 Conservation Compliance Status Review data (the most recent review data available), 95.9 percent of producers were actively applying conservation systems. Two percent of producers were actively applying conservation systems with variances. Fewer than 0.1 percent of operators subject to conservation compliance were *not* actively applying conservation systems in 1997.

Conservation systems are made up of conservation practices, such as conservation tillage or terraces. While 1,674 different combinations of conservation practices are approved as conservation compliance systems (Claassen et al., 2000), most systems are combinations of a handful of practices.

Table 5—The nine most widely used conservation compliance practices

Soil conservation practice	Definition	HEL acres using practice[1] (percent)	Requires large initial investment	May provide cost savings	Removes land from production
Conservation cropping	Crop rotation that preserves organic residue and improves soil tilth	81.1			
Crop residue use	Plant residue to protect cultivated fields during critical erosion periods	51.3			
Conservation tillage	System in which at least 30 percent of surface is covered by plant residue after planting	33.0	X[2]	X	
Contour farming	Preparing, planting, and cultivating land on the contour	19.3			
Terrace	Earth embankment, channel, or ridge and channel across slope	13.0	X		
Grassed waterway	Natural or constructed channel to provide for stable runoff	9.2	X		X
Surface roughening	Roughening soil by ridge or clod forming tillage	4.6			
Cover/green manure	Grasses, legumes, or small grain for seasonal protection and soil improvement	3.4			
Field border	Strip of perennial vegetation on edge of field	3.0	X		X

[1] Source: USDA, ERS, compiled from NRCS 1997 Status Review of Conservation Compliance data. Percentages sum to more than 100 because of multiple practices being applied to the same land.

[2] An 'X' indicates column consistent with row.

provisions and a CRP that melded conservation and supply control objectives.

In retrospect, the program consistency or coordination aspects of the 1985 legislation were highly successful. The conservation compliance, sodbuster, and swampbuster provisions assured that in order to participate in commodity and other farm programs, participants had to meet a minimum standard for environmental protection. Incentives to expand cropland into environmentally sensitive areas to build the “base” upon which commodity program benefits were multiplied ended in 1986 with a new base acreage calculus. And the CRP further targeted for retirement a large portion of that expansion acreage, about which there were environmental worries.

Program consistency and coordination remain concerns, however. As of 1996, federally subsidized crop insurance cannot be withheld from producers who violate conservation compliance, sodbuster, and swampbuster. Yet most empirical evidence suggests that the availability of subsidized crop insurance does result in expanding cropland acreage (Young et al., 1999; Keeton et al., 1999; Wu, 1999;). Griffin (1996) argues that much of the erosion reduction achieved in the Great Plains through CRP was offset by shifting land from pasture or hay to crop production to capitalize on subsidized crop insurance and disaster payments. Goodwin and others (1999) obtained similar results.

While some proposals for future legislation, such as the Conservation Security Program, do address agri-environmental issues and farm income simultaneously, there is little evidence that the issue of program coordination among future programs is getting a lot of attention. Nevertheless, it is only by explicitly addressing how future farm, commodity, insurance, resource conservation, and agri-environmental programs will interact that inherent inconsistencies can be minimized and complementarities found.

Producers have utilized flexibility in the conservation compliance program. In many cases, farmers can change production methods in more than one way (e.g., crop rotations, tillage practices, etc.) to achieve an environmental objective. A program is **flexible** if producers are allowed to select the production methods most suitable to their economic objectives yet consistent with the environmental goals of the program.

Flexibility can reduce costs to growers of participating in or complying with an agri-environmental program. The geophysical and biological environment, as well as producer management skills, production practices, preferences, and attitudes regarding environmental performance, vary widely among agricultural producers, even within small geographic areas. A specific conservation practice may fit well into one farming operation and boost environmental benefits, but increase production costs or provide little environmental gains when adopted by others. Thus, a one-size-fits-all agri-environmental program is unlikely to minimize costs.

The implementation of conservation compliance provided great producer flexibility. The program requires application of soil-conserving production systems on highly erodible cropland as a condition of farm program eligibility but gives producers significant latitude in customizing conservation plans (see box, "Conservation Compliance Requirements"). The program goal is to reduce erosion (as estimated by the Universal Soil Loss Equation (USLE) or the Wind Erosion Equation (WEE)) to a level that can be sustained without long-term damage to agricultural productivity.

A 1997 USDA review of conservation compliance found 1,674 different conservation systems that brought erosion to compliance levels had been approved (Claassen et al., 2000). Conservation systems involving only conservation cropping sequences, conservation tillage, crop residue use, or some combination of these three practices were applied on 54 percent of HEL cropland (Claassen et al., 2000). Plans vary widely among regions, based on cropping patterns, production systems, climate, and soils (USDA, FSA, 2000a).

Targeting has increased environmental benefits of the CRP. The Conservation Reserve Program was USDA's first exercise in environmental **targeting** in agri-environmental programs. In 1985, CRP was designed to enroll highly erodible land to reduce soil erosion and, perhaps more importantly, to reduce farm production during a time of low farm incomes. Improved water quality, wildlife, and air quality were secondary objectives and played no role in program qualification. The 1990 farm bill mandated that program enrollment be based on a more comprehensive assessment of potential environmental benefits that must then be compared with costs. The Environmental Benefits Index (EBI) was devised to meet this program objective.

The EBI is made up of a number of factors that account for environmental benefits (e.g., water quality) and contract costs (the proposed annual rental payments and cost of practice installment). Some environmental factors are given more points (e.g., water quality) than others are (e.g., air quality) because their nonmarket benefits are thought to be larger. The scoring of points for each EBI factor for each field that farmers offer to enroll is based on features such as soil type, location, county population, and the proposed CRP land cover (e.g., multiple grasses, trees, etc.) (table 4). The factor points a field earns serves as a proxy for the relative value of the field's potential environmental impact. For example, a field located near surface water receives a higher water quality score because its sediment, nutrients, and pesticides are more likely to reach the water. Fields in counties with large populations also rate a higher score because there are more people to appreciate (value) the increase in water quality.

An early economic analysis of environmental targeting indicated that the first EBI substantially increased environmental benefits relative to costs, compared with the program's original, erosion-based design (Osborn, 1993). This first EBI was based on four major benefit areas (water quality, wildlife, erosion, and permanent cover).

A more recent study shows that moving to environmental targeting provided a $370-million/year increase in CRP benefits with program acreage and costs virtually unchanged (Feather et al., 1999). This value represents a lower-bound estimate of the increase in benefits because only three environmental benefits—water-based recreation, pheasant hunting, and wildlife viewing—are included.

While it is clear that environmental targeting with the EBI has increased benefits relative to program costs, recent research indicates two adjustments that would further this increase. First, points given some EBI factors could be adjusted to reflect the associated benefits. That is, making EBI factor points earned proportional to the factor benefit estimates would increase environmental benefits from the CRP. The actual EBI points earned by acres selected into the CRP in signups 1997-2000 totaled 1,685 million for wildlife, 1,097 million for water quality, 1,382 million for soil productivity, and 263 million for air quality. By contrast, factor benefits are estimated at $704 million/year for wildlife impacts, $499 million/year for gains in water quality, $145 million/year for gains in soil productivity, and $50 million/year for gains in wind erosion benefits. Thus the estimated annual water quality and wildlife benefits are approximately 40 percent of their respective total EBI scores. However, total CRP erosion reduction benefits are only 10 percent of the total EBI points for erosion reduction. Since 10 percent is one-fourth of 40 percent, the EBI factor scores for erosion are four times what they should average if proportional to benefits. Likewise, the EBI factor score for air quality is approximately twice what it should be if factor score and benefits are to be proportional. However, adjusting factor scores is tenuous because only the erosion factor's benefit estimate is thought to be nearly comprehensive (Feather et al., 1999).

Second, environmental improvements near populated areas are, in many cases, of higher value than those in more rural areas because more people are there to enjoy the improvements. As previously noted, the current EBI attempts to incorporate this effect by including county populations. However, populations in neighboring counties are also relevant when impacts to environmental amenities are local, and populations in more distant areas are relevant when impacts are downstream, downwind, or along a migratory route. Research results indicate that the relative size and distance of the population surrounding the environmental improvement and the fate and transport of the environmental resources determine this population effect (Feather et al., 1999). An accounting of the impact on the affected population would likely enhance the targeting efficiency of the EBI and the CRP.

While coordination, flexibility, and targeting are three significant improvements in program design, they are not likely to be the only way an agri-environmental policy might be improved. However, these are the most apparent improvements demonstrated in programs implemented over the last two decades.

Agri-Environmental Payments: Policy Objectives and Program Design

In this section, we take up issues related to the selection of agri-environmental payment program objectives and the design of programs to meet these objectives. We focus on a payment or subsidy program for several reasons. First, voluntary subsidy mechanisms are the most widely used agri-environmental policy instrument in agriculture, owing largely to longstanding concern for and support of farm incomes. Second, two environmental payment programs have recently been proposed: the Conservation Security Program (CSP) proposed as a part of the Clinton Administration's FY2001 budget proposal, and the Conservation Security Act (CSA) introduced by Sen. Tom Harkin (D-IA). (Our analysis is not based on the specifics of either proposal.) Third, a payment program that deals with environmental performance on land in production may be suitable for addressing agri-environmental problems not well addressed by traditional land retirement or cost-share programs, namely nutrient loss to surface and ground water. Finally, we focus on a payment program because little formal analysis has been devoted to the design of such a program.

We raise a range of issues and analyze each issue conceptually, noting tradeoffs that may arise in developing a practical agri-environmental payment program. Ultimately, however, analyzing the effect of policy design on environmental, farm income, and other program outcomes benefits from empirical analysis. To illustrate some of these tradeoffs, we provide some empirical results from an analysis of hypothetical program scenarios.

We use two analytic tools for the empirical analysis. Our first tool, the U.S. Agriculture Sector Mathematical Programming Model (USMP) (see appendix 2), allows us to simulate a number of program alternatives. USMP is designed to predict producer response to policy incentives. Our second tool is a cross-analysis of data from the Agricultural Resources Management Survey (ARMS) and environmental indicators developed from USDA and the U.S. Geological Survey (USGS) data (see appendix 3). This analysis is designed to assess the overlap between specific producer groups and environmental indicators.

In our simulation modeling, we assume continuation of current farm programs, as specified by the Federal Agricultural Improvement and Reform (FAIR) Act of 1996: Production Flexibility Contract (PFC) payments are funded at their 2002 level (roughly $4 billion), Loan Deficiency Payments (LDP's) are available in case of low prices, and the Conservation Reserve Program (CRP) is continued at roughly 36 million acres. We also assume that conservation compliance, sodbuster, and swampbuster remain in place, but that producers are otherwise free to expand (or contract) crop acreage, consistent with the end of farm program base acreages and annual set-aside requirements under the 1996 Act. We model changes in commodity prices, farm income, and other economic variables as changes from those projected by the 1998 USDA baseline for the year 2005 (USDA-WOAB, 1998).

Agri-Environmental Payment Program Priorities

Agri-environmental payments could be used to address a myriad of environmental or farm income purposes. For example, payment programs may seek to improve water quality, increase wildlife populations, maintain soil productivity, and/or support farm incomes. Agricultural policy is now made up of multiple programs serving varying farm income, environmental, and other objectives. Because agricultural policy has multiple objectives, conflicts among objectives inevitably arise, if for no other reason than limited federal resources available to address these objectives. However, program design or lack of coordination among programs can also create or unnecessarily intensify tradeoffs among policy objectives.

Coordination across the full range of farm programs can reduce contradictory or duplicate efforts. The policy context is important to the selection of agri-environmental payment program objectives. If existing farm income support mechanisms are continued (e.g., production flexibility contract payments or loan deficiency payments), it may be appropriate to focus agri-environmental payment programs more heavily on environmental purposes. Likewise, if existing environmental programs are continued, it may be appropriate to focus on environmental issues not addressed by existing programs. For example, if land retirement programs are continued, policymakers may want to focus payments on production management or conservation practices on land in crop production.

In a multi-objective policy, addressing each objective explicitly will minimize tradeoffs. Stated another way, failure to explicitly address each objective can result in unnecessary tradeoffs among objectives. Some conflicts arise due to the *physical* nature of agri-environmental problems and cannot be avoided. For example, crop production management practices to slow rainfall runoff can reduce nitrogen runoff and soil erosion, but may increase nitrogen leaching into ground water (USGS, 1999). In other cases, environmental problems may be somewhat complementary, i.e., addressing one problem also addresses another, at least partially. For example, because a significant majority of phosphorus is lost to the surface through soil erosion (Litke, 1999; Sharpley et al., 1999), erosion reduction can reduce both sediment and nutrient damage to surface water. In general, however, failing to address each objective will expose policymakers to tradeoffs that could be avoided and may produce unintended consequences.

Some Examples of Likely Tradeoffs

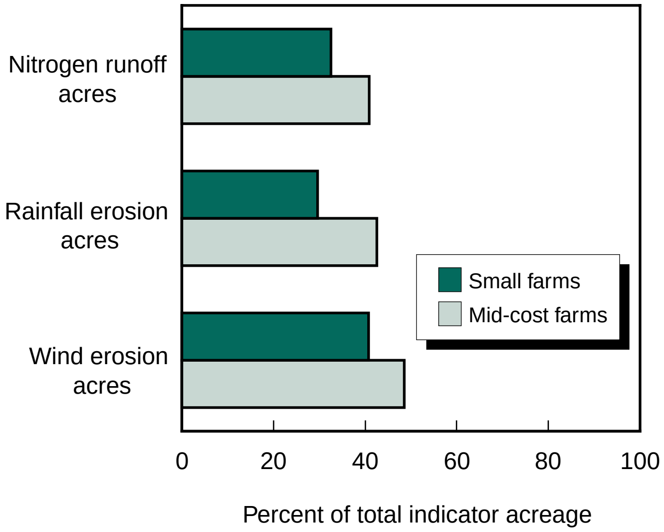
Targeting a specific environmental problem will not necessarily address other environmental problems and may make some worse. Even when environmental objectives are not at odds due to the physical nature of the environmental problems involved, policies that focus exclusively on a single environmental objective may produce unintended consequences that make other environmental problems worse.

To illustrate, we analyzed programs designed to reduce (1) sediment damage to water quality and (2) nitrogen damage to water quality (see box, "Evaluating Alternative Environmental Objectives"). Results suggest that conflict can arise. Directing payments to reduce sediment damage produces no change in nitrogen lost to water or excess nitrogen balances at the national level. By contrast, directing payments to reduce nitrogen damage *increases* annual soil erosion by 5.6 million tons or roughly 0.5 percent. This unintended consequence arises because payments are based on the use of "low" nitrogen application rates. Although producers reduce application rates on some acres in production, they also expand crop production where it is profitable using the low application rate, given the subsidy. The potential cures for such unintended consequences are discussed later in this report.

Tradeoffs can also arise between farm income support and environmental objectives. Environmental objectives can be achieved through payments for farm income support only to the extent that environmental problems occur on farms receiving income support. On the other hand, income support can be achieved through environmental payments only to the extent that farms targeted for income support also create environmental damages. To illustrate, we consider agri-environmental indicators related to rainfall erosion, wind erosion, and nitrogen runoff to surface water (see box, "Defining Farm Income Support 'Target' Groups and Environmental Indicators"). We assume that two specific groups are targeted for farm income support based on considerations of farm size and financial need: "small" farms and "moderately unprofitable" farms, e.g., farms that are not financially viable but could be with additional support. More generally, we look at the overlap between groups defined in the ERS farm typology (appendix 4) and the agri-environmental indicators.

Targeting payments to producers in need of income support is unlikely to fully address any specific agri-environmental problem. Directing payments to farms on the basis of financial or income criteria means that payments would not reach a large amount of land with environmental problems. For example, less than half of all *rainfall erosion*, *wind erosion, and nitrogen runoff* acres are likely to be located on either a small or moderately unprofitable farm (fig. 4). Of the three indicators, the proportion of *wind erosion acreage* managed by farms we target for income support in this example is highest, roughly 40 percent for moderately unprofitable farms and approaching 50

Figure 4
Percent of environmental indicator acreage on farms that could be targeted for income support

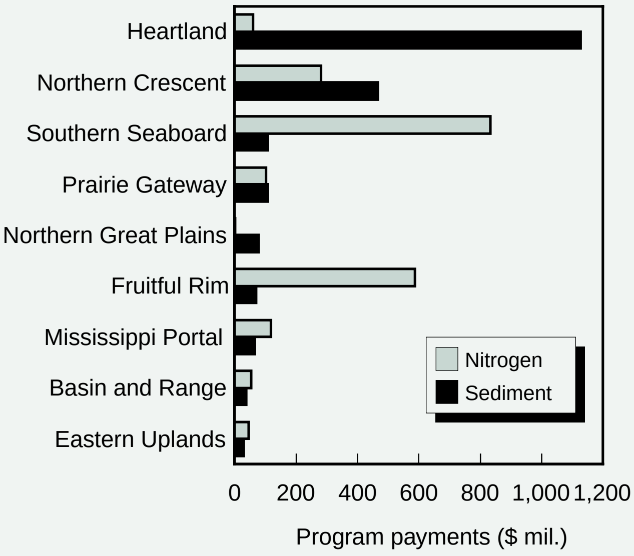


Evaluating Alternative Environmental Objectives

We use USMP (appendix 2) to compare programs designed to (1) reduce water quality damage due to sediment, and (2) reduce water quality damage due to nitrogen runoff from land in crop production (see table). Nitrogen runoff can be transported hundreds of miles, particularly in large rivers. Water quality damage due to nitrogen generally occurs in the coastal zone.

To focus program activity on regions where soil erosion or nitrogen runoff causes the largest potential damage to water quality, producers in those regions can receive higher payments, commensurate with higher water quality damages per ton of soil erosion or pound of nitrogen fertilizer application (see appendix 5, figs. 9 and 10). However, farm income support objectives may imply higher payment rates. Payment rates are varied by multiplying the benefit-based payment rate per acre by a constant. As payment rates increase, total program payments increase. Reported results are for program payments of $2.1 billion. Although this figure is arbitrary, it is modest relative to overall farm program expenditures in recent years. Finally, to guard against expanding crop production onto highly erodible land (HEL), producers who bring previously uncropped HEL into crop production are penalized. This provision is similar to sodbuster because the penalty is based on the level of other farm program payments (primarily Production Flexibility Contract (PFC) payments) and will be referred to as a sodbuster-type penalty. Results indicate that the sediment damage reduction and nitrogen damage reduction scenarios are not complementary. Targeting sediment damage exclusively produces no change in nitrogen fertilizer use or excess nitrogen balances. However, targeting nitrogen damage exclusively produces an *increase* in soil erosion and associated water quality damages. Because any non-highly erodible land is eligible for the “low” nitrogen application rate subsidy, producers

Program payments, by region, for alternate environmental objectives



USMP scenarios on alternate environmental objectives

USMP scenario	Environmental objective	Payment base	Payment rate (per acre)[1]
Sediment damage	Reduce sediment damage to water quality	Use of “low rainfall erosion” production systems[2]	Soil conserved[4] (tons per acre) multiplied by estimated water quality damage per ton (see appendix 5)
Nitrogen damage	Reduce nitrogen damage to water quality	Use of “low” nitrogen application rates[3]	Nitrogen application forgone[5], multiplied by a value per pound of reduced nitrogen application (see appendix 5)

[1] Payment rates are also adjusted by constant multiples of these rates to provide results on a range of program sizes. We report a range of results because environmental benefits may be underestimated and/or farm income support objectives may imply higher rates.

[2] A production system with a rainfall erosion rate below that for a system using a **predominant crop rotation** in combination with **conventional tillage** on the same soil and in the same region.

[3] A nitrogen application is considered “low” if it is below the average rate for a specific crop rotation, on a specific soil, in a given region.

[4] Difference between (1) the maximum erosion rate observed for any production system for a given soil in a given region (the reference level) and (2) the estimated rate of erosion for the system in use on the same soil in the same region.

[5] Difference between (1) the highest nitrogen application rate observed for a specific crop rotation, on a specific soil, in a given region (the reference level) and (2) nitrogen application rate in use on the same soil, for the same crop rotation, in the same region.

Continued on page 29

expand crop production using "low" nitrogen application rates. Erosion is increased, increasing sediment damage to water quality by $72.2 million.

The sediment damage scenario directs the largest payments to the Heartland and Northern Crescent regions (see figure on previous page). The Heartland benefits because the program pays for use of production systems with "low" erosion rates regardless of when these rates were achieved. The Heartland region contains more than one-fourth of U.S. cropland acreage and has been the focus of considerable conservation policy effort (e.g., conservation compliance). The Northern Crescent region receives large payments because the value of reduced soil erosion is high (fig. 9, p. 34.).

The nitrogen damage scenario directs payments to the Southern Seaboard, Fruitful Rim, and, to a lesser extent, the Northern Crescent (see figure). The proportion of nitrogen applied in agricultural production that ultimately reaches coastal waters depends greatly on the distance to the coast or major rivers (see appendix 5). Nearly all of the U.S. coastline is included in these three regions. Moreover, nearly all of the 5.6-million ton increase in rainfall erosion occurs in the Southern Seaboard and Fruitful Rim.

percent for small farms. While small farms contain just over 40 percent of rainfall erosion and nitrogen runoff acres, only about 30 percent of these acres are likely to be located on moderately unprofitable farms.

More generally, targeting any group defined by gross sales or source of household income (farm vs. nonfarm) is unlikely to capture a majority of environmental problems, unless the criteria are very broadly defined. No single group defined within the ERS farm typology accounts for more than 25 percent of any of our environmental indicator acreages (fig. 5).

Nationally, targeting multiple environmental problems makes it likely that most farms targeted for income support could participate in an agri-environmental payments program. In our illustration, 70 percent or more of both moderately unprofitable and small farms contain acreage susceptible to at least one of the three indicators (fig. 6), although not all acreage on these farms would be eligible. *Rainfall erosion acreage* occurs on roughly 70 percent of moderately unprofitable farms and 65 percent of small farms. Regionally, however, the proportion of small and moderately unprofitable farms that contains at least one of the three indicator acreages varies widely. More than 95 percent of small farms in the Heartland would qual-

Figure 5

Environmental indicator acreage by ERS farm type

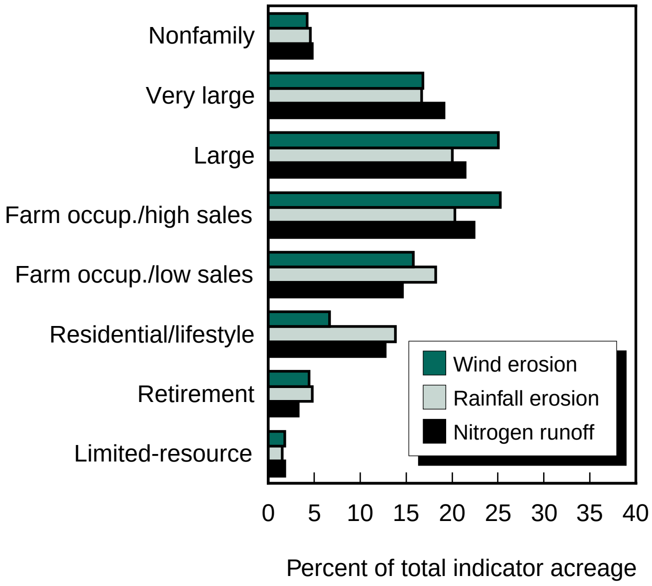
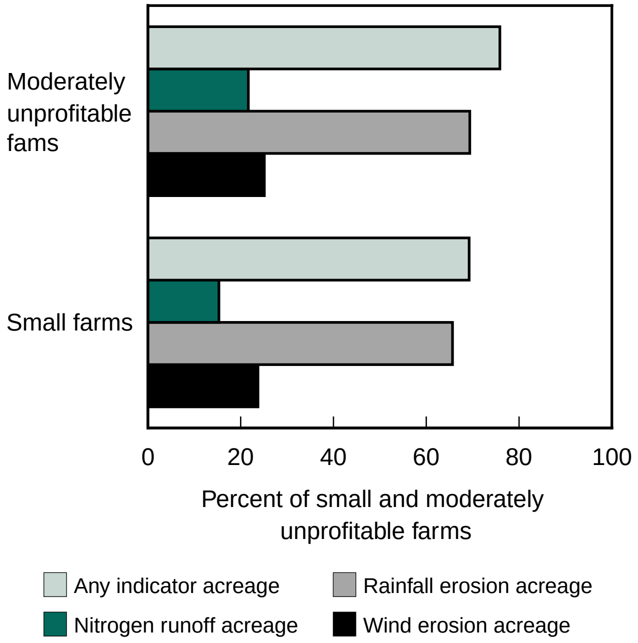


Figure 6

Percent of small and moderately unprofitable farms with some environmental indicator acreage



Defining Farm Income Support "Target" Groups and Environmental Indicators

We use a linkage between Agricultural Resource Management Survey (ARMS) data and some environmental indicators (see appendix 3) to estimate the extent of overlap between groups of farmers who could be targeted for farm support and selected environmental indicators.

Farm Income Objectives. We consider two groups that could be targeted for farm income support. Our objective is not to endorse any specific group for income support, but to illuminate issues that policymakers may face in designing a multi-objective agri-environmental payment policy. We also consider the groups defined in the ERS farm typology (see appendix 4). While the typology does not define or suggest a farm income target group, it divides farms into groups that may be useful to policymakers in targeting payments or assessing the distribution of agri-environmental (or other program) payments.

Small farms are farms with gross annual farm income of $250,000 or less, where farming is considered a primary occupation for at least one member of the household. The fate of small farms has concerned policymakers. The National Commission on Small Farms was created in 1997 to assess the status of small farms and determine ways USDA could "recognize, respect, and respond to their needs" (USDA, National Commission on Small Farms, 1998).

Moderately unprofitable farms are farms where the full (economic) costs of production exceed total revenue by up to 50 percent. These farms are not financially viable (i.e., revenue does not cover the full economic cost of production) but are more likely than higher cost farms to become so through government support payments (Morehart, Kuhn, and Offutt, 2000). If a policy goal is to keep farmers in farming, income support may be most helpful if directed toward moderately unprofitable farms.

Environmental Indicators. Agriculture affects a wide range of environmental resources (e.g., water quality), which provide many environmental amenities (e.g., water-based recreation). Many agri-environmental indicators could be used to determine eligibility for agri-environmental payments. For illustrative purposes, we consider three indicators:

- *Rainfall erosion acreage*—non-highly erodible cropland with rainfall erosion rates greater than the soil loss tolerance (T);
- *Wind erosion acreage*—non-highly erodible cropland with wind erosion rates greater than the soil loss tolerance (T);
- *Nitrogen runoff acreage*—cropland acreage where nitrogen runoff to surface water is estimated to exceed 1,000 kg/km^2/year.

Non-highly erodible cropland is considered here because it is not already subject to conservation compliance requirements, as is highly erodible land. The level of nitrogen runoff designated at "high" is arbitrary but is a level classified as high by Smith et al. (1997).

ify for payments while only 34 percent of small farms in the Eastern Uplands would be eligible (fig. 7). For moderately unprofitable farms, regional differences are more widespread. More than 90 percent of these farms in the Heartland and Northern Crescent regions would be eligible while less than 40 percent would qualify for payments in the Eastern Uplands and Fruitful Rim (fig. 8).

Nationally, the proportion of small and moderately unprofitable farms eligible for agri-environmental payments would almost surely be increased by targeting a wider range of environmental problems. Whether other environmental indicators (e.g., potential pesticide runoff) could significantly increase the proportion of producers covered in the Eastern Uplands and Fruitful Rim regions is difficult to predict. **However, targeting multiple environmental problems also means that significant funding would be directed toward farms that are not targeted for income support.** Given the high proportion of environmental indicator acreage outside small and moderately unprofitable farms, significant program funding would go to farms not targeted for income support.

A Framework for Considering Tradeoffs

Tailoring a program to meet multiple objectives as effectively as possible requires that each program objective be specifically addressed. Doing so requires a method for prioritizing objectives and devising a program to translate those objectives into producer incentives for program participation.

Figure 7

Percent of small farms with some environmental indicator acreage, by region

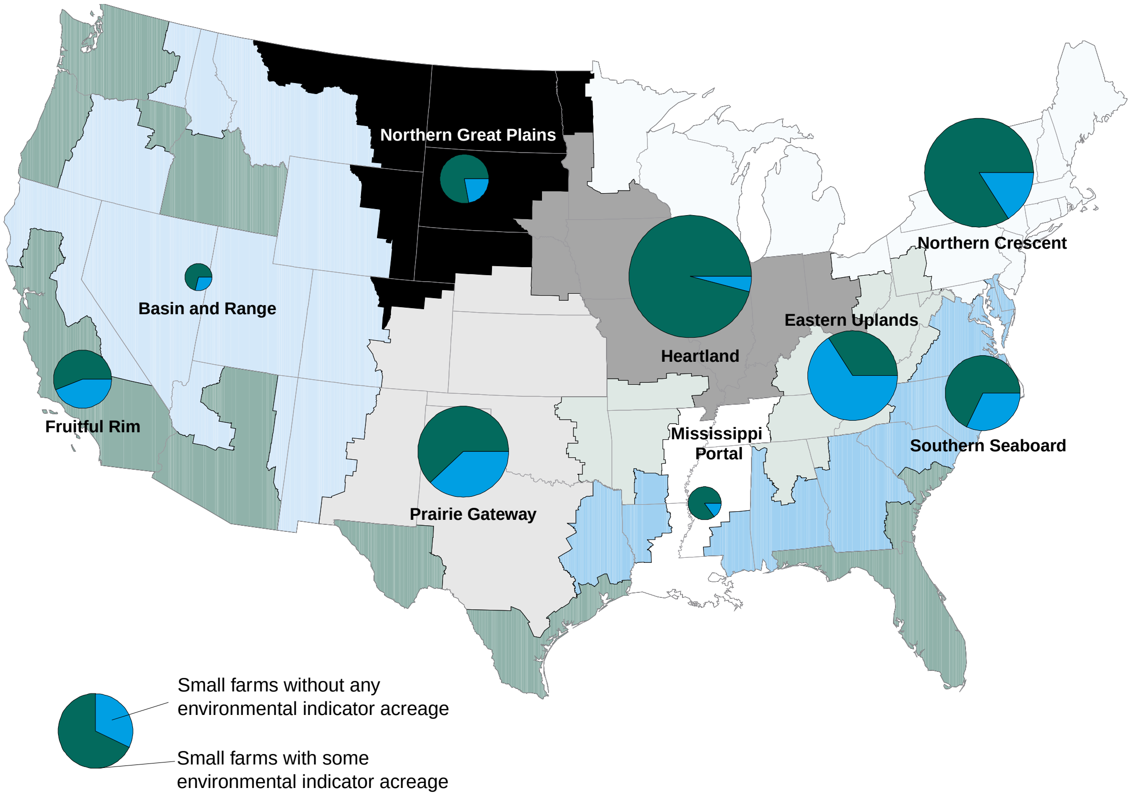
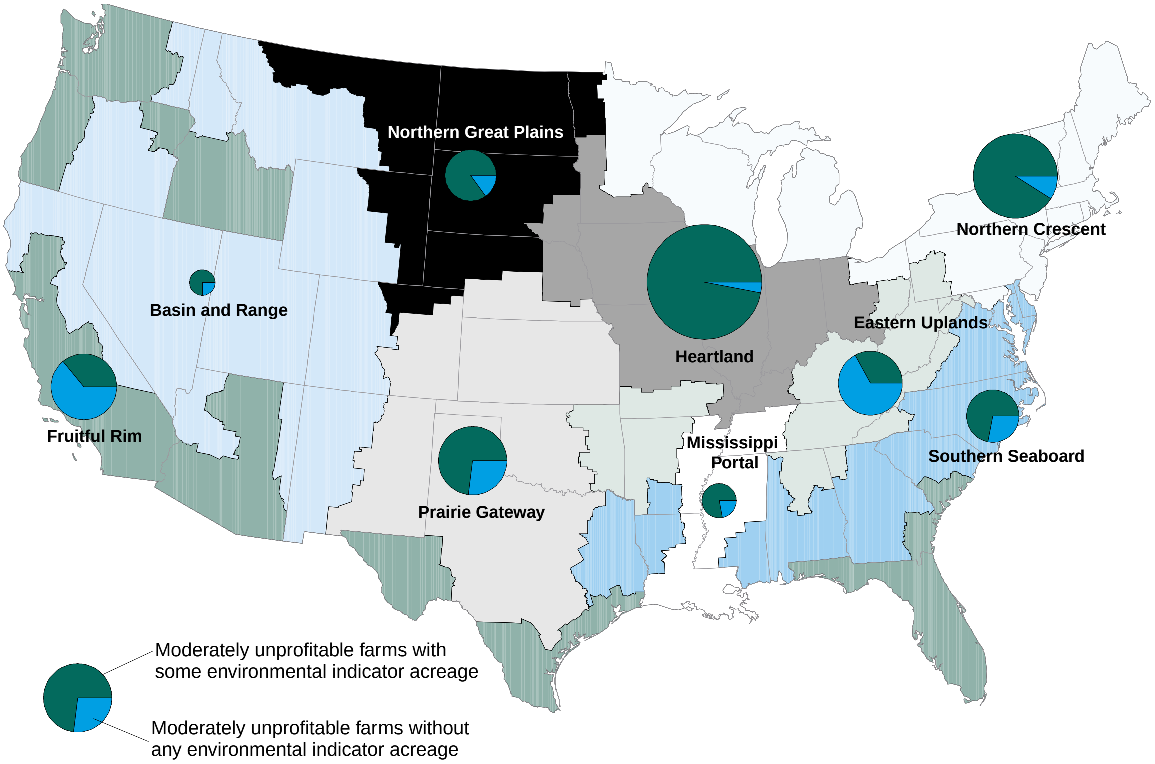


Figure 8

Percent of moderately unprofitable farms with some environmental indicator acreage, by region



In theory, agri-environmental problems can be prioritized on the basis of net economic benefits, i.e., the benefit of increasing environmental quality less the costs of making these improvements. Economic benefits flow from an increase in the quality of nonmarketed goods and services that depend on environmental quality; they are an estimate of the dollar value society places on improvements in such activities as boating, fishing, hunting, or wildlife viewing. Costs include the public and private costs of changing farm production management and conservation practices to obtain these improvements. Society gains when environmental benefits exceed the cost of producing those benefits.

If farm income is of concern, policymakers can assign a level of priority to farm income support. Then program funds can be allocated among environmental and farm income purposes in a way that maximizes the sum of net environmental benefits and gains due to farm income support.

The reality is considerably more complex. The nonmarket benefits of environmental improvements can be difficult to measure, improvements in environmental amenities can be difficult to link to specific changes in production management and conservation practices on a specific farm, and the cost of changing specific practices on specific farms is uncertain.

Nonetheless, a simplified version of the benefit-cost framework can be useful for program implementation. For example, policymakers or program designers can establish weights to account for (1) the relative size of potential benefits from specific environmental amenities and (2) the likelihood that a specific action, taken on a specific field, will increase the environmental amenity by a given amount. These weights can be derived from a variety of sources, including formal valuation studies, studies of physical links between agricultural production and resource quality, and expert opinion. A similar approach has been used, with some success, for targeting in the CRP.

Agri-Environmental Payment Program Design

Assuming that program budgets are limited, how can a program be best designed to make available funds go as far as possible toward achieving environmental and farm income objectives? For simplicity, we focus explicitly on maximizing environmental gains. Nonetheless, we note farm income implications of policy options and structure our empirical analysis around program designs that would have a relatively large farm income effect. Specifically, payments are designed to exceed the cost of environmental actions that trigger payment for at least some producers on some land. We also consider **equity** as it relates to whether so-called “good actors”—producers who have already attained a relatively high level of environmental performance or adopted good production management or conservation practices—would qualify for payments under various program designs.

Our review of past and present agri-environmental programs suggests that the net environmental benefits of a program can be enhanced by

- **spatial targeting**, directing payments to would-be program participants who can achieve the largest environmental gains relative to costs; and
- **producer flexibility**, giving farmers the flexibility to select the lowest cost method of improving environmental performance in specific resource and management settings.

In this section, we expand our discussion to consider

- **environmental effectiveness,** or program design features that pay for changes in production management or conservation practice that most directly address environmental objectives;
- **information** that will be needed to implement a given program design; and
- **administrative costs** such as conservation planning, technical assistance, enforcement, and other costs that may be required to deliver the program.

Finally, a critical point of our analysis will be to identify the **potential for unintended consequences** and to suggest ways to minimize them.

Some Program Design Options

Key program design choices are encompassed in three major issues: How much is paid to whom for taking what action on what land?

What Action? The action that triggers payment is often referred to as the ***payment base***. Choice of a payment base can be considered in two dimensions (table 6). First, payments can be based on environmental performance or on the use of specific production management or conservation practices. For example, producers could be paid for conserving soil (a per-

Table 6—Summary of payment base options for an agri-environmental payments program

Improve	Performance	Pay for adoption of production systems that improve environmental performance
	Practices	Pay for adoption of "good" conservation or production practices
Good	Performance	Pay for use of production systems that produce "good" environmental performance
	Practices	Pay for use of "good" conservation or production practices

formance-based payment) or for using soil-conserving practices such as conservation tillage, contour farming, or terraces (a practice- or design-based payment).

Agri-environmental payments cannot be based on *actual* environmental performance, such as nutrient runoff or soil erosion, because actual performance cannot be monitored at a reasonable cost and often varies with the weather or other factors outside the producer's control (Braden and Segerson, 1993; Shortle and Abler, 1994; Shortle and Dunn, 1986). However, average or expected environmental performance can sometimes be *estimated* using physical process models like Universal Soil Loss Equation (USLE) or the Wind Erosion Equation (WEE). From here forward, we use the term "environmental performance" to refer to application of a set of production management or conservation practices that results in a specific level of *estimated* environmental performance.

A second dimension of the payment base decision refers to the timing of and reason for a farmer's change in environmental performance or related production management or conservation practices. Payments might go to those who improve environmental performance or adopt specified practices after enactment of the program. In other words, producers would not be paid for production management or conservation practices previously adopted.

Alternately, payments may be extended on the basis of "good" environmental performance or the use of "good" production management or conservation practices, regardless of when or why good performance was attained or good practices were adopted. In other words, all "good actors" would be eligible for payments. To implement such a program, *good performance or good practices* must be defined. For example, *good performance* could be tied to a specific threshold of estimated soil erosion or nutrient runoff. *Good practices* could be defined as use of conservation tillage, nutrient management, or other production management or conservation practices.

What Land? If producers choose to expand crop production, will the additional land be eligible for agri-environmental payments? Will producers be penalized in some way for converting environmentally sensitive land, such as HEL or wetland, from noncrop uses to crop production? In other words, will sodbuster- or swampbuster-type provisions apply to these payments? This question is particularly relevant to payments based on *good performance* or *good practices* because these payment bases do not explicitly require environmental improvement, as does the *improve performance* payment base. *Good performance*, for example, does not depend on past land use. If previously uncropped land is eligible for the agri-environmental subsidy, it could encourage producers to expand crop production with negative consequences to the environment. Improved performance, on the other hand, does depend on past land use and, thus, will not encourage producers to expand crop production.

How Much? To Whom? In a voluntary program, producers will participate only if the payment offered covers the cost of changing production management or conservation practices as required by the program. On the other hand, payments larger than the value of the environmental benefit produced by the change in production management or conservation practices (to the extent this is known) need to be justified on grounds of other program objectives (e.g., farm income support). We consider three cases. First, policymakers could set payments that approximate the social benefit of environmental gains. Second, payments could be based on producer cost of participation. Because information on benefits and costs is limited, these cases cannot be fully achieved in practice. However, they are quite instructive. A third option is to establish payments, based on environmental actions, at levels that could support farm income. Thus, payments would exceed producers' costs, for at least some producers on some land.

Benefit-level payments. First, we consider the case where producer payments attempt to approximate the environmental benefit that flows from subsidized changes in conservation and management practices. This approach can provide direct income support to producers because payments can exceed the producer's cost of changing production management or conservation practices. In a sense, producers can earn profit from the "sale" of environmental goods and services. Subsidy rates effectively serve as "prices" for these environmental goods, inducing producers to allocate additional effort to producing them. If production declines because of the program, indirect farm income support may also result from higher commodity prices.

If payments vary spatially with the variation in expected environmental benefits (see appendix 5; figs. 9 and 10), **spatial targeting** is accomplished through producer self-selection. Producers who can achieve large environmental gains (i.e., are located in areas where the value of improved environmental quality is large) at a relatively low cost have the largest incentive to participate. Producers who can achieve only small environmental gains or can achieve gains only at a high cost will have less incentive to participate.

If benefit-level payments are based on *good performance* or use of *good practices*, policy decisionmakers will also have to decide how much environmental "improvement" or practice "change" will be credited to "good actors." For example, if a program seeks to conserve soil (to reduce water quality damage due to sediment, for example), how much soil conservation will be credited to a producer who has already achieved relatively low soil erosion rates?

One way to determine payment credit is to establish a *reference level* of environmental performance or practice use. Consider subsidies for soil conservation. The soil conservation credit assigned to a production system (that qualifies as good performance) could be calculated as the difference between the reference erosion rate and the estimated erosion rate for the system. Then the *payment rate* for the production

Figure 9

Estimated water quality damage from soil erosion

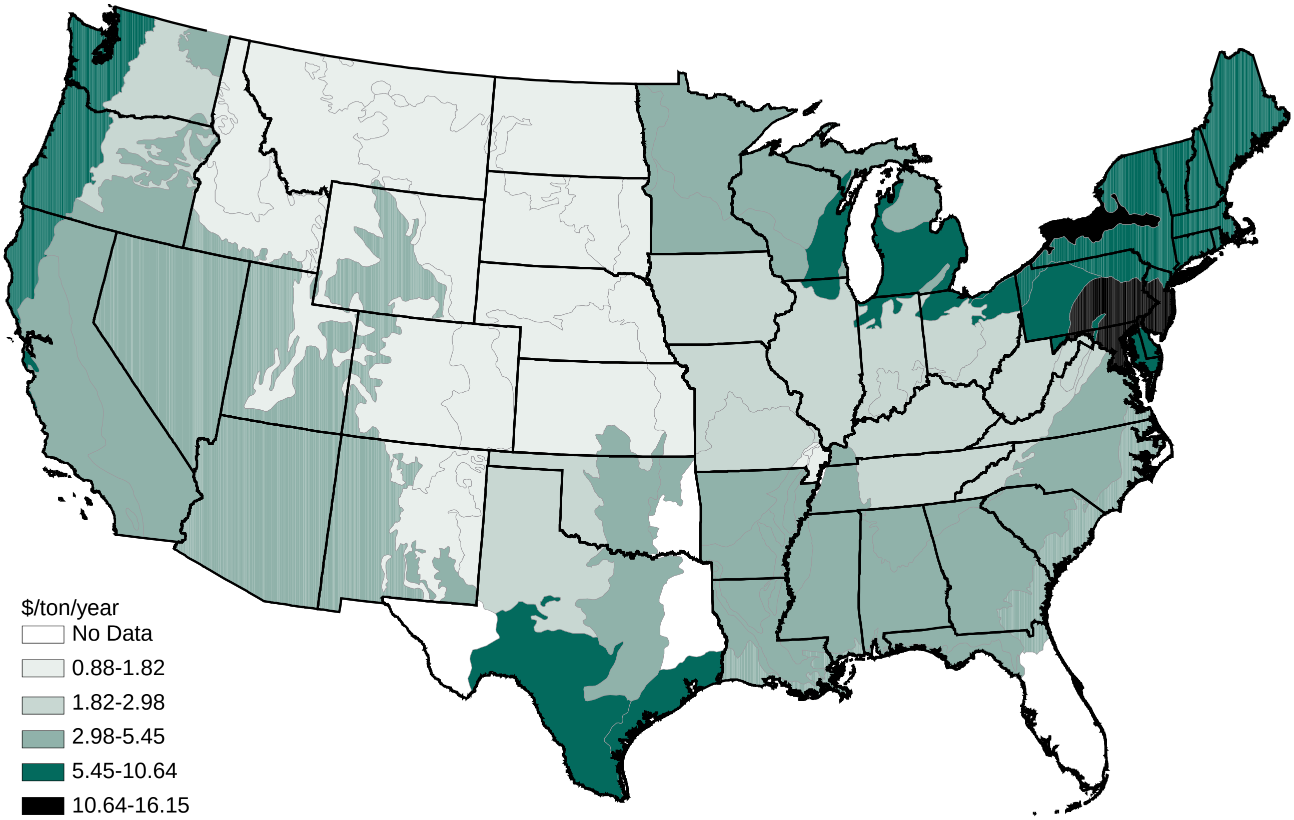
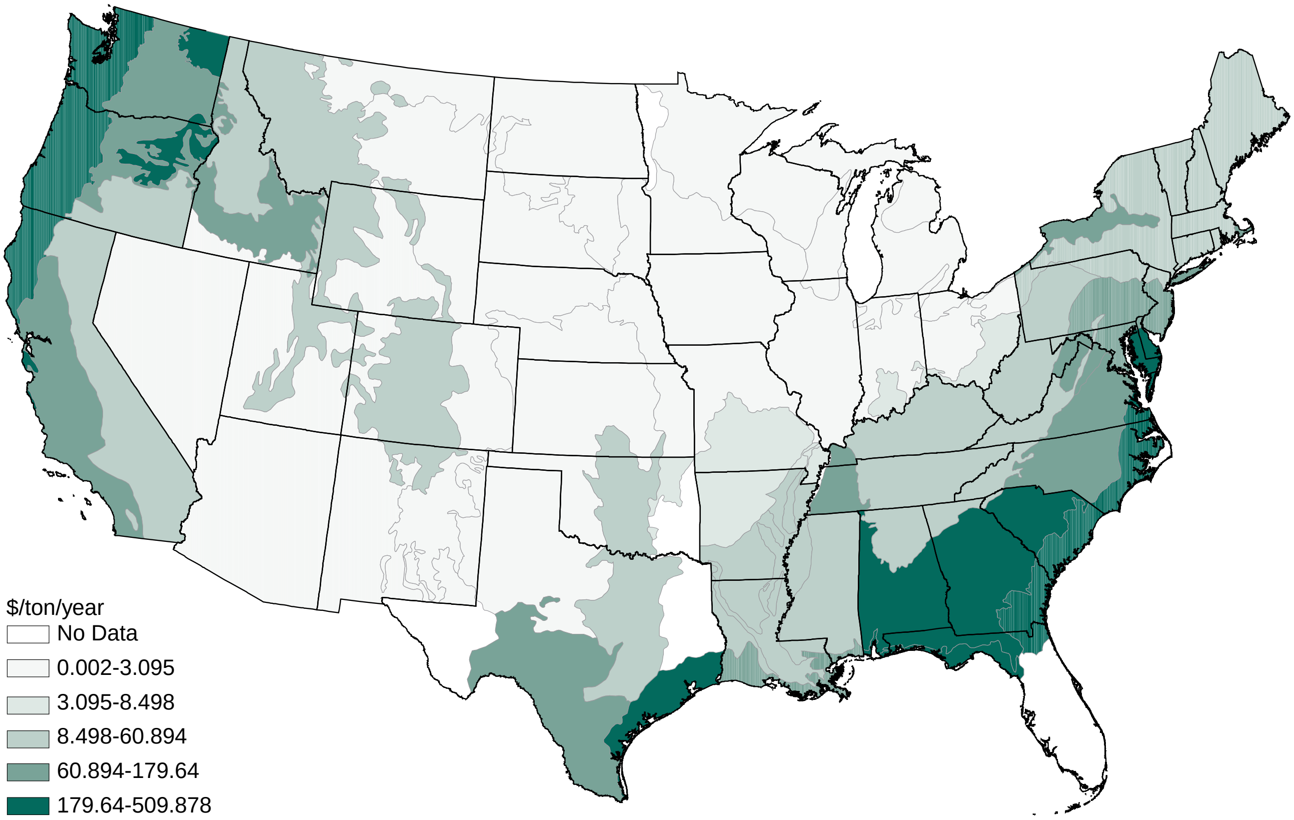


Figure 10

Estimated coastal water quality damage from runoff of fertilizer nitrogen



system could be the soil conservation credit (in tons) multiplied by the (dollar) value per ton of soil conserved. (Note that the reference level need ***not*** be the threshold used to determine which systems qualify as good performance.)

Reference levels could vary with soil type and topography, geographic region, or all these factors. While a reference level is not an environmental baseline—it would not be specific to a particular farm or field—it would reflect the cropping patterns and production management or conservation practices generally in place under homogeneous soil and climate conditions.

Reference levels will be a direct determinant of payment rates. If the reference level reflects poor environmental performance for a specific soil and region, soil conservation credits to “low erosion” production systems would be large. Alternately, if producers are credited only with gains beyond a typical or predominant level of environmental performance, credits and payments will be smaller. Clearly, a wide range of reference levels and associated rationale are possible.

Finally, program size (total government expenditure for producer payments) would ultimately be determined by producer participation, much as in past commodity programs. Participation would depend largely on the subsidy rates offered to producers. Policymakers could attempt to adjust program size by adjusting one or more of the variables (e.g., the reference level or the payment rate (dollars per ton of soil conserved)) that go into determining the per-acre payment rate for specific systems, in much the same way past commodity programs were adjusted. However, such adjustments may result in only imprecise control over total program size.

Cost-level payments. If payments are to approximate the cost of making changes in production management or conservation practices, a different set of issues arises. Because payments are designed to more closely approximate costs than benefits, there will be less direct income support under this type of a program. However, producer incomes may still rise if commodity production is reduced and prices rise.

Because farm-specific costs are unknown, cost information must be gotten from farmers. Requiring farmers to produce receipts for purchases would work for changes involving large one-time expenditures (e.g., for building a terrace), but may fail to capture the costs of less concrete changes (e.g., reduced yields or increased labor). Or producers could submit bids describing proposed actions and a proposed level of payment. If the bid process is well designed, bids will represent the lowest payment the bidder is willing to accept for taking the proposed action. These bids may approach producers' costs in very competitive situations.

Moreover, **spatial targeting** does not happen by producer self-selection under cost-level payments. To target producers who can achieve high net benefits, bid acceptance can be based on producer bids *and* an estimate of potential environmental benefits. In the CRP, for example, producer bids for rental payments are considered together with EBI scores to determine which contracts will be accepted (see table 4). Targeting is achieved because producers who exhibit high environmental scores relative to their participation costs are more likely to have their bids accepted.

Finally, policymakers can control program costs by deciding how many proposed agri-environmental payment contracts to accept. By adjusting the acceptance criteria once bids are received but before they are accepted or rejected, policymakers may gain some additional measure of control over program expenditures with a cost-level payment approach.

Farm income support-level payments. Payments would be based on agri-environmental actions, as in the benefit-level or cost-level payments. However, the level of payment would depend on the level of income support policymakers want to extend to agricultural producers. Actual income support to producers would depend on the level of payments, producer participation costs, and income gain or loss due to commodity price changes.

Analysis of Alternative Program Designs

To illustrate the consequences of some program design choices, we focus on a limited number of program designs. This approach is necessary because some program features interact so that individual features cannot be adequately analyzed apart from overall program design.

Our comparison of program designs is organized around the question of payment base. Payment rates consider both environmental benefits and farm income considerations. Thus, farm income is supported directly. Payment rates recognize spatial variation in potential benefits (see figs. 9 and 10, appendix 5), so spatial targeting is achieved through producer self-selection. Payment rates are also varied (by multiplying all payments rates by a constant) to reflect the possibility that a larger program may be desirable on the basis of farm income considerations.

For the *good performance* and *good practices* payment bases, non-HEL that was not previously cropped is eligible for agri-environmental payments if it is converted to crop production using *good practices* or production systems that meet the definition of *good performance*. However, producers who bring previously uncropped HEL into crop production are penalized. This provision is similar to sodbuster because the penalty is based on the level of other farm program payments (primarily Production Flexibility Contract (PFC) payments) and will be referred to as a sodbuster provision in the subsequent discussion.

We discuss and demonstrate the potential for unintended consequences in several ways. In one case, we relax the sodbuster provision. In another case, we compare a spatially targeted scenario (i.e., where the value per ton of soil conserved varies with potential benefits) with one where the value per ton of soil conserved is uniform across the country. These comparisons help illustrate how high payment rates in specific regions can encourage expansion of crop production and, potentially, undo the beneficial effects of spatial targeting.

Paying producers on the basis of improved environmental performance ensures that payments leverage environmentally effective actions, minimize producer participation costs, and minimize the risk of unintended consequences.

Paying producers on the basis of improved environmental performance ensures that payments leverage environmentally effective actions, minimize producer participation costs, and minimize the risk of unintended consequences. First, payments are **effective** in furthering the program's environmental objectives because they are based on production management and conservation practice changes that *directly improve* environmental performance, adding to environmental quality. Second, performance-based payments are **flexible** for producers, allowing them to select low-cost methods of achieving environmental gains. Finally, the risk of unintended consequences due to cropland expansion is minimized because producers must *improve* overall performance on the entire farm. For example, bringing hay or pasture land into crop production would almost surely reduce environmental performance and would count against the producer in determining an overall level of environmental performance.

However, payments based on improved performance also require USDA to have a great deal of information, may entail high costs for planning and enforcement, and may be viewed as inequitable by some producers. First, a farm-level or field-specific baseline of past production management and conservation practices will be needed to assess the change in performance. Depending on the environmental performance measure sought, extensive data on past land use, crop rotations, input use (e.g., fertilizer application rates), and cropping practices (e.g., tillage systems) will be needed. Such baseline information is not widely available. Collecting baseline information after enactment of an agri-environmental payment program would invite gaming: producers could temporarily abandon some environmentally favorable practices to obtain a more favorable baseline. Second, basing payments on estimated environmental performance may entail significant planning and enforcement costs. To date, only the USLE and WEE models have been used in program implementation. Other models for estimating other physical processes (e.g., nutrient runoff) are more complex, requiring more user training and more data for successful implementation. Finally, paying for *improvement* in environmental performance excludes past gains by "good actors." These producers may argue that past gains entitle them to the same payments received by producers who improved environmental performance only in response to agri-environmental payments.

Paying for "good" environmental performance requires no baseline information and treats "good actors" equally with other producers. Significant environmental effectiveness and producer flexibility are maintained, but payments are less effective and less flexible than in the *improve performance* scenario. This approach may also result in significant unintended consequences.

Payments based on good environmental performance are less effective environmentally and less flexible than payments based on improved performance because some options for improving environmental performance are precluded. In some cases, for example, the best way to improve environmental performance will be to retire land from crop production. The *good performance* payment base does not subsidize land retirement (to subsidize land not in crop production, simply because it is not in crop production, would be quite expensive). In this case, coordination between land retirement and agri-environmental payments may be important to ensure that gains from land retirement are realized and that the more appropriate instrument is used case-by-case. An agri-environmental payment program with broader objectives could also provide payments for good grazing management that would provide some incentive for returning land to, or retaining land in, grazing.

Payments based on improved performance require USDA to have a great deal of information, may entail high costs for planning and enforcement, and may be viewed as inequitable by some producers.

Moreover, if payments are limited to production systems with *good performance*, some more modest conservation strategies that do not attain the *"good performance"* standard (e.g., giving up a moldboard plow for conventional tillage) would be excluded from the subsidy program. If the focus of the program is on mitigation of offsite damages, any improvement in onfarm environmental performance is useful. Still, there may be legitimate objections to extending agri-environmental payments to producers who do not meet some minimum standard of environmental performance. If "bad actors" receive subsidies for modest environmental improvement while "good actors"—with much better environmental performance—are excluded, producers will be discouraged from taking any unsubsidized action that improves environmental performance.

Our empirical analysis illustrates how differences in environmental effectiveness and producer flexibility affect environmental outcomes in the *improve performance* and *good performance* scenarios (see box, "Payment Bases and Program Performance"). These scenarios are directed toward soil conservation and targeted to reduce sediment damage to water quality.

Paying for "good" environmental performance requires no baseline information and treats "good actors" equally with other producers. Significant environmental effectiveness and producer flexibility are maintained, but payments are less effective and less flexible than in the improve performance scenario. This approach may also result in significant unintended consequences.

Differences in erosion reduction per dollar of program payment between the *improve performance* and *good performance* scenarios are quite large. At $1 billion in producer payments, the *improve performance* scenario reduces soil erosion by roughly 110 million tons, just under 15 percent. By contrast, the *good performance* and *good practices* scenarios produce only 20 million and 22 million tons of erosion reduction. Moreover, as the level of producer payments rises (as the result of raising payment rates per ton of soil erosion reduced or soil conserved), the level of erosion reduction increases rapidly for the *improve performance* scenario but only slightly for *good performance* and *good practices* scenarios.

There are several reasons for the difference in erosion reduction per dollar of program payments. First, much of the additional money in the *good performance* and *good practices* scenarios goes to increasingly large payments to "good actors." Very little of the additional program funds leverage new conservation effort. A second reason for this large difference in performance is the effect of alternate designs on land use. In the *improve performance* scenario, when annual producer payments are $1 billion, total land in crop production declines nearly 8 million acres. In the *good performance* scenario, crop acreage increases by 500,000 acres. Basing payments on improved performance is unlikely to be practical given information requirements. However, this comparison does suggest that there could be advantages to using *good performance* or *good practices* programs in conjunction with a land retirement program.

The cropland expansion effect in the *good performance* scenario results from unintended incentives to expand crop production. Subsidizing the expansion of environmentally good crop production systems or specific practices will *not* ensure that these systems are expanded on cropland where environmentally damaging production systems are being used. Without proper safeguards, subsidies could prompt producers to convert hay or pasture land to crop production, possibly increasing—rather than reducing—environmental damage (Malik and Shoemaker, 1993).

In the absence of a sodbuster provision, our empirical analysis (see box, "'Good Performance' and Unintended Consequences") indicates cropland expansion can severely undercut environmental gains. Without sodbuster, a program that subsidizes good performance on soil conservation (the use of "low erosion" production systems) can actually *increase* total soil erosion. Because the program has a very modest effect on commodity prices, cropland acreage expansion and erosion increases are due almost entirely to subsidy response.

Cropland expansion can also undercut efforts to increase water quality benefits by offering relatively high payments to producers in areas or regions where the water quality benefits of erosion reduction are high. Even with a sodbuster provision, subsidies can encourage expansion of crop production on non-highly erodible land. When payments are varied to reflect variations in potential benefits, the cropland expansion effect can be particularly severe in regions where payments are high.

When payments are based on *good performance*, empirical analysis suggests that water quality benefits due to sediment reduction can be larger when payments per ton of soil conserved ***do not*** vary spatially to reflect potential benefits. High payments in high-benefit regions intensify incentives to expand crop production on non-highly erodible land, undercutting the increase in soil conservation effort on previously existing cropland.

By contrast, when payments are based on *improved performance*, varying payments to reflect variation in potential benefits does increase water quality benefits. Producers can receive payments only in exchange for erosion reduction. In this context, varying payments to reflect variation in potential benefits intensifies efforts for environmental improvement because payments subsidize only those actions that result in environmental improvement.

These empirical results do not imply that payments based on *good performance* cannot be successfully targeted to increase environmental benefits. However, agri-environmental payment programs that induce producers to increase cropland acreage—even on land that is not highly erodible—can erase environmental gains on existing cropland. Policymakers may want to consider land-use safeguards that go beyond a sodbuster provision. It may be useful to limit eligibility for agri-environmental payments to land already in crop production, as closely as that can be determined. A more aggressive solution would be to expand sodbuster to cover non-HEL, requiring strict conservation and environmental compliance on any additional land brought into crop production after enactment of the agri-environmental payment program. Also, a broader program, which included payments for *good performance* or the use of *good practices* on grazing land or other non-cropland, could reduce the incentive to shift land into crop production.

Paying for use of specific practices can mean low planning and enforcement costs and low information requirements, and will ensure that early adopters are treated equitably. However, this approach eliminates producer flexibility and may not be environmentally effective in some resource settings.

A key difference between payments based on *good performance* and *good practices* is the level of environmental effectiveness and producer flexibility. Our empirical analysis shows that the *good performance* scenario produces more erosion reduction and water quality benefit than the *good practice* scenario ***per dollar of measured net cost to the economy*** (for definition see box, "Payment Bases and Program Performance"). However, this analysis could not measure the planning and enforcement costs associated with a performance-based payment. The greatest advantage of a *good practices* payment base is its potential for low planning and enforcement costs. For example, if producers are paid to adopt conservation tillage, planning and enforcement are straightforward: 30 percent of the soil surface must be covered with crop residue after planting. Implementation would require limited planning, and compliance is readily measurable. While no specific conclusion can be drawn from our empirical example, it is generally important to consider both potential savings due to flexibility and program implementation costs in selecting a program payment base.

Paying for use of specific practices can mean low planning and enforcement costs and low information requirements, and will ensure that early adopters are treated equitably. However, this approach eliminates producer flexibility and may not be environmentally effective in some resource settings.

Paying for adoption of a specific practice can mean low planning and enforcement costs. However, producer flexibility is eliminated, environmental effectiveness may be low in some resource settings, and baseline information will be required. Producers who have already adopted a given practice or cannot easily use the favored practice may view this approach as inequitable. These issues have been discussed at length in the preceding discussion and will not be repeated here.

Who Pays? Who Gains?

The choice of payment base will largely determine who reaps economic gain and who suffers loss due to an agri-environmental payment program. The distribution of gains and losses among producers[15], consumers, and taxpayers and among different producers depends on (1) how payments are distributed among producers, (2) the cost producers incur in changing production management or conservation practices to earn payments, (3) how these costs translate into commodity output and price changes, and (4) how price changes affect farm income and consumer welfare. On a conceptual basis, little can be said about the distribution of cost and benefits. This section focuses on empirical analysis, with specifications exactly as reported in the box, "Payment Bases and Program Performance."

In the *improve performance* scenario, producers must reduce erosion to receive payments. In many cases,

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[15] Our analysis cannot distinguish returns to farmers versus returns to landowners. When farmers are not landowners, support may accrue to landowners (see box "Supporting Farm Incomes and Protecting the Environment: The Case Where Farmers Are Not Landowners").

Payment Bases and Program Performance

We use USMP (see appendix 2) to analyze the relative efficiency of achieving environmental gains using three alternative payment bases, or approaches to defining the action(s) that will trigger agri-environmental payments: ***improve performance***, ***good performance***, and use of ***good practices***.

In our hypothetical scenarios, the policy objective is to reduce water quality damage due to sediment. At the farm level, soil conservation is the focus of the payment base alternatives (see table). To focus program activity on regions where soil erosion causes the largest potential damage to water quality, producers in those regions can receive higher payments, commensurate with higher water quality damages per ton of soil erosion (see appendix 5 and fig. 9). However, farm income support objectives may imply higher payment rates. Payment rates are varied by multiplying the benefit-based payment rate per acre by a constant. As payment rates increase, total program payments increase. Finally, to guard against expanding crop production onto highly erodible land (HEL), producers who bring previously uncropped HEL into crop production lose other farm program benefits. This provision is similar to the sodbuster provisions of current farm commodity policy and is referred to as a sodbuster-type penalty.

Producer payments are the government expenditure for payments to producers, excluding conservation planning, technical assistance, and enforcement costs. ***Measured cost*** reflects the change in total income in the economy required to produce the agri-environmental gains due to the subsidy program, including the direct cost of changing production management or conservation practices to achieve environmental gains and indirect costs such as the loss of commodity output if producers shift to less erosive but less productive production systems. The *measured costs* reported here *do not include* (1) payments to producers, (2) government expenditures for program implementation, and (3) economic costs of raising taxes to fund government program expenditures.[1] Producer payments are not included because they are transfers of income from taxpayers to agricultural producers rather than actual costs to the overall economy. Government expenditures for program implementation and the economic cost of taxation are real costs of achieving environmental gains but could not be accounted for in our modeling framework. Thus, differences in measured costs must be considered against the potential for differences in costs not accounted for.

The *improve performance* scenario produces *much greater* erosion reduction per dollar of program payment and per dollar of *measured cost* to the economy than either the *good performance* or *good practice* scenarios.

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[1] The economic cost of taxation is the value of economic activity lost due to the tax. Taxes on productive resources will reduce the utilization of those resources. For example, an increase in the tax on labor income may prompt some workers to leave the workforce, reducing production. While the magnitude of these costs is unknown, reasonable estimates range from 20 to 50 cents for each dollar of additional tax revenue (Browning, 1987).

Payment bases and payment rates for reducing sediment damage to water quality

USMP scenario	Payment base	Payment rate (per acre)[1]
Improve performance	Reduce erosion from pre-program baseline	Erosion reduction (tons per acre) *multiplied by* estimated water quality damage per ton (see appendix 5)
Good performance	Use of "low rainfall erosion" production systems[2]	Soil conserved[4] (tons per acre) *multiplied by* estimated water quality damage per ton (see appendix 5)
Good practices	Use of "conservation tillage" production systems[3]	Soil conserved[4] (tons per acre) *multiplied by* estimated water quality damage per ton (see appendix 5)

[1] Payment rates are also adjusted by constant multiples of these rates to provide results on a range of program sizes. We report a range of results because environmental benefits may be underestimated and/or farm income support objectives may imply higher rates. [2] A production system with a rainfall erosion rate below that for a system using a **predominant crop rotation** in combination with **conventional tillage** on the same soil and in the same region. [3] Any tillage system that **covers 30 percent or more of the soil surface with crop residue**, after planting, to reduce erosion by water. [4] Difference between (1) the maximum erosion rate observed for any production system for a given soil in a given region (the reference level) and (2) the estimated rate of erosion for the system in use on the same soil in the same region.

Continued on page 41

At $1 billion in producer payments, the *improve performance* scenario reduces soil erosion by roughly 110 million tons, just under 15 percent. By contrast, the *good performance* and *good practice* scenarios produce only 20 million and 22 million tons of erosion reduction. For $250 million in *measured cost*, the *improve performance* scenario produces more than 100 million tons of erosion reduction, compared with 37 million tons in the *good performance* and 30 million tons in the *good practices* scenarios. Similar results are obtained with respect to water quality benefits.

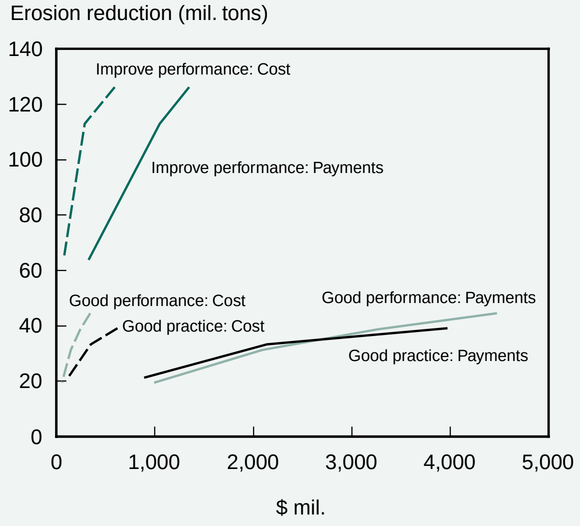
As the level of producer payments rises, these differences rapidly become larger. Erosion reduction ranges from just 2 to 5 percent in the *good performance* and *good practices* scenarios as producer payments range from $1 billion to $4 billion. Much of the additional money expended in these scenarios goes to increasingly large payments to "good actors." Very little of the additional program funds leverage new conservation effort.

However, information for a pre-program baseline is not likely to be available and equity concerns may require that "good actors" be eligible for payment. Then agri-environmental payments must be based on current producer actions without regard to past actions, e.g., *good performance* or *good practices*. Per dollar of *measured costs*, the *good performance* payment base delivers greater erosion reduction and water quality benefits than do payments for *good practice*. However, program administration costs may be significantly higher for the *good performance* scenario due to (1) the effort needed to develop farm- or field-specific conservation plans and (2) the complexity of enforcement when every farm or field has a unique plan. When these costs are considered, the *good practice* scenario may well be more cost-effective in achieving environmental gains.

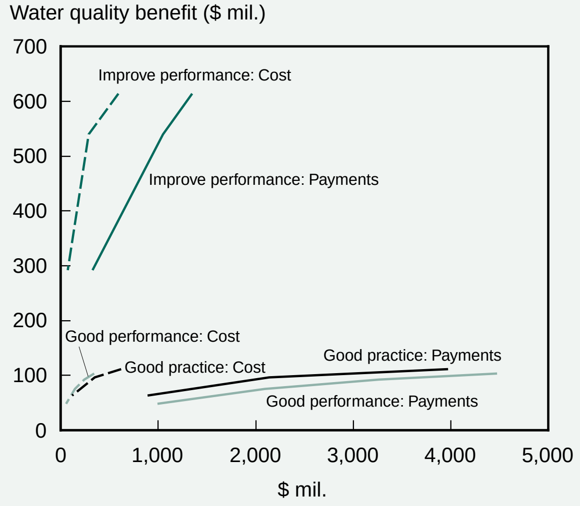
On the other hand, per dollar of *producer payments*, the *good practices* scenario produces *more* erosion reduction (for producer payments of up to $2.7 billion) and *more* water quality benefit over the full range of program sizes investigated. In general, there is no reason that erosion reduction or water quality benefits per dollar of *payment* under these scenarios should have any specific relationship, since payments are not based on erosion reduction (as they are in the *improve performance* scenario). The *good practice* scenario compares favorably with the *good performance* scenario in terms of producer payments for two reasons. First, the practice subsidized—conservation tillage—is well adapted in regions where potential water quality benefits (and therefore payments) are high. This is particularly true in the Northern Crescent region. Second, because conservation tillage is not as widely used as some other conservation practices, relatively few funds are used for payment of erosion credits due to past actions.

Finally, the analysis presented here was designed to illustrate program design issues and cannot be construed as a cost-benefit analysis. The water quality benefits we measure exceed the costs we measure for the *improve performance* scenario but fall short of measured costs for the *good performance* and *good practices* scenarios. However, some benefits of soil erosion reduction (e.g., maintenance of soil productivity) and some costs (e.g., conservation planning, technical assistance, and enforcement) are not measured. Moreover, we have no estimate of the value of farm income support, although farm income support legislation in recent years indicates that policymakers do value it.

Producer payments, measured costs, and erosion reduction for alternate payment bases



Producer payments, measured costs, and water quality benefit for alternate payment bases



“Good Performance” and Unintended Consequences

We use USMP to demonstrate the potential for expanded crop production under a *good performance* base. Similar criticisms may apply to *good practices* bases for agri-environmental payment programs. Safeguards against expansion of crop production can include sodbuster-type provisions or program “base” acreage provisions (or eligibility criterion) similar to those of previous farm commodity programs. Programs that provide payments on grazing land or other noncropland may also be effective if the profitability of that acreage rises due to the agri-environmental payment program.

In our hypothetical scenarios, the policy objective is to reduce water quality damage due to sediment. At the farm level, soil conservation is the focus of the program alternatives. The scenarios analyzed here include two payment bases: *improve performance* and *good performance* (see table). To focus program activity on regions where soil erosion causes the largest potential damage to water quality, producers in those regions can receive higher payments, commensurate with higher water quality damages per ton of soil erosion (see appendix 5 and fig. 9). However, farm income support objectives may imply higher payment rates. Payment rates are varied by multiplying the benefit-based payment rate per acre by a constant. As payment rates increase, total program payments increase.

Finally, to guard against expanding crop production onto highly erodible land (HEL), producers who bring previously uncropped HEL into crop production lose other farm program benefits. This provision is similar to the sodbuster provisions of current farm commodity policy and is referred to as a sodbuster-type penalty. We also estimate *good performance* scenarios in which (1) payments per ton of soil conserved are uniform across the Nation (not targeted), and (2) the sodbuster penalty is dropped.

First, we compare erosion reduction in the *good performance* scenario, with and without the sodbuster provision. Without sodbuster, previously uncropped HEL land is eligible for subsidy payments. Crop production expands significantly onto uncropped HEL, resulting in a net *increase* in soil erosion. Even with the sodbuster provision non-highly erodible land can be brought into crop production and receive agri-environmental payments.

Payment bases and payment rates for reducing sediment damage to water quality

USMP scenario	Payment base	Payment rate (per acre)[1]
Good performance	Use of “low rainfall erosion” production systems[2]	Soil conserved[3] (tons per acre) *multiplied by* estimated water quality damage per ton (see appendix 5)
Good performance: No Sodbuster	Use of “low rainfall erosion” production systems[2]	Soil conserved[3] (tons per acre) *multiplied by* estimated water quality damage per ton (see appendix 5)
Good performance: Not Targeted	Use of “low rainfall erosion” production systems[2]	Soil conserved[3] (tons per acre) *multiplied by* nationally uniform rate per ton
Improve performance	Reduce erosion from pre-program baseline	Erosion reduction (tons per acre) *multiplied by* estimated water quality damage per ton (see appendix 5)
Improve performance: Not Targeted	Reduce erosion from pre-program baseline	Erosion reduction (tons per acre) *multiplied by* nationally uniform rate per ton

[1] Payment rates are also adjusted by constant multiples of these rates to provide results on a range of program sizes. We report a range of results because environmental benefits may be underestimated and/or farm income support objectives may imply higher rates.

[2] A production system with a rainfall erosion rate below that for a system using a **predominant crop rotation** in combination with **conventional tillage** on the same soil and in the same region.

[3] Difference between (1) the maximum erosion rate observed for any production system for a given soil in a given region (the reference level) and (2) the estimated rate of erosion for the system in use on the same soil in the same region.

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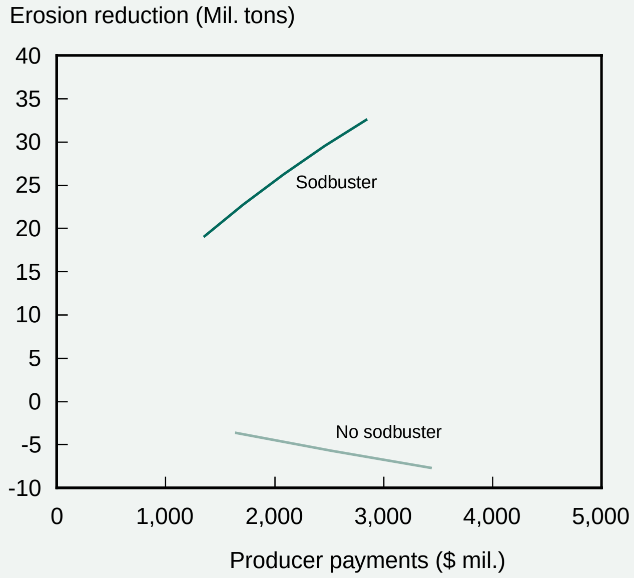
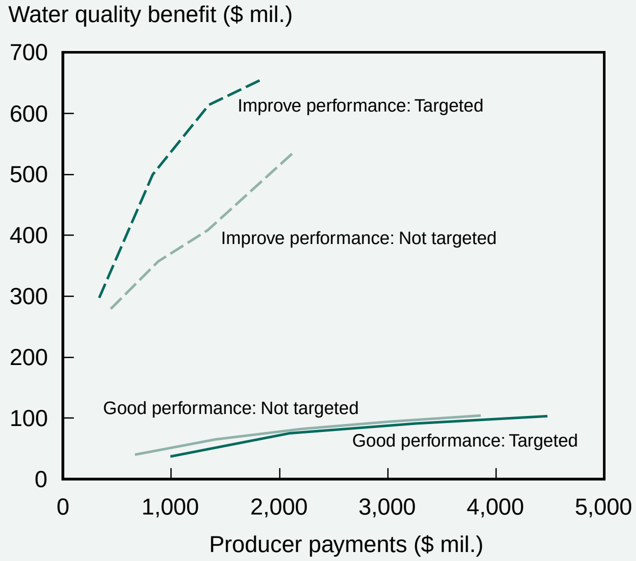
Producer payments and erosion reduction with and without sodbuster



This cropland expansion effect also limits the environmental performance of good performance programs, although not as much as expanding crop production on HEL. The consequences of bringing non-HEL into production can best be seen by comparing scenarios in which payments per ton of soil erosion vary with potential benefits (targeted) and where this payment is uniform across the Nation (nontargeted). Targeting is designed to redirect conservation effort from low-cost/low-benefit erosion reductions to higher cost/higher benefit reductions. Targeting results in less erosion reduction but, presumably, more water quality benefits.

For the *improve performance* scenarios, targeting produces greater water quality benefits per dollar of producer payments. For example, at roughly $1 billion in producer payments, targeting produces roughly $550 million in water quality benefits, a 32-percent increase over the nontargeted scenario ($375 million). However, erosion reduction is less in the targeted scenario because targeting redirects program funds away from low-cost/low-benefit erosion reductions to higher cost/higher benefit reductions.

Improved performance vs. good performance: Producer payments and water quality benefits



Regional changes due to targeting in the low erosion systems scenario

Farm resource region	Change from nontargeted to targeted scenario: Payment	Water quality benefit	Crop acreage
	$ Million	*$ Million*	*Million acres*
Northern Crescent	282.7	4.1	0.5
Southern Seaboard	30.9	-0.7	0.7
Mississippi Portal	14.4	0.3	0.2
Fruitful Rim	9.0	-0.8	0.1
Eastern Uplands	1.7	0.0	0.0
Basin and Range	-6.2	-0.3	-0.3
Prairie Gateway	-60.0	-1.4	0.1
Northern Great Plains	-79.6	-2.9	0.0
Heartland	-171.0	-2.4	-0.1
U.S. Total	21.9	-4.1	1.2

[1] Benefits associated with reductions in water erosion including water-based recreation benefits, municipal water cleaning, industrial impacts, shipping, water storage, etc.

Continued on page 44

For the *good performance* scenarios, however, the targeted scenario produces less erosion reduction ***and slightly less water quality benefit*** per dollar of producer payments over a wide range of program sizes. For example, if producer payments in both scenarios are roughly $2.1 billion, the targeted scenario produces $4.1 million less in water quality benefits.

This result stems from the fact that *erosion reduction* is not guaranteed in the *good performance* scenario. A significant share of higher payments may simply go to increase payments to "good actors," and without safeguards, the *good performance* scenario will encourage expansion of crop production.

Regional results show how the cropland expansion effect undercuts spatial targeting in the *good performance* scenario. Targeting increases payments in five regions: the Northern Crescent, Southern Seaboard, Mississippi Portal, Fruitful Rim, and Eastern Uplands (see table). However, water quality benefits improve in only two regions—the Northern Crescent and Mississippi Portal—and actually decline in the Southern Seaboard and Fruitful Rim regions. Total cropland acreage expands (relative to the nontargeted case) in four of the five regions where payments rise, offsetting gains from adoption of low erosion systems on existing cropland. The sodbuster provision, included in both scenarios, affects only highly erodible land, leaving producers free to expand production onto, and receive agri-environmental payments on, other land.

These results do not imply that "good actor" programs cannot be successfully used to improve environmental performance or cannot be targeted to increase environmental benefits. However, program designs that induce producers to increase cropland acreage – even on land that is not highly erodible – can erase program-induced environmental gains on existing cropland. A sodbuster provision is critical, and policymakers may want to add land-use safeguards similar to the "base acreage" (land eligibility) provisions of previous commodity programs.

producers opt for less productive (but less erosive) production systems, reducing commodity output and increasing commodity prices. Consumer welfare is reduced due to higher commodity prices (fig. 11). The increase in overall farm income exceeds producer payments because of higher commodity prices, although producer gains are offset to some extent by the costs of erosion reduction. The incomes of livestock producers fall modestly due to higher feed grain prices.

In the *good performance* and *good practices* options, producers can receive payments based on past actions, so the increase in conservation practices is lower for a given level of producer payments. Commodity price effects and producer costs for changes in production management or conservation practices are small compared with the *improve performance* scenario. Consumers are largely unaffected, but taxpayers shoulder a larger burden for farm income support than for the *improve performance* scenario. Small price effects and little change in production and conservation costs mean that 1 dollar in producer payments translates roughly into 1 dollar in increased farm income (fig. 11).

The choice of payment base also affects the regional distribution of payments and farm income gains. Regions with many "good actors" will receive a relatively large share of payments from the *good performance* or *good practices* scenarios. In our empirical examples, producers in the Heartland and Northern Crescent regions reap relatively large gains in the *good performance* and *good practices* scenarios (fig. 12). Because price effects are small, payments translate more or less directly into farm income gains in most regions (fig. 13). Rice, soybean, and cotton prices decline in the *good practices* scenario, leading to small declines in farm income in the Fruitful Rim and Mississippi Portal regions (fig. 13).

Payments in the *improve performance* scenario fall in areas where environmental improvement is valuable and/or can be achieved at low cost. In our empirical example, payments for erosion reduction are largest (relative to the baseline level of farm income) in the Northern Crescent, Basin and Range, and Mississippi Portal regions (fig. 12). Because price effects are significant, however, farm income gains may be larger or smaller than payments. Farm income gains are larger than payments in the Heartland and Prairie Gateway regions (fig. 13). In these regions, producers benefit from increased grain prices, while making only minimal investments in erosion reduction. Farm income gains are smaller than payments (or even negative) in the Northern Crescent, Northern Great Plains, Mississippi Portal, and Fruitful Rim. In all four regions, significant erosion reduction is achieved as land is removed from crop production. Although per-acre payments tend to be high in these regions, land retirement

Figure 11

Producer payments and consumer and producer welfare for various payment bases

is also an expensive erosion reduction strategy, so that costs largely offset payments.

In summary, program outcomes—environmental improvement and effects on agricultural producers, consumers, and taxpayers—vary widely depending on the details of program design. We find that **no single program design rises above others as an obvious choice** for agri-environmental policy. The *improve performance* scenario appears to offer the most environmental improvement per dollar of producer payments and provides the largest farm income boost per dollar of payment. However, baseline information needed to implement the improve performance payment base is not available. Moreover, this approach could also be viewed as inequitable by "good actors" and requires consumers to shoulder a significant share of program costs through higher commodity prices.

Figure 12

Payments as a percentage of farm income, by region, for various payment bases

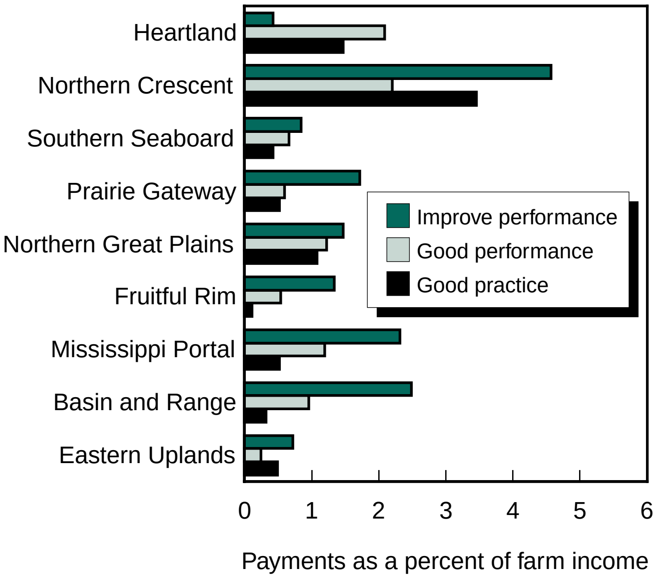
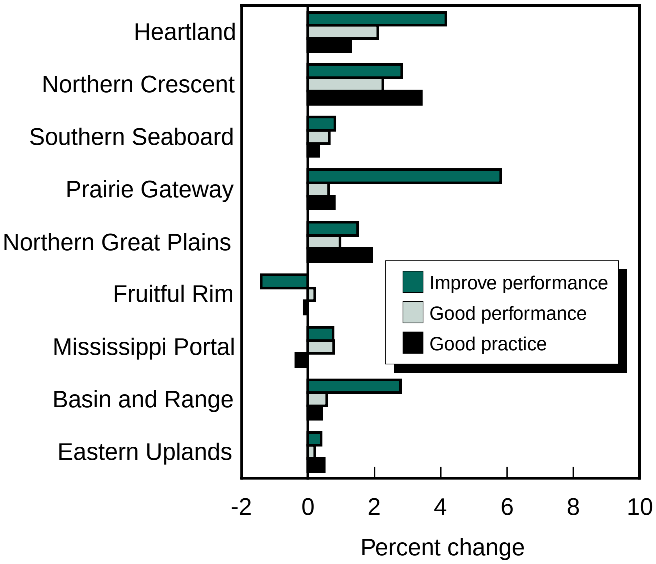


Figure 13

Percent change in farm income, by regions, for various payment bases



The *good performance* and *good practices* payment bases offer significant income support, do not adversely affect consumers, and do not require pre-program baseline information. While these payment base options are realistic, they produce only modest environmental gain and place a significant burden on taxpayers. Program designers must be careful to minimize incentives for cropland expansion. The *good performance* payment base offers some advantages over the *good practices* payment base in terms of directing payments to environmentally effective actions and allowing producers to select low-cost options where there is more than one way to achieve an environmental outcome. On the other hand, the *good practices* payment base is likely to require significantly less planning and enforcement effort.

Summary and Conclusions

Changes in the agri-environmental landscape have brought agri-environmental policy to a crossroads. In the upcoming farm bill debate, policymakers face a broadening array of agri-environmental problems. While farm price and income support appears likely to continue, the form this support will take is unknown. Trade agreements may limit program options. Because farm income and agri-environmental policies are intertwined (e.g., through compliance mechanisms), uncertainty about farm income policy also creates uncertainty about agri-environmental policy. This context may signal an overall rethinking of agricultural policy, including agri-environmental policy.

Agri-environmental policy—the collection of programs that encourage improved conservation and environmental performance in agriculture—has evolved significantly in recent years. Compliance mechanisms have greatly increased consistency between farm commodity programs and environmental objectives, yielding significant environmental gains. Environmental targeting has increased environmental benefit in the CRP. Cost-share programs have been largely consolidated into EQIP, refocusing effort toward livestock operations and nutrient management.

At present, agri-environmental policy employs a range of policy instruments, including land retirement, cost-share payments, and compliance mechanisms, which affect both *whether* and *how* land is farmed. Still other options are available. Agri-environmental payments—subsidy programs that pay producers who achieve good environmental performance or who use environmentally sound practices—have been proposed by the Clinton Administration and in Congress but have been the subject of only limited formal analysis. Agri-environmental payments may be useful in addressing emerging agri-environmental issues and boosting farm income.

In this report, we identified some tradeoffs that policymakers may face in the selection of objectives and the design of an agri-environmental payments program. Because the choices policymakers face are complex, this report cannot provide a plan or "road map" for future agri-environmental policy. It may, however, help in reading the signs along the way.

A number of general lessons can be drawn from our review of existing programs and empirical analysis of a series of hypothetical program designs. First, in a multi-objective policy, there is considerable risk of conflict among potential objectives. Consistency between farm income support and environmental objectives has been enhanced through compliance mechanisms. However, continued coordination among *all* farm programs will be needed to minimize contradictory or duplicative efforts.

Second, performance-based payments may be advantageous in that only environmentally relevant actions are subsidized and producers have significant flexibility to select low-cost alternatives. One-size-fits-all solutions are unlikely to be successful in dealing with agri-environmental problems. Soils, climatic conditions, crops, and management practices vary widely across the Nation. Practices that work well on one farm may be environmentally ineffective or overly expensive on another. Performance-based payments will (1) focus activity on the subset of practices that are effective in a given resource and production setting, and (2) reduce producer participation costs by allowing them to select least-cost alternatives. However, performance-based payments may also involve high costs for planning and enforcement because farm- or even field-specific plans must be devised. Performance-based payments may appear to be a less costly method of leveraging environmental gains because they promote environmental relevance and allow producer flexibility. However, they may be more costly than practice-based payments when planning and enforcement costs are considered.

Third, spatial targeting can improve the cost-effectiveness of an agri-environmental payments program, as evidenced by the CRP. Benefit estimates can help policymakers identify those agri-environmental problems that will yield the greatest net benefit to society. While current environmental benefit estimates are not complete, useful information is available. For example, the benefits of reducing nitrogen runoff from agriculture are likely to predominate in coastal estuaries, where nitrogen is typically the nutrient causing eutrophication (Bricker et al., 1999). Farms near the coast or near major rivers are more likely to contribute to coastal nitrogen loads (Alexander et al., 1999).

Finally, unintended incentives to expand crop production can undermine program performance. Our empirical analysis suggests that agri-environmental payments for *good performance* or *good practices* can encourage expansion of crop production onto previously uncropped land. In the absence of a sodbuster-type provision, this problem can be severe. Even with sodbuster, cropland expansion can be a problem. Our analysis suggests that the potential benefits of spatial targeting can be undercut if high regional payment rates, designed to encourage greater participation where the value of environmental improvement is high, also encourage cropland expansion.

Agri-environmental policies can provide substantial benefits to society. If policymakers choose to implement a program of agri-environmental payments, their challenge will be to design one that achieves the greatest possible benefit per dollar of cost to society.

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Appendix 1: Major Conservation Programs Related to Agriculture

USDA Programs

Agricultural Conservation Program—Initiated in 1936, ACP provided cost-sharing (up to $3,500 annually per farmer) and technical assistance to farmers who carried out approved conservation and environmental protection practices on agricultural land and farmsteads. During the past 20 years, outlays generally ran between $175 million and $200 million each year. The number of participants gradually declined from more than 300,000 annually in the mid-1970's to some 120,000 in the first half of the 1990's. Annual assistance per participant averaged approximately $1,600 from 1990 to 1994. Since the 1980s, an increasing amount and proportion of cost-sharing was directed to water quality practices. In 1994, 23 percent of ACP cost-sharing went for water quality practices, up from 7 percent in 1988. Authority for ACP terminated on October 1, 1996, when its functions were subsumed by EQIP.

Conservation Compliance, Sodbuster, and Swampbuster—Enacted through the Food Security Act of 1985. Farmers remain eligible for programs such as Commodity Credit Corporation price supports, CRP payments, farm storage facility loans, disaster payments, Federal Crop Insurance, and FmHA loans when they comply with measures of each. Conservation compliance requires those who farm highly erodible land (HEL) to implement a soil conservation plan. Sodbuster requires that HEL not being cropped have a conservation plan implemented if brought under production. Swampbuster requires farmers not to drain any wetland. All three provide water quality benefits, however, swampbuster also maintains wetland habitat.

Conservation Reserve Enhancement Program—CREP, authorized in the 1996 Farm Act and operated by FSA, is a State-Federal conservation partnership program targeted to address specific State and nationally significant water quality, soil erosion, and wildlife habitat issues related to agriculture. The program offers additional financial incentives beyond the CRP to encourage farmers and ranchers to enroll in 10-15 year contracts to retire land from production. CREP is funded through CCC.

Conservation Reserve Program—was initiated by Congress in Title XII of the Food Security Act of 1985, was extended by the Food, Agriculture, Conservation and Trade Act of 1990, and has been extended to 2002 by the Federal Agriculture Improvement and Reform Act of 1996. The CRP is a voluntary cropland retirement program with a maximum enrollment of 36.4 million acres. The program provides farmers an annual rental payment on land enrolled in a 10-15 year contract. Land is placed in a permanent cover. Parcels are selected based on the magnitude of the likely environmental gain relative to the rental payment. Environmental gains include habitat improvements, water quality impacts, soil productivity gains, air quality improvements, and carbon sequestration.

Conservation Technical Assistance—Since 1936, CTA, has provided technical assistance to farmers for planning and implementing soil and water conservation and water quality practices. Both farmers adopting practices under USDA conservation programs and other producers who ask for assistance in adopting approved NRCS practices can receive technical assistance. In recent years, CTA has prepared conservation plans for highly erodible lands to help farmers maintain eligibility for USDA program benefits.

Emergency Wetlands Reserve Program—The EWRP was established in 1993, using funds from the Emergency Watershed Protection Program authorized under emergency supplemental appropriations after the Midwest flood. The voluntary program helped landowners convert flood-damaged cropland to wetlands if the cost of the levee restoration and cropland renovation exceeded the value of the land. Approximately 89,500 acres have been enrolled in the EWRP through 1997 (Heimlich et al., 1998).

Environmental Quality Incentives Program—EQIP was established by the 1996 Farm Act to consolidate and better target the functions of the ACP, WQIP, GPCP, and Colorado River Basin Salinity Program. The objective of EQIP, like its predecessor programs, is to encourage farmers and ranchers to adopt practices that reduce environmental and resource problems by providing education, technical assistance, and financial assistance, targeted to watersheds, regions, or areas of special environmental sensitivity identified as priority areas. Contracts are for 5 to 10 years, and the annual payment limit is $10,000 per person, with a maximum of $50,000 per contract. In 1997, 56 percent of EQIP funds were allocated to water quality concerns, 23 percent to soil erosion, 11 percent to water quantity, and 4 percent to wildlife habitat (USDA, NRCS, 1998). EQIP is designed to consider all sources of conservation funding from CRP, WRP, other Federal programs, State or local programs, and nongovernmental partners. Proposed projects with greater funding from these sources receive more favorable scoring for EQIP funding.

Wildlife Habitat Incentives Program—The WHIP was created in 1996 to provide cost-sharing assistance to landowners for developing habitat for upland and wetland wildlife, threatened and endangered species, fish, and other types of wildlife. Participating landowners, with the assistance of the NRCS district office, develop plans that include schedules for installing wildlife habitat development practices and requirements for maintaining the habitat for the 5- or 10-year life of the agreement. Cost-share payments of up to 75 percent may be used to establish new practices, maintain or replace practices needed to meet the objectives of the program, and replace practices that fail for reasons beyond the landowner's control. Cooperating State wildlife agencies and nonprofit or private organizations may provide expertise or additional funding to help complete a project. About 90 percent of projects approved are for improvements to upland habitat, with the balance in riparian area, wetland, and aquatic improvements.

Water Quality Incentive Projects—The WQIP was created by the 1990 Food, Agriculture, Conservation and Trade Act, and was administered as an ACP practice. The goal of WQIP was to reduce agricultural pollutants through sound farm management practices that restore or enhance water resources compromised by agricultural nonpoint source pollution. Areas eligible for WQIP included: watersheds identified by States as being impaired by nonpoint source pollution under Section 319 of the Clean Water Act; areas identified by State agencies for environmental protection and so designated by the Governor; and areas where sinkholes conveyed runoff directly into ground water. A total of 242 projects were started during FY 1993-95. Eligible producers entered into 3- to 5-year agreements with USDA to implement approved management practices on their farms, as part of an overall water quality plan, in return for an incentive payment. In 1995, WQIP assistance was applied to over 800,000 acres. EQIP was consolidated into EQIP by the 1996 Farm Act.

Wetlands Reserve Program—Authorized by the Food, Agriculture, Conservation and Trade Act of 1990, the WRP provides an easement payment and covers wetland restoration costs for land permanently converted back to a wetland. As of July 2000, a total of 5,230 contracts had been accepted and over 915,000 acres enrolled (USDA, NRCS, 2000d). The WRP is primarily a habitat protection program but also serves as a water purification system.

Federal Programs Outside of USDA

Coastal Zone Act Reauthorization Amendments—CZARA, of 1990, added important nonpoint source water pollution requirements to the Coastal Zone Management Act. This is the first federally mandated program requiring specific measures to deal with agricultural nonpoint sources. CZARA requires that each of the 29 States and territories with an approved coastal zone management program submit to EPA and to the National Oceanic and Atmospheric Administration a program to "implement management measures for nonpoint source pollution to restore and protect coastal waters" (U.S. EPA, 1996). States can utilize voluntary incentives to get farmers to adopt economically achievable measures for controlling agricultural NPS pollution (education, technical assistance, and financial assistance) but must enforce adoption if voluntary approaches fail. Implementation of plans is not required to begin until 2004. In general, annual costs of CZARA management measures are estimated to be less than $5,000 per farm for most farm sizes (Heimlich and Barnard, 1995).

Endangered Species Act—The ESA of 1973 is the Nation's chief statute to conserve endangered or threatened species and their ecosystems. Farmers may not "take" a member of a species determined to be in danger of extinction. ("Take" is defined within the ESA as "to harass, harm, pursue, hunt, shoot, kill, trap, capture, or collect" an endangered or threatened species or attempt to do so.) In some cases, habitat destruction might be prohibited under the ESA, or cropping practices or pesticide use may be restricted (Daugherty, 1997). More likely, farmers will be affected to the extent that they require a Federal permit (e.g., for filling wetlands) or depend on the use of Federal resources (e.g., irrigation water supplied by the Bureau of Reclamation or public grazing lands) because the agencies providing those services may be restricted from doing so by the act's requirement that Federal agencies help restore listed species.

Federal Insecticide, Fungicide, and Rodenticide Act—FIFRA of 1947 provides the legal basis under which pesticides are regulated. A pesticide can be restricted or banned if it poses unacceptable risks to human health or the environment. The re-registration process, mandated in 1988 for all active ingredients then on the market, has resulted in manufacturers' dropping many less profitable products rather than paying the registration fees.

Federal Water Pollution Control Act Amendments (Clean Water Act)—Enacted in 1972, the CWA has focused on reducing water quality impacts of point sources of pollution (factory discharge and municipal sewage). In recent years, attention has turned to nonpoint sources, primarily runoff from agricultural operations, and to an agricultural point source—confined animal feedlot operations (CAFO's). Currently, over 6,000 livestock operations are large enough to be classified as CAFO's under the Clean Water Act (EPA and USDA, 1998). The Clean Water Act requires that CAFO's obtain a permit to discharge. However, enforcement has been a problem, and many facilities lack permits (Westenbarger and Letson, 1995). To address nonpoint sources, EPA and USDA jointly developed a Clean Water Action Plan (CWAP), as requested by the White House. The initiatives of the CWAP, released in 1998, will bring better interagency coordination and cooperation to better farmers' efforts to address runoff problems in impaired watersheds.

Appendix 2: The U.S. Agricultural Sector Mathematical Programming Model (USMP)

Environmental and economic effects of various green payment program scenarios are derived as comparative static changes in the U.S. Regional Agricultural Sector Model (USMP). An agriculture sector spatial equilibrium model as described in McCarl and Spreen, USMP incorporates agricultural commodity supply, use, and policy measures (House). USMP has been applied to project the effects on U.S. national and regional agriculture of changes in export levels and variability (Miller et al.), trade agreements (Burfisher et al.), imports (Spinelli et al.), input taxes (Peters et al.), irrigation policy (Horner et al.), ethanol production (House et al.), wetlands policy (Heimlich et al., 1997a, Claassen et al., 1998), sustainable agriculture policy (Faeth), and various other policy and program scenarios.

USMP models production of 10 crops: corn, sorghum, oats, barley, wheat, rice, cotton, soybeans, hay, and silage. Sixteen primary livestock production enterprises are included, the principal being dairy, swine, beef cattle, and poultry. Coefficients in crop and livestock enterprise budgets were developed from USDA National Resources Inventory (NRI), Cropping Practices Survey (CPS), and Farm Costs and Returns Survey (FCRS) data. CPS and FCRS data are collected and analyzed by the Economic Research Service and National Agricultural Statistics Service of the U.S. Department of Agriculture. Several dozen processed and retail products are included in the model structure, the principal being dairy products, pork, fed and nonfed beef, poultry, soy meal and oil, livestock feeds, and corn milling products. Acreage, commodity supply/use, conservation reserve program acreage, prices, production practices, and so forth are validated exactly to USDA baseline projections for 2005 (USDA-WAOB) and corresponding geographic information. For example, USMP's base U.S. corn acreage planted in 2005 equals the USDA baseline projection and corn acreage in each model region/practice stratum is determined by share information from NRI and CPS regional data. On the demand side, domestic use, exports, ending stocks, and price levels for crop and livestock commodities and most processed or retail products are endogenously determined within the model structure with domestic consumption, commercial stock, export and other demand functions specified with elasticities from the FAPSIM econometric simulation model (Green and Price).

USMP models 45 regions and two soils within each region (highly erodible and non-highly erodible soil). For analysis of green payments, the primary strength of USMP lies in the specification of multiple combinations of crop rotations and production practices for each soil in each region. For example, in response to incentives for soil erosion reduction, producers may switch to rotations that include less erosive crops or increase residue cover through adoption of conservation tillage methods.

Appendix 3: Linking Environmental Indicators and ARMS data

Environmental indicators are linked spatially to farm-level economic data from ARMS. Environmental indicator values are averaged over space and assigned to counties using a geographic information system. ARMS data points located in a given county are associated to these average environmental indicators assigned to the county. This spatial association is valid to the extent that spatial variations in land resources and farms (e.g., variation in acreage, sales, crops, production practices) are interrelated. The development of ERS farm resource regions (the level at which results of our ARMS-environmental indicator link are reported) supports this assumption. Regions are based on relatively uniform farms and land resources, based on a cluster analysis of U.S. farm characteristics (Sommer and Hines, 1991), old USDA farm production regions, USDA land resource regions (USDA-SCS, 1981), and NASS crop reporting districts.

The distribution of farms by financial and income characteristics—used to define income support target groups and the ERS typology—is derived from data collected through USDA's Agricultural Resource Management Survey (ARMS) data. The ARMS is designed to capture the physical, financial, demographic, and managerial attributes of farm businesses and people engaged in farming. The survey is conducted annually by the Economic Research Service (ERS) and the National Agricultural Statistics Service (NASS).

Environmental indicator acreages for rainfall and wind erosion were estimated from the National Resource Inventory (NRI) point data files. NRI point data files are collected and maintained by the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture (USDA) and contain detailed data on land use and condition, including estimates of rainfall and wind erosion, for each of more than 800,000 points nationwide. High-nitrogen-runoff acreage is estimated as cropland acreage in areas estimated by the SPARROW model (Smith et al., 1997) to have nitrogen yields (runoff per unit area of land) from commercial fertilizer application in excess of 1,000 kg/km^2/year.

Appendix 4: The ERS Farm Typology

*Small Family Farms (sales less than $250,000)**

Limited-resource. Any small farm with gross sales less than $100,000, total farm assets less than $150,000, and total operator household income less than $20,000. Limited-resource farmers may report farming, a nonfarm occupation, or retirement as their major occupation.

Retirement. Small farms whose operators report they are retired (excludes limited-resource farms operated by retired farmers).

Residential/lifestyle. Small farms whose operators report a major occupation other than farming (excludes limited-resource farms with operators reporting a nonfarm major occupation).

Farming occupation, lower-sales. Small farms with sales less than $100,000 whose operators report farming as their major occupation (excludes limited-resource farms whose operators report farming as their major occupation).

Farming occupation, higher-sales. Small farms with sales between $100,000 and $249,999 whose operators report farming as their major occupation.

Other Farms

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

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

Nonfamily farms. Farms organized as nonfamily corporations or cooperatives, as well as farms operated by hired managers.

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*The National Commission on Small Farms suggested the $250,000 cutoff for small farms.

Appendix 5: Two Indices for Targeting Nonmarket Impacts

Agriculture affects a wide variety of environmental resources including water, wildlife, and clean air, which, in turn, are important in producing a wide variety of environmental amenities or nonmarket goods and services including clean water for recreation, better bird watching, and healthy air to breath. People value improvements in environmental amenities.

It has long been understood that markets are not able to fully link those who supply improvements (in this case, the farmers) with those who benefit from the increase in amenities. Thus, without public action, individuals do not experience the level of environmental quality they would otherwise purchase.

What is the appropriate level of public action? One way to answer this question is to estimate the value that the public places on a change in the amenities and compare them with the associated costs of their provision through an agri-environmental program—much the same way consumers trade off costs and benefits.

In order to value changes in agricultural land use for policy analyses, both physical and economic relationships must be estimated. The fundamental steps involved in estimating the relationships relevant to valuing sediment and nitrogen impacts are:

1. the value the public places on an improvement in an environmental amenity;
   - ➢ example: the value visitors place on a 10 percent increase in the clarity of beach water in August;
2. the change in the amenity associated with a change in sediment or nitrogen in the water;
   - ➢ example: the change in clarity resulting from a 15 percent change in the water's sediment loading;
3. the change in sediment or nitrogen in the water due to a change in erosion or excess nitrogen on the field;
   - ➢ example: the change in sediment loadings at a beach due to a 17 percent change in field erosion;
4. the change in erosion or excess nitrogen due to a change in agricultural practices;
   - ➢ example: the change in field erosion due to adopting contour tillage by all corn producers of the relevant watershed(s).

Included in Step 3 is the fate-and-transport process when environmental impacts are not local. For example, nitrogen has its greatest impact on environmental amenities when it reaches coastal waters, especially estuarial zones (Bricker et al., 1999). Soil sediment impacts on shipping tend to be at downstream ports (Davis et al., 2000).

Details on how these relationships were estimated follow. While the focus is on valuing impacts of sediment and nitrogen, the reasoning applied in these cases is applicable to valuing other environmental amenities.

While the best available data and information are used, many uncertainties remain. However, the proposed measures are structured so that additional data and information can be incorporated, as they become available.

Sediment. The values the public places on reductions in soil erosion have been estimated for the following environmental amenities: municipal water use, industrial uses, irrigation ditch maintenance, road ditch maintenance, water storage, flooding, and soil productivity (Ribaudo et al., 1990; Ribaudo, 1986), freshwater-based recreation (Feather et al., 1999), and navigation (Davis et al., 2000). These are not all of the environmental amenities affected by sediment. Amenities not included are: increases in waterfowl populations, cleaner coastal and estuarine recreation areas, population survival of endangered species, and quality of commercial fisheries. Therefore, the value used here should be viewed as a minimum estimate.

These studies have, directly or indirectly, attempted to account for steps 2 and 3—amenity response to sediment and the fate-and-transport process. All have relied on the USLE (Universal Soil-Loss Equation) to determine the current level of soil erosion within a watershed. Each then either uses this measure of erosion as a water-quality indicator or as a link to changes in water quality. For example, Feather et al. (1999) estimated recreational behavior based on (among other things) geographic variation in erosion within watersheds as given by the USLE. Davis et al. (2000) estimated cost as a function of total upstream erosion, as measured by the USLE. Ribaudo used a slightly different approach. His models estimate values based on water quality but then linked changes in water quality to changes in erosion, as measured by the USLE.

Finally, changes in erosion following any change in farmland use (step 4) are commonly measured using the USLE. With this tool, the field-level measures of soil erosion changes can be derived from field-level data detailing changes in farmland use.

Annual values of a 1-ton reduction in soil erosion will differ across fields in the country because both the physical impacts on amenities and economic values of changes in the amenities vary (fig. 9, p. 34). This variation in the field-level value of a reduction in soil erosion emphasizes the advantages of environmental targeting.

Nitrogen. The value the public places on a reduction of nitrogen to estuaries includes impacts on boating, swimming, and recreational fishing (Hellerstein and Breneman, 2000). These are not all of the activities affected by the water quality impacts of nitrogen. Research has focused on these activities because they appear to be especially significant (Bockstael et al., 1986). However, other impacts, such as impacts to bird watchers, water views, and commercial fisheries, are also likely to be significant. Experts are still studying the impacts of nitrogen in our waters. For example, nitrogen's impact on the 5,000-7,000 square mile zone of hypoxia in the northern Gulf of Mexico may be having significant impacts on environmental amenities. Hypoxia is a deficiency in breathable oxygen (< 2.0 mg/l of dissolved oxygen) sufficient to cause damage to living tissue and death. While the link between hypoxia in the northern Gulf and nitrogen loadings from the Mississippi River is recognized (Rabalais et al., 1996), the impact of hypoxia on wildlife, and thus the need for concern, continues to be debated. Nitrogen inflows to the Chesapeake Bay and other bays and coastal areas may also be affecting environmental amenities. If nitrogen does have high-valued impacts in these areas, then the nitrogen amenity value employed here is biased downward in the associated watersheds.

As in the studies that valued changes in sediment impacts on amenities, an indirect measure of the amenity was used. In this case, studies assumed that the change in amenities in an estuary is proportional to the change in nitrogen delivered to the estuary—an indirect approach to estimating fate and transport relationships.

The link between field-level nitrogen and nitrogen inflow to each estuary is estimated in two steps. In the first step, the USGS SPARROW (SPAtially Referenced Regressions On Watershed Attributes) model (Smith et al., 1997) provides nitrogen delivery ratios between a stream's edge and the estuary for all watersheds. This 'water-based' delivery ratio accounts for nitrogen loss as it moves downstream. The delivery ratio for a watershed is the fraction of a pound of nitrogen that will make it from the stream's edge to the estuary. As a geographic foundation, the SPARROW model uses the 2,112 eight-digit hydrologic cataloging units (HUCs) or watersheds representative of the 48 States. The model is based on empirical evidence that stream depth is a critical factor in preventing nitrogen absorption by the environment. Thus the proximity of agricultural land to major rivers and streams is a critical determinant of the portion of nitrogen that reaches the estuary (Alexander et al., 2000; Smith et al., 2000).

The second step in linking field-level nitrogen to estuary nitrogen accounts for the fate-and-transport of nitrogen from the field to the stream's edge for each estuary. This delivery ratio accounts for nitrogen losses as nitrogen moves from the field to the water (Hellerstein and Breneman). This "field-to-stream" delivery ratio is approximated by dividing the pounds of agricultural nitrogen reaching a stream's edge by the pounds of the excess nitrogen (nitrogen not absorbed by the crop) associated with crop production within each watershed. Stream-edge (agricultural) nitrogen for each HUC comes from the USGS SPARROW model. Field-level, excess nitrogen estimates come from the EPIC model (USDA, ARS, 1990). The product of the field-to-stream and stream-to-estuary delivery ratios for each watershed produces a "field-to-estuary" delivery ratio for each watershed. The field-to-estuary delivery ratio estimates the portion of a pound of excess nitrogen on a field within a watershed that is likely to reach the downstream estuary.

Variations in the stream-to-estuary delivery ratios, along with variations across estuaries in the value of the environmental impact of a pound of nitrogen, result in variations in the field-level value of a pound of excess nitrogen (fig. 10, p. 35). This variation in the field-level values also illustrates the advantages of environmental targeting for control of excess agricultural nitrogen.

With changes in nitrogen application rates, cropping mix, tillage practice, etc., will come changes in excess nitrogen. The EPIC model is able to estimate the change in excess nitrogen based on changes in agricultural practices that follow a change in agricultural policy. The EPIC model also accounts for other losses of nitrogen (e.g., the atmosphere) and thus provides an estimate of nitrogen in water reaching the field's edge (step 4).

Appendix 6: ERS Farm Resource Regions

The U.S. farm sector is highly diverse. Farms vary widely in terms of resource base, products produced, production practices, and financial performance. The Economic Research Service (ERS) developed the nine new farm resource regions to more accurately depict geographic variation and facilitate the reporting and interpretation of farm sector data and research results.

County clusters, based on the types of commodities produced, have shown that a few commodities tend to dominate farm production in specific geographic areas that cut across State boundaries. The climate, soil, water, and topography in these geographic areas tend to determine the dominant crop and livestock enterprises. In developing the new regions, ERS recognized the limitations of using State boundaries and that new information technology makes finer resolution practical.

The new ERS regions are derived from four sources: (1) the Farm Production Regions—Corn Belt, Northern Plains, etc., (2) a cluster analysis of U.S. farm characteristics (Sommer and Hines, 1991), (3) the USDA Land Resource Regions, and the National Agricultural Statistics Service's (NASS) Crop Reporting Districts. The ERS regions were constructed by identifying areas where similar farm types (in terms of commodity production) intersected with areas of similar physiographic, soil, and climatic traits, as reflected in USDA's Land Resource Regions. Final boundaries were drawn to conform with NASS Crop Reporting Districts, which are aggregates of counties.

The farm resource regions are no longer constrained to follow State boundaries and are not necessarily contiguous. Contiguous areas within single States are

Basin and Range

- Largest share of nonfamily farms, smallest share of U.S. cropland.
- 4% of farms, 4% of value of production, 4% of cropland.
- Cattle, wheat, and sorghum farms.

Northern Great Plains

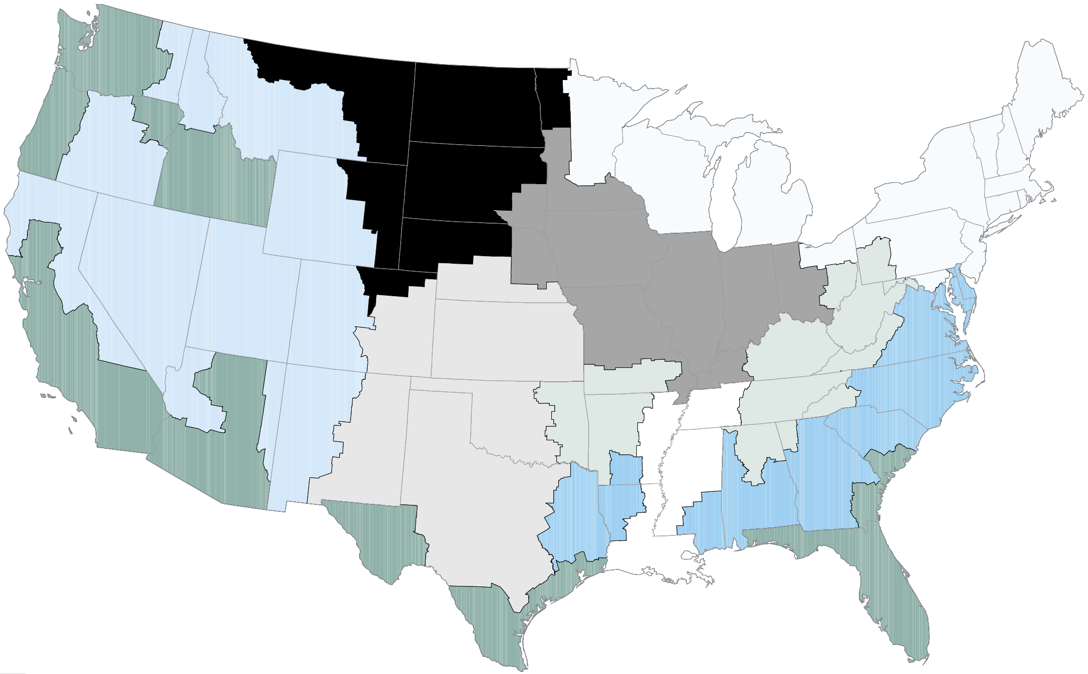
- Largest farms and smallest population.
- 5% of farms, 6% of value of production, 17% of cropland.
- Wheat, cattle, and sheep farms.

Heartland

- Most farms (22%), highest value of production, (23%), and most cropland (27%).
- Cash grain and cattle farms.

Northern Crescent

- Most populous region.
- 15% of farms, 15% of value of production, 9% of cropland.
- Dairy, general crop, and cash grain farms.



Fruitful Rim

- Largest share of large and very large family farms and nonfamily farms.
- 10% of farms, 22% of value of production, 8% of cropland.
- Fruit, vegetable, nursery, and cotton farms.

Prairie Gateway

- Second in wheat, oat, barley, rice, and cotton production.
- 13% of farms, 12% of value of production, 17% of cropland.
- Cattle, wheat, sorghum, cotton, and rice farms.

Mississippi Portal

- Higher proportions of both small and larger farms than elsewhere.
- 5% of farms, 4% of value of production, 5% of cropland.
- Cotton, rice, poultry, and hog farms.

Southern Seaboard

- Mix of small and larger farms.
- 11% of farms, 9% of value of production, 6% of cropland.
- Part-time cattle, general field crop, and poultry farms.

Eastern Uplands

- Most small farms of any region.
- 15% of farms, 5% of value of production, and 6% of cropland.
- Part-time cattle, tobacco, and poultry farms.

sometimes split up among multiple regions. For example, farms in the old Appalachian region (Tennessee, Kentucky, North Carolina and Virginia) vary widely in topography, soil, and commodities produced. In the new ERS farm resource regions, these four States are split among four different regions: the Heartland, Mississippi Portal, Eastern Uplands, and Southern Seaboard. Three regions—the Eastern Uplands, Fruitful Rim, and Southern Seaboard—are discontiguous. The Fruitful Rim, which covers parts of nine States from Florida to Washington, is an extreme example of the spatial separation that can exist between farms that produce similar commodities under similar conditions.