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Environmental Compliance in U.S. Agricultural Policy

Past Performance and Future Potential

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Abstract

Since 1985, U.S. agricultural producers have been required to practice soil conservation on highly erodible cropland and conserve wetlands as a condition of farm program eligibility. This report discusses the general characteristics of compliance incentives, evaluates their effectiveness in reducing erosion in the program's current form, and explores the potential for expanding the compliance approach to address nutrient runoff from crop production. While soil erosion has, in fact, been reduced on land subject to Conservation Compliance, erosion is also down on land not subject to Conservation Compliance, indicating the influence of other factors. Analysis to isolate the influence of Conservation Compliance incentives from other factors suggests that about 25 percent of the decline in soil erosion between 1982 and 1997 can be attributed to Conservation Compliance. This report also finds that compliance incentives have likely deterred conversion of noncropped highly erodible land and wetland to cropland, and that a compliance approach could be used effectively to address nutrient runoff from crop production.

Keywords: conservation compliance, Sodbuster, Swampbuster, conservation policy, agri-environmental policy, nutrient management, buffer practices.

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Farm commodity programs may have encouraged crop production on environmentally sensitive land in the 1970s and early 1980s. Although unintended, farm program incentives to expand production may have increased environmental damage associated with agricultural production and undercut the effectiveness of conservation programs designed to mitigate that damage. Compliance provisions, introduced in the Food Security Act (1985 Farm Act), aim to counteract that influence.

In essence, compliance provisions leverage farm program payments for the environment; farmers who want to remain eligible for benefits from selected Federal agricultural programs, including price support loans and income support payments, must implement soil conservation systems on highly erodible land (HEL) and refrain from draining wetlands. The question addressed by this report is to what extent compliance provisions created sufficient incentives to motivate the types of behavioral shifts they were designed to address.

In fact, the annual rate of soil erosion on U.S. cropland declined by nearly 40 percent between 1982 and 1997. About a fourth of that decline can be directly attributed to compliance. But that is only part of the story. A large share of cropland erosion reduction occurred on land that was not subject to compliance requirements. Non-HEL cropland accounted for 38 percent of all cropland erosion reduction. This begs the question: How much erosion reduction would have been realized without compliance requirements? Reduced soil erosion on land not subject to compliance suggests that other factors, such as technology, information, and markets, played an important role in triggering large-scale erosion reduction. Conversely, compliance may have acted as a catalyst for change, accelerating the adoption of farming practices—such as conservation tillage—that can conserve soil and save farmers money.

Compliance mechanisms have clearly increased consistency between income support and environmental programs. While consistency is an important goal, this report focuses on the broader potential of the compliance mechanism as an agri-environmental policy instrument.

Compliance mechanisms may provide the best bang for the buck as a deterrent to environmentally damaging actions such as draining wetlands or bringing new HEL into crop production. Compliance sanctions are triggered only when a violation occurs. In contrast, using conservation payments to achieve these same ends is likely to be difficult or expensive. The difficulty is in deciding which wetlands or noncropped HEL are vulnerable enough to warrant conservation payments. If that is too difficult, policymakers could opt to subsidize protection of a significant share of these environmentally sensitive lands—an expensive alternative, indeed.

Compliance incentives have motivated farmers to reduce soil erosion on highly erodible cropland. Between 1982 and 1987, excess erosion (any erosion in excess of the maximum level consistent with maintaining soil productivity) on highly erodible cropland fell by 331 million tons annually. Nearly

90 percent of this reduction occurred on farms receiving government program payments, and thus can be directly attributed to conservation compliance.

Compliance incentives may deter producers from expanding crop production onto highly erodible land or wetland. Without compliance requirements, between 7 million and 14 million acres of highly erodible land or wetland that are not currently being farmed could be profitably converted to crop production, under favorable market conditions.

Existing government payments have the potential to leverage a broader set of agricultural conservation and environmental gains. The majority of cropland with potential for nutrient runoff is located on farms receiving government program payments. Whether these payments are large enough to spur farmers to address nutrient runoff depends on the methods available for remediation and their cost.

Because they depend on payments from other programs for compliance incentives, compliance mechanisms will be effective only on farms where government payments exceed the cost of required conservation actions.

Introduction

The 1985 Food Security Act (FSA) ushered in a new era of U.S. agri-environmental policy. Although much attention has been focused on large-scale, long-term land retirement through the Conservation Reserve Program (CRP), the adoption of compliance mechanisms was an important agri-environmental policy innovation. In general, compliance mechanisms require farmers to meet some minimum standard of environmental protection on environmentally sensitive land as a condition of eligibility for Federal farm program benefits—principally farm commodity program payments. Coupled with changes in the 1985 FSA that made commodity program participation more attractive to producers, compliance mechanisms have come to play a significant role in U.S. agri-environmental policy. The most recent farm bill, the Farm Security and Rural Investment Act of 2002, retained compliance mechanisms with only minor technical revisions.

At present, compliance mechanisms address soil conservation on highly erodible land—provisions widely known as “Conservation Compliance” and “Sodbuster”—and wetland conservation—a provision widely known as “Swampbuster.” Conservation Compliance requires producers already cropping highly erodible land (HEL) to implement soil conservation plans or risk losing their Federal farm program benefits (see box, “Soil Erodibility and Soil Erosion”). Sodbuster places similar, albeit more stringent, requirements on producers who bring previously uncropped HEL into crop production. Under Swampbuster, producers who convert wetland for crop production can lose Federal farm program benefits.

Compliance mechanisms are part of broader strategies for soil conservation and wetland protection. CRP and Conservation Compliance/Sodbuster were enacted in 1985 as part of an overall strategy to conserve soil. Farmers who already cropped HEL could adopt required conservation systems or retire land by enrolling it in the CRP, while Sodbuster was designed to deter farmers from bringing more HEL into crop production. Swampbuster was also one of a number of policy changes designed to stem wetland loss in agriculture. The Tax Reform Act of 1986 eliminated tax breaks that encouraged conversion of land to crop production, reducing the incentive to convert both HEL and wetland to crop production, complementing the Sodbuster and Swampbuster provisions of the 1985 FSA. The Wetland Reserve Program (WRP), enacted in 1990, restores and protects previously drained wetlands on agricultural land.

Since compliance mechanisms have taken effect, soil erosion on HEL cropland and wetland conversions for agricultural production have declined sharply (Heimlich et al., 1998; Claassen et al., 2000; 2001). Nonetheless, questions about the effectiveness of compliance mechanisms remain: What proportion of overall cropland erosion reduction is actually due to Conservation Compliance? Is Swampbuster actually constraining wetland conversion for agricultural production? Will environmental benefits increase if compliance is extended to address additional environmental problems?

Soil Erodibility and Soil Erosion

Largely through compliance mechanisms, U.S. soil conservation policy targets highly erodible land (HEL). HEL is defined as land with an erodibility index (EI) of 8 or larger. The erodibility index is, in turn, defined by the ratio of inherent erodibility to the soil loss tolerance. Inherent erodibility for a given soil is the rate of erosion (tons per acre per year) that would occur on land that was continuously clean-tilled throughout the year. The soil loss tolerance is an estimate of the rate of soil erosion that can occur on a given soil without significant long-term productivity loss. Thus, the erodibility index captures both the propensity of a soil to erode and the potential for damage from erosion. Actual soil erosion, however, reflects a complex interaction of climate, topography, soil characteristics, land use, and land management practices. Actual erosion is typically far less than a soil's inherent erodibility due to ground cover (grass, trees, crops, crop residue) and conservation practices (e.g., terraces or windbreaks) installed by farmers and landowners.

While soil erosion is difficult to measure under field conditions, physical process models can be used to predict both inherent erodibility and the average annual rate of soil erosion, given climate, topography, soils, land use, and land management. The Universal Soil Loss Equation (USLE; Wischmeier and Smith, 1978) and, more recently, the Revised Universal Soil Loss Equation (RUSLE; see http://www.sedlab.olemiss.edu/rusle/overview.html), and the Wind Erosion Equation (WEE; Skidmore and Woodruff, 1968) have been used widely in conservation planning and program implementation.

Because average annual erosion rates can be estimated with and without various conservation practices, the models have greatly facilitated policy implementation. Farmers, working with conservation planners, can use physical process models to develop cost-effective conservation systems. These models are used to implement conservation compliance and other USDA conservation programs.

In this report, we define compliance mechanisms, discuss their general characteristics, analyze the effectiveness of compliance mechanisms (with particular focus on the role of Conservation Compliance in reducing soil erosion on highly erodible cropland), and discuss the potential for expanding compliance to address nutrient runoff and leaching from land in crop production.

Compliance Mechanisms: A Primer

Compliance mechanisms require that agricultural producers undertake certain resource conservation activities as a condition of eligibility for selected Federal agricultural programs, including commodity price and income support programs and voluntary conservation programs such as CRP, WRP, and the Environmental Quality Incentives Program (EQIP). Producers who violate compliance requirements or who fail to take the required actions to reduce existing environmental damage may become ineligible for all program benefits, not just on those acres where the violation has occurred. Under Swampbuster, for example, program payments can be denied to producers who take action to convert wetland to crop production. Under Conservation Compliance, producers who fail to act to reduce soil erosion on HEL cropland can be similarly sanctioned.

Compliance mechanisms can be viewed in two ways. As a method of policy coordination, they can reduce unintended adverse environmental consequences of farm programs. As an agri-environmental policy tool, compliance can be used to further agri-environmental objectives. In this latter role, compliance mechanisms have properties that set them apart from other agri-environmental policy instruments—especially subsidies designed to encourage good environmental performance—making them useful in situations where subsidies would be difficult or especially costly to use.

Program coordination was a key motivation for adoption of compliance provisions in the 1985 Food Security Act (FSA). In the 1970s and early 1980s, evidence suggested that farm commodity programs encouraged production of relatively erosive crops on erosion-prone land, even as conservation programs attempted to mitigate these damages (Reichelderfer, 1985). High commodity prices of the mid-1970s probably spurred the conversion of highly erodible land from pasture or native grass to crop production—a process commonly referred to as sodbusting—although evidence linking this practice with farm commodity programs is limited (Watts et al., 1983; Heimlich, 1986). Likewise, evidence showing that government payments were an important incentive to swampbusting is quite limited (see Heimlich et al., 1998, for a survey), even though the purpose of most wetland drainage has, historically, been to allow or improve crop production (Dahl, 1990).

Even if government payments are not a critical underlying motivation for agricultural production on HEL or wetland, linking payments with compliance requirements can encourage improved environmental performance and deter producers from expanding crop production onto environmentally sensitive land. Withholding payments on the entire farm, rather than only on acres in violation of a compliance requirement, makes the potential sanction quite serious for many farms.

Compliance is a unique policy tool that is not easily placed in traditional categories of subsidy, tax, or regulation (Heimlich and Claassen, 1998a). Compliance mechanisms are similar in some ways to both environmental regulation and environmental taxes, but bear little resemblance to environmental subsidies. Like regulation, compliance mechanisms prescribe limits on producer actions and provide for penalties (loss of farm program benefits in the case of noncompliance). Like taxes and fees, however, violation does not imply illegal activity and maximum penalties are limited and known in advance. Unlike an environmental subsidy program (e.g., EQIP[1]), producers do not receive a benefit in exchange for taking an action that enhances (or is designed to enhance) environmental performance. Instead, they are penalized, through withholding of benefits from otherwise unrelated programs, when an environmental standard is not achieved. One could argue that programs with a compliance requirement actually seek a "bundle" of benefits including environmental protection. However, there is no evidence to suggest that commodity program design is influenced by the potential for environmental benefits through compliance. Thus, the economic properties of compliance mechanisms are quite different from those of a classic environmental subsidy program.

In general, compliance mechanisms are not subject to some of the problems that can arise with the use of environmental subsidies. For example, poorly designed subsidies for environmental improvement can encourage producers to continue or expand crop production where it would not otherwise be profitable, sometimes undercutting environmental gains (see Claassen et al., 2001, for a full discussion). Moreover, compliance mechanisms do not require subsidy payments *in addition* to those already in place through price and income support or other programs.[2] Note, however, that the effective level of income support provided to complying producers is reduced by the cost of complying with soil and wetland conservation requirements. These farm commodity programs provide much of the underlying incentive for producers to comply.

Compliance mechanisms may be particularly well suited to deter certain environmentally damaging actions. For example, a hypothetical subsidy program designed to prevent wetland drainage would require policymakers to pay for protection of all wetlands on agricultural land—a potentially expensive proposition—or decide which wetlands are sufficiently vulnerable to agricultural conversion as to warrant protection—a potentially difficult task (Heimlich and Claassen, 1998b). In contrast, Swampbuster penalties are assessed when a violation occurs, eliminating the need for broad-based subsidies or the need to anticipate the potential for a violation to occur on any given wetland. No direct costs are imposed on producers, although there may be an opportunity cost associated with production forgone on wetlands that would otherwise have been converted to crop production.

The success of compliance mechanisms depends on the commodity programs that provide most of the compliance incentive. Farm commodity programs have been in place for more than 65 years and their benefits have been largely capitalized into the value of farmland (Goodwin et al., 2003; Ryan et al., 2001; Barnard et al., 1997; Duffy et al., 1994).[3] For many producers, the ability to purchase land or pay cash rent depends significantly on government payments. In addition to introducing compliance mechanisms, the 1985 FSA shifted the emphasis of commodity programs from price support to income support. With a market price support program, farmers could benefit from farm programs without direct participation (sometimes referred to as "free riding"). With income support payments, producers must participate to receive benefits. Consequently, many producers may feel that they

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[1] Through EQIP, the Federal Government shares the cost of installing or adopting conservation practices that address key resource concerns.

[2] The Government does bear some cost for existing compliance programs. USDA provides conservation planning and technical assistance to producers without charge. Effective monitoring and enforcement by USDA can also be costly. These costs, however, are not specific to compliance mechanisms. They would generally be incurred with the implementation of other types of agri-environmental programs as well.

[3] A compliance requirement, to the extent it reduces a producer's net return to farm program participation, may also reduce capitalization.

have little choice but to accept compliance requirements, even though, strictly speaking, participation in these programs is voluntary and producers could opt out to avoid compliance requirements. The 1996 Federal Agriculture Improvement and Reform (FAIR) Act ended annual acreage set-aside programs, reducing the cost of program participation and increasing the compliance incentive.

Although working within the context of existing programs has some advantages over a subsidy mechanism, it also limits the potential effectiveness of compliance mechanisms. Unlike an environmental subsidy program or regulation, the design of compliance mechanisms is, by definition, constrained by the existence and design of other farm programs. In other words, the scope and features of other farm programs largely determine how effective a compliance mechanism can be. In designing a compliance mechanism, policymakers can determine:

- the environmental objective(s);
- minimum standards of environmental performance or practice implementation;
- the programs and payments that are subject to the compliance sanction.

But the effectiveness of compliance mechanisms will also depend on other factors related to commodity programs and the agri-environmental problems targeted by compliance. These include:

- whether targeted environmental problems occur largely on farms that participate in Federal farm programs subject to compliance;
- the producer’s net benefit from farm program participation before the compliance requirement;
- the producer’s cost of meeting the compliance standard or requirement.

In other words, the effectiveness of compliance mechanisms—relative to other agri-environmental policy tools—depends largely on the size and spatial distribution of government payments relative to the spatial distribution of targeted agri-environmental problems and the costs involved in mitigating those problems.

Given the configuration of current farm programs, compliance mechanisms have the potential to address many cropland-based conservation and environmental problems. Data from the Agricultural Resource Management Survey (ARMS) show that farms receiving some type of government payment accounted for 86 percent of U.S. cropland. Other environmental issues, such as livestock waste management and disposal problems, occur more frequently on farms that do not participate in current farm programs and, thus, are less likely candidates for compliance mechanisms.

Current Compliance Mechanisms

Current compliance mechanisms include Wetland Conservation provisions—commonly known as Swampbuster—and Highly Erodible Land (HEL) Conservation provisions, which include provisions commonly referred to as Conservation Compliance and Sodbuster. Conservation Compliance generally refers to requirements that apply to HEL that was cropped before enactment of the 1985 Food Security Act (FSA). Sodbuster refers to compliance requirements on HEL converted to crop production after 1985.

Compliance Objectives and Standards

The objectives of the **Highly Erodible Land Conservation** provision are to maintain soil productivity by maintaining soil depth and to reduce offsite damages due to sediment loads, e.g., to reduce sediment delivered to water bodies.

After the 1985 FSA, compliance implementation efforts focused on reducing erosion to the soil loss tolerance (“T”) level. Developed largely in the 1940s and 1950s, T values were designed to represent the maximum rate of soil erosion consistent with maintaining a given level of soil productivity indefinitely. Before Conservation Compliance plans were devised and implemented on farms, however, several factors prompted movement away from the T standard. First, there were unresolved questions about the scientific validity of the T value. By the 1970s, the scientific basis for T values was widely recognized as weak, yet efforts to adjust T values to reflect higher erosion loss tolerance in some soils were unsuccessful (Cook, 1982). Alternate methods of assessing the potential for erosion productivity damage had been developed (see Pierce et al.) but were not used by USDA in establishing compliance requirements. Second, it became apparent that reducing soil erosion to the T level would be costly on some soils. By 1987, USDA had determined that reducing erosion to T or even 2T might be so costly that crop production would no longer be profitable on a great deal of highly erodible land (Canning, 1994). Finally, policymakers increasingly recognized the offsite damage associated with sediment (which is unrelated to T). Offsite damages can be substantial and are often larger than onsite damages (see Ribaudo, 1989; Ribaudo et al., 1990; Feather et al., 1999).

Ultimately, Conservation Compliance was implemented to consider both soil erosion and the cost of erosion reduction, without a fixed erosion standard. Where erosion could be reduced to the T level without making crop production unprofitable, producers were required to develop “basic” conservation plans (which reduce erosion to T). Where reducing erosion to T was more costly, producers were allowed to develop “alternative” conservation systems. Alternative conservation systems require the application of soil conservation practices that are technically and economically feasible in a given local area and achieve “significant” erosion reduction. However, producers are not required to reduce erosion to T or any other specific level. Some alternative systems allowed erosion to remain at 2T or even higher levels.

This focus on local conditions and site-by-site development of conservation plans allowed conservation systems to be tailored to climate, soils, cropping patterns, and the producer’s management skills, leading to a broad array of approved conservation systems. USDA data show that more than 1,600 distinct conservation systems have been approved. Although 51 percent use only conservation cropping sequences, conservation tillage, crop residue use, or some combination of these three practices (table 1), this flexibility probably resulted in more erosion reduction per dollar of cost than could have been achieved using a more prescriptive approach that relied on a few standard practices.

The use of alternative conservation systems is limited to HEL that was cropped during 1981-85. On HEL not previously cropped—i.e., sodbusted land—producers must use conservation systems that hold erosion to T, regardless of cost. In 1996, USDA tightened standards for alternative conservation systems developed after July 3, 1996. First, alternative systems must reduce erosion by at least 75 percent of potential erosion[4] and planned erosion cannot exceed 2T (USDA-NRCS, 1996). An exception is made for land returning to crop production from the Conservation Reserve Program (CRP), where compliance requirements cannot exceed those in force when the land entered the CRP. Second, for HEL not cropped during 1981-85, conservation systems must hold soil erosion to no more than the soil loss tolerance level (T) *and* prevent a "substantial increase" in erosion, defined as 25 percent of potential erosion (USDA-NRCS, 1996).

Wetland Conservation provisions, widely known as Swampbuster, are designed to protect wetland functions and values by preserving existing wetlands.[5] Wetland values and functions include wildlife habitat, water purification, groundwater recharge, and mitigation of flood peaks.

To comply with Swampbuster, producers must refrain from altering wetlands to make agricultural production possible. In keeping with the focus on wetland functions and values, however, the 1996 Federal Agriculture Improvement and Reform (FAIR) Act allows some flexibility to alter some small areas of wetland if certain conditions are met. Producers are exempted from the sanction if:

- wetland conversion will have a minimal effect on overall wetland functions and values;

Table 1—Conservation management systems and practices applied on HEL cropland subject to compliance, 1997

Item	Percent of cultivated HEL
Conservation management systems	
Conservation cropping/crop residue use	27.5
Conservation cropping/conservation tillage	10.8
Conservation cropping only	7.8
Crop residue use only	4.9
Total	51.0
Conservation practices*	
Total with conservation cropping	81.1
Total with crop residue use	51.3
Total with conservation tillage	33.0

*Percentages sum to more than 100 because some conservation systems require the application of more than one practice.

Source: USDA, ERS, compiled from NRCS 1997 Status Review of Conservation Compliance data.

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[4] Potential erosion is defined as inherent erodibility as calculated by the Universal Soil Loss Equation and Wind Erosion Equation.

[5] See regulations implementing Swampbuster, 7 CFR 12, 61 FR 47019.

- the wetland conversion project is fully mitigated through creation or restoration of similar wetlands in the same general area;
- the action is permitted under the Clean Water Act *and* the Natural Resources Conservation Service (NRCS) determines that mitigation requirements are adequate; or
- a wetland is inadvertently altered without intent to violate the law and the wetland is restored within 1 year.

Programs and Payments Subject to Compliance

Producers who violate compliance requirements may be denied benefits from a wide range of Federal agricultural programs. Ongoing commodity and disaster programs make up the large majority of direct payments subject to compliance, accounting for 92 percent of these payments in fiscal year (FY) 2000, 90 percent in FY 2001, and 79 percent in FY 2002 (table 2). The 2002 Farm Security and Rural Investment (FSRI) Act will extend similar payments, in similar amounts, to a slightly broader group of producers (see box, “Farm Programs in the 2002 Farm Act: Will Compliance Be Affected?”). Conservation payments are also significant, including the Conservation Reserve Program (CRP), Wetland Reserve Program (WRP), Environmental Quality Incentives Program (EQIP), Emergency Conservation Program (ECP), and the Watershed Protection and Flood Prevention Program. Conservation program spending is authorized to expand by 80 percent over the life of the 2002 FSRI Act.[6] Federally subsidized crop insurance, which could be withheld under the original compliance provisions enacted in 1985, was removed from the list of programs

Table 2—Direct payments subject to Wetland and/or HEL conservation provisions

	FY1997 actual	FY1998 actual	FY1999 actual	FY2000 actual	FY2001 actual	FY2002 actual
			Million $			
Ongoing commodity programs						
Production Flexibility Contract	6,350	5,719	5,476	5,057	4,105	3,968
Loan Deficiency	0	0	3,360	6,419	5,293	5,345
Other direct payments*	0	0	277	1	1,159	182
Subtotal--Commodity programs	6,350	5,719	9,113	11,477	10,557	9,495
Disaster programs						
Market Loss Assistance	0	0	3,011	12,436	5,455	0
Noninsured Disaster	63	69	54	38	64	181
Disaster	48	15	2,264	1,452	3,146	254
Subtotal--Disaster	111	84	5,329	13,926	8,665	435
Conservation programs						
Conservation Reserve Program	1,774	1,798	1,462	1,513	1,655	1,785
Environmental Quality Incentives Program	200	200	170	170	163	313
Wetland Reserve Program	119	219	123	165	182	263
Emergency Conservation Program	25	29	28	50	80	0
Watershed Protection and Flood Prevention	90	106	194	176	102	200
Subtotal--Conservation	2,208	2,352	1,977	2,074	2,182	2,561
Total	8,669	8,155	16,419	27,477	21,404	12,491

* Includes cotton user marketing payments and other direct payments.

Source: ERS, based on data from the Office of Budget and Program Analysis, USDA, the Highly Erodible Land and Wetland Conservation final rule (7 CFR 12, 61 FR 47019), and communications with national program staff, Farm Service Agency, USDA.

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[6] For more details, see the ERS Farm Bill side-by-side comparison of 1996-2001 farm policy and the 2002 FSRI Act, http://www.ers.usda.gov/Features/FarmBill/Titles/TitleIIConservation.htm

Farm Programs in the 2002 Farm Bill: Will Compliance Be Affected?

Compliance requirements are continued in the 2002 Farm Security and Rural Investment (FSRI) Act with only minor, technical changes. Changes in commodity and conservation programs, however, may affect producers' incentives to participate in Federal farm programs and, therefore, meet compliance requirements.

Spending on commodity and conservation programs is projected to increase by 80 percent (compared with continuing current programs), according to Congressional Budget Office (CBO) estimates. However, much of the increase in commodity program spending will replace ad hoc "market loss assistance" payments provided to producers annually by Congress for the 1998-2001 seasons. Thus, a majority of new funds authorized directly in the FSRI Act will go to producers of traditional program crops: corn, wheat, cotton, rice, sorghum, oats, and barley. Ad hoc disaster assistance, which has been authorized by Congress frequently in recent years, may be distributed somewhat differently, but is likely to augment commodity program spending mandated by the 2002 FSRI Act.

A modest amount of new spending will be used to extend commodity program payments to crops not previously eligible for these subsidies. For the first time, producers of soybeans, other oilseeds, and peanuts will be eligible for direct payments. Soybean and other oilseed producers were already eligible for price support loans. Price support loans will also be extended to producers of peanuts, wool, mohair, honey, small chickpeas, lentils, and dry peas. Whether these program extensions will expand the reach of compliance depends on (1) the acreage devoted to these crops and (2) whether farms producing them are already subject to compliance through production of other program crops.

Analysis of Agricultural Resource Management Survey (ARMS) data in conjunction with the National Resources Inventory (NRI) indicates that peanuts, wool, mohair, honey, small chickpeas, lentils, and dry peas are produced by more than 35,000 farms that encompass more than 8 million acres of highly erodible cropland. Nearly all of these farms, however, already receive Federal farm program payments based on other crops. We estimate that fewer than 5,000 farms encompassing less than 500,000 highly erodible cropland acres could come under compliance requirements for the first time. Thus, program expansion can be expected to have little, if any, effect on the reach or overall effectiveness of conservation compliance (or other compliance mechanisms).

Conservation program spending is also projected to increase by 80 percent. Over the 6-year life of the 2002 FSRI Act, the CBO projects conservation spending of $20.9 billion. The largest increases are for "working land" conservation programs, i.e., programs that support good conservation practices on land in agricultural production. Key working land programs include the Environmental Quality Incentives Program (EQIP) and the newly formulated Conservation Security Program (CSP). Authorized funding was also increased for the Conservation Reserve Program (CRP), Wetland Reserve Program (WRP), and a range of other conservation and environmental programs. Because these programs are open to all producers—not just producers of certain crops—and can address a wide range of agri-environmental problems, the extent to which expansion of these programs could extend compliance requirements is unknown.

subject to compliance in the 1996 Act and is not currently subject to compliance requirements.

Eligibility for Federal agriculture-related loans or loan guarantees (e.g., price support loans and farm credit loans) can also be denied (table 3). Unlike direct payments, the actual benefit received by producers is less than that indicated by the program level. While the program level is the total amount available for direct loans or loan guarantees, most direct loans and loans covered by a guarantee are, in fact, repaid. Producer subsidies come in the form of lower interest rates than would otherwise be available. For example, direct government loans (e.g., price support loans) are often provided at rates lower than are commercially available. Other loan and loan guarantee programs provide credit or assistance in obtaining credit for farmers who cannot afford commercially available credit.

The effectiveness of compliance depends critically on the spatial distribution of payments relative to the environmental problems addressed through compliance mechanisms. Figure 1 shows the spatial distribution of key commodity program payments for the 1998 crop year: Production Flexibility Contract (PFC) payments, Market Loss Assistance (MLA) payments, and Loan Deficiency Payments (LDPs).[7] These payments are concentrated in the Corn Belt, the Plains States, and the Mississippi Delta—areas that account for roughly two-thirds of U.S. cropland. Although the total amount of these payments has varied from year to year, we assume that the spatial distribution of these payments does not change significantly from year to year because it depends largely on the spatial distribution of base acres.[8] Our assumption is consistent with the USDA baseline, which assumes ongoing funding for income support tied to base acreage. Ad hoc disaster payments, approved by Congress on an annual basis, could shift the distribution of overall payments if a significant share of ad hoc payments goes to farmers who are not clients of the traditional farm commodity programs. Recent history suggests, however, that these payments will augment, not replace, more traditional farm income support payments.

Table 3—Government loan programs subject to Wetland and/or HEL conservation provisions

	FY1999	FY2000	FY2001
		Million $	
Commodity loan programs			
Price support/Marketing asst. loans	8,358	9,669	8,567
Farm storage facility loans*	0	102	81
Total--Commodity loan programs	8,358	9,771	8,648
Farm credit loan programs			
Farm operating loans	2,565	2,465	2,153
Farm ownership loans	944	1,106	1,016
Emergency loans	330	151	90
Total--Farm credit loan programs	3,839	3,722	3,259
Total--Loan programs	12,197	13,493	11,907

*Not subject to Wetland Conservation provisions.

Source: ERS, based on data from the Office of Budget and Program Analysis, USDA, the Highly Erodible Land and Wetland Conservation final rule (7 CFR 12, 61 FR 47019), and communications with national program staff, Farm Service Agency, USDA.

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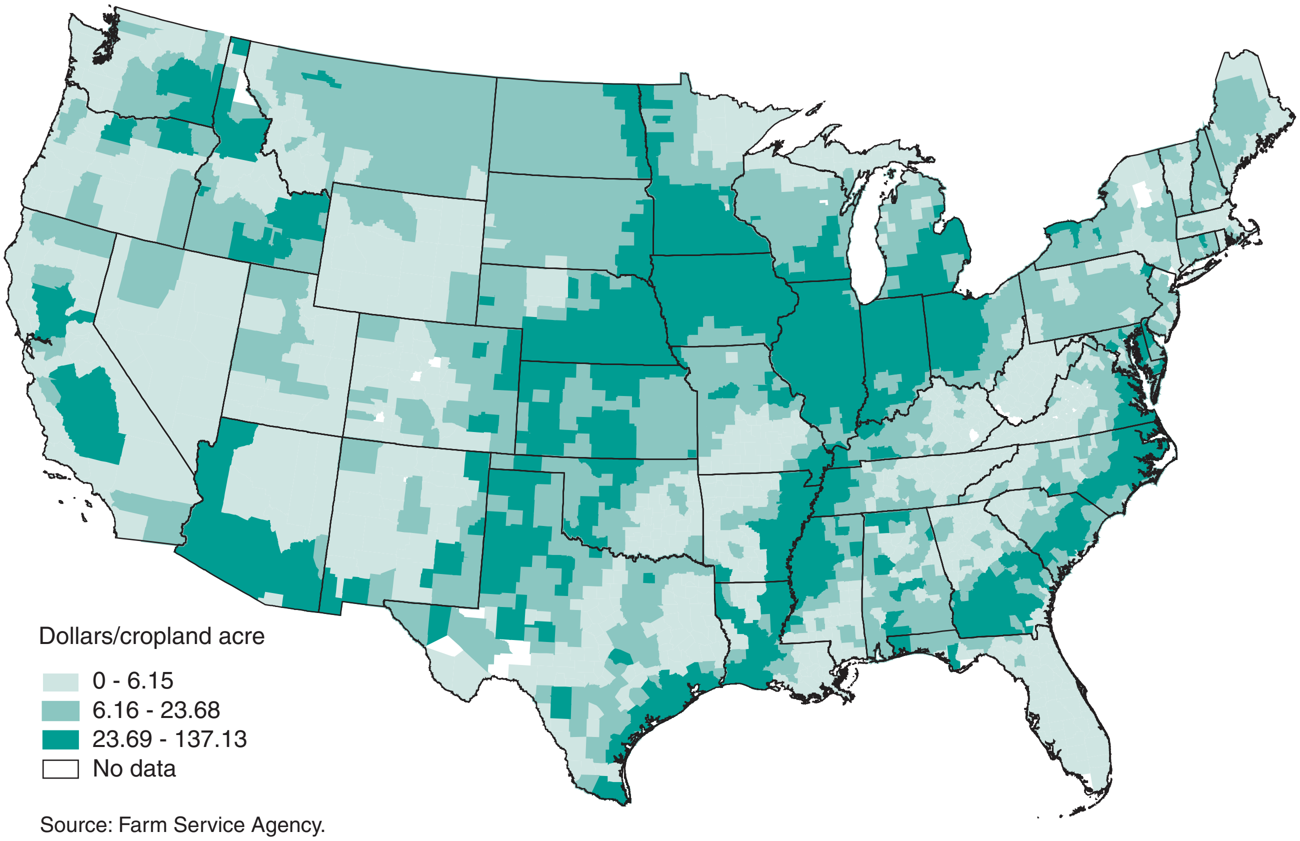
[7] Loan Deficiency Payments and Market Loss Assistance payments associated with the 1998 crop were made largely during FY 1999.

[8] Base acres are the land that is eligible for income support payments through Federal farm commodity programs. Base acreage is determined by historical plantings, and does not depend on current crop acreages.

Figure 1

Distribution of commodity program payments, 1998



Source: Farm Service Agency.

Analysis of Conservation Compliance

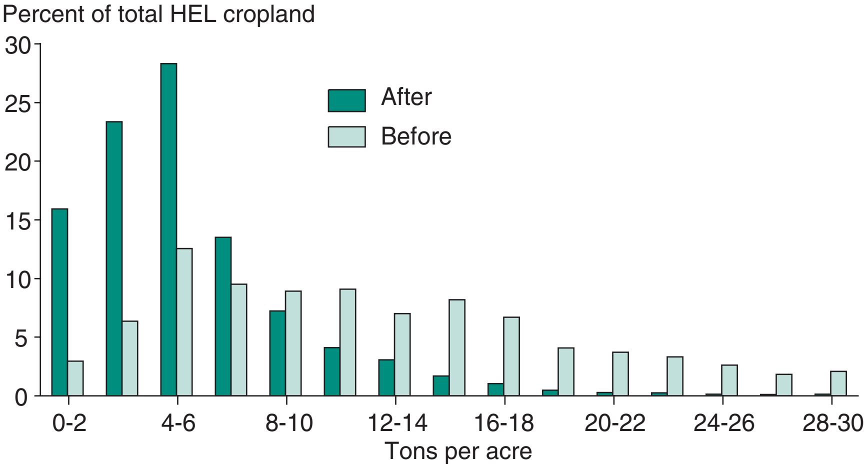
According to USDA's annual Conservation Compliance Status Review (CSR), overall compliance with Conservation Compliance provisions is high. Based on the 1997 CSR data (the year matching the most recent National Resources Inventory, which we use extensively in the analysis that follows), 95.9 percent of producers subject to compliance were actively applying approved conservation systems. In more recent years, the CSR has shown compliance rates of roughly 98 percent. The 1997 data also indicate that the distribution of HEL cropland by erosion rate has shifted dramatically to lower erosion rates (fig. 2). In other words, the rate of soil erosion has declined significantly on most HEL cropland acres subject to compliance.

A recent General Accounting Office (GAO) study, however, identifies deficiencies in the CSR that cast some doubt on NRCS compliance estimates (see box, "Enforcement: The Compliance Status Review"). GAO criticized the CSR on the selection of the review sample, a lack of consistency and clarity in the guidance provided to local offices, data handling and analysis, failure to cite producers for significant deficiencies, and inadequate justification for waiver of penalties.

We take an alternate approach, using existing datasets not created for the express purpose of evaluating compliance mechanisms in an attempt to determine the overall effectiveness of compliance in reducing erosion on HEL

Figure 2

Distribution of highly erodible cropland subject to compliance by soil erosion rate before and after Conservation Compliance, 1997



Source: ERS analysis of 1997 Compliance Status Review.

cropland. It is clear that erosion has been reduced on land subject to compliance—even if the magnitude of those reductions is somewhat in doubt. Even so, a broader look at soil erosion reduction provides context for evaluating the overall role of Conservation Compliance in achieving those reductions. Specifically, what is the extent of erosion reduction that can be directly attributed to Conservation Compliance? Has soil erosion been reduced more on land subject to compliance than on land not subject to compliance?

We analyze these questions using a two-step process. First, we analyze overall erosion reduction using data from the 1997 and previous National Resources Inventories (NRI). (See box, "Conservation Compliance and NRI Point Data"). The NRI contains data on HEL cropland and changes in annual erosion over time but, with the exception of the Conservation Reserve Program (CRP), do not specify whether a specific tract is enrolled in a government program. We use NRI data to estimate the amount of erosion reduction that *could be* directly attributed to compliance, *if* it occurred on land in a farm receiving payments subject to compliance. In other words, we believe that reduction in "excess" erosion (erosion exceeding T) on HEL that was cropped in both 1982 and 1997, *if* it occurred on a farm receiving payments subject to compliance, is the best estimate of erosion reduction that could be directly attributed to Conservation Compliance. We exclude erosion reduction below the T level on HEL cropland because it was not required by Conservation Compliance. We note, however, that the discrete nature of conservation practices may have resulted in the development of Conservation Compliance systems with erosion rates of less than T. Moreover, because compliance requirements were designed to allow HEL cropland to remain in crop production, we exclude erosion reduction due to land-use change. No erosion reduction would have been required on HEL cropland with a pre-compliance erosion rate equal to or less than T. Erosion reduction on non-HEL cropland is clearly not subject to compliance.

Enforcement: The Compliance Status Review

The Food Security Act Compliance Status Review (CSR) is USDA's primary mechanism for enforcement of Highly Erodible Land Conservation (HELC) and Wetland Conservation (WC) provisions. Each year, through the CSR, USDA field staff assess HEL and wetland compliance on a sample of tracts that are identified as part of farms receiving Federal farm program payments subject to HELC or WC provisions. Some tracts are selected at random from USDA’s Farm Service Agency (FSA) database while others are added by State FSA offices because of potential for noncompliance. For example, tracts on which temporary variances or waivers were previously granted must be checked to establish a return to full compliance.

In 2001, a total of 17,723 tracts were reviewed, including about 4.9 million acres (from NRI we estimate that there are about 330 million acres of cropland and 104 million acres of HEL cropland). Of the total tracts, 13,552 were identified through random sampling of the national database, while 4,171 were added by States. The CSR summary prepared by the Natural Resources Conservation Service (NRCS) shows 98 percent of reviewed tracts and 98.9 percent of reviewed acres in compliance with HELC requirements. Of that total, roughly 3 percent were in compliance, but were complying with a variance, condition, or exception. For example, variances can be granted for personal hardship or unusual weather-related factors that made it impossible to carry out the plan. Potential WC violations were found in 0.7 percent of tracts reviewed. These results are consistent with previous compliance reviews that showed HELC compliance of 97-98 percent.

A recent General Accounting Office (GAO) report, *Agricultural Conservation: USDA Needs to Better Ensure Protection of Highly Erodible Croplands and Wetlands*, identified a variety of deficiencies in the CSR that "make questionable USDA's claim that 98 percent of the Nation's cropland tracts subject to the conservation provisions are in compliance" (U.S. General Accounting Office, 2003). GAO criticized USDA's CSR on a variety of issues, including methods used to select the review sample, consistency and clarity of guidance provided to local offices, data handling and analysis, failure to cite producers for significant deficiencies, and inadequate justification for waiver of penalties.

For example, one issue raised by the GAO report is the inclusion in the CSR of many tracts that do not require a compliance plan. In the 2001 CSR, 33 percent of the tracts reviewed did not require conservation plans. Often, these tracts were permanent pasture or rangeland, yet these tracts are included as in compliance with HELC and WC provisions. If these tracts are removed from the CSR data, the overall compliance rate drops to 92.8 percent.

Deficiencies in the CSR identified by GAO do not necessarily imply that HELC provisions have been ineffective in reducing soil erosion on highly erodible cropland. Even if better enforcement could increase erosion reductions and associated environmental benefits, erosion reductions due to compliance may have been significant. The uncertainty suggests the importance of improved evaluation of conservation compliance.

Second, we combine NRI data with data on farms whose operators responded to the 1997 Agricultural Resource Management Survey (ARMS). Combining these data sets allows us to:

- gauge the proportion of HEL cropland located on farms that receive payments subject to compliance;
- estimate the distribution of payments over HEL cropland acres; and
- calculate the reduction in excess erosion (erosion exceeding T) on HEL that was cropped in both 1982 and 1997 on farms with and without government payments.

Reduction in excess erosion on HEL cropped in 1982 and 1997 that is located on farms with payments is our estimate of erosion reduction that *could be* directly attributed to compliance. Other factors, such as technical change, may have also played a role.

Erosion Reduction, 1982-1997

The 1985 FSA required development of Conservation Compliance plans by 1990 and full implementation by 1995. Between 1982 and 1997, annual cropland erosion declined by 1.174 billion tons per year, a reduction of

Compliance Requirements and NRI Point Data

The National Resources Inventory (NRI) is a sample of roughly 1.3 million points of land throughout the United States. For each point, NRI provides a wealth of data on land use and land condition. Typically, the NRI contains data for three points of land within each primary sampling unit (PSU), which is usually a 40-acre tract. Because the characteristics of land vary continuously, sampling at discrete points allows single-valued measures of land use, soil type, topography, etc. When appropriately weighted, the point data can be aggregated to produce estimates of land use, soil erosion, etc.

Compliance requirements, however, are determined on a field-by-field basis. To be subject to compliance, a field must be made up predominately of highly erodible soils. If a field is designated as highly erodible land (HEL), conservation requirements apply to the entire field, not just the highly erodible portion of the field. Field boundaries are carefully defined to make it difficult for producers to redefine fields to avoid compliance requirements.

Using point-based data from NRI to analyze a field-based program like Conservation Compliance may lead to some estimation errors. Some NRI points of HEL may fall in fields that are not predominately HEL and, therefore, not subject to compliance requirements. Any reduction in excess erosion at these points could be incorrectly included in our estimate of soil erosion reduction that could be attributed to Conservation Compliance. Likewise, NRI points of non-HEL land may be located in fields that are predominately HEL and, therefore, could be incorrectly excluded from our estimate of soil erosion that can be attributed to Conservation Compliance.

Because the spatial relationship between field boundaries and NRI points is unknown, it is impossible to accurately assess the level of error introduced by this difference in program implementation and data collection. The errors may, to some extent, offset one another because some points that should be included are excluded and vice versa.

Table 4—Erosion reduction on U.S. cropland between 1982 and 1997

	Cropland erosion, 1982			Cropland erosion, 1997			Change in erosion due to		
Cropland type	Water	Wind	Totals	Water	Wind	Totals	Water	Wind	Totals
				Million tons per year					
HEL									
Cropped in 1982 and 1997									
Excess erosion[1]	432.9	396.8	829.7	225.2	273.5	498.7	-207.7	-123.3	-331.0
Non-excess erosion	147.6	140.8	288.4	134.9	117.3	252.2	-12.7	-23.5	-36.2
Land-use change									
CRP[2]	114.8	175.2	290.0	0.0	0.0	0.0	-114.8	-175.2	-290.0
Non-CRP[3]	119.3	48.6	167.9	54.3	38.7	93.0	-65.0	-9.9	-74.9
Total, HEL	814.6	761.4	1,576.0	414.4	429.5	843.9	-400.2	-331.9	-732.1
Non-HEL									
Cropped in 1982 and 1997	737.1	540.8	1,277.9	611.8	386.7	998.5	-125.3	-154.1	-279.4
Land-use change									
CRP	62.1	47.8	109.9	0.0	0.0	0.0	-62.1	-47.8	-109.9
Non-CRP	74.7	22.0	96.7	29.5	14.2	43.7	-45.2	-7.8	-53.0
Total, non-HEL	873.9	610.6	1,484.5	641.3	400.9	1,042.2	-232.6	-209.7	-442.3
Total									
Cropped in 1982 and 1997	1,317.6	1,078.4	2,396.0	971.9	777.5	1,749.4	-345.7	-300.9	-646.6
Land-use change									
CRP	176.9	223.0	399.9	0.0	0.0	0.0	-176.9	-223.0	-399.9
Non-CRP	194.0	70.6	264.6	83.8	52.9	136.7	-110.2	-17.7	-127.9
Total, HEL and non-HEL	1,688.5	1,372.0	3,060.5	1,055.7	830.4	1,886.1	-632.8	-541.6	-1,174.4

[1] Excess erosion is equal to erosion less the soil loss tolerance or "T" value, or zero, whichever is larger.

[2] CRP erosion is minus 1982 erosion on land cropped in 1982 but in CRP in 1997.

[3] Non-CRP land-use change is 1997 erosion on land cropped in 1997 but not 1982, less 1982 erosion on land cropped in 1982 but not 1997.

Source: ERS analysis of NRI data

nearly 40 percent (table 4). Average annual wind and water erosion declined by 541.6 million tons and 632.8 million tons, respectively.

Erosion reductions that cannot be attributed directly to compliance account for erosion reductions of 843.4 million tons per year. These reductions in average annual erosion include 442.3 million tons on non-HEL cropland, 365 million tons due to land-use change (290 million tons due to CRP enrollment of HEL cropland, and 74.9 million tons due to a net movement of HEL land out of crop production[9]) and 36.2 million tons of "non-excess" erosion on HEL cropland (fig. 3).

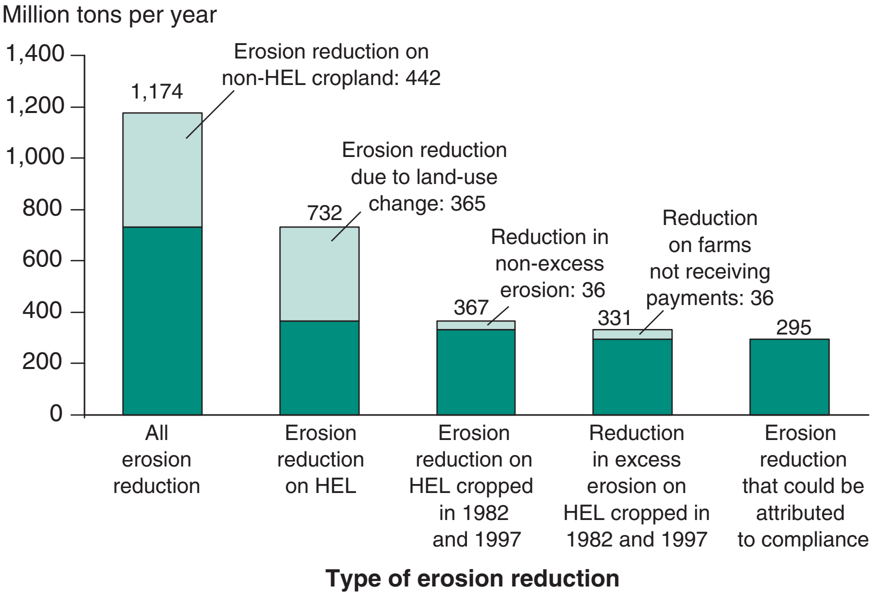
Reduction in excess erosion on HEL cropped in 1982 and 1997 was 331 million tons, 28.2 percent of all erosion reduction and 42.8 percent of all erosion reduction not associated with land retirement in CRP. More than 60 percent of this erosion reduction, 207.7 million tons per year, was excess erosion due to water while 123.3 million tons was excess erosion due to wind. The proportion of these reductions that occurred on farms receiving government payments—which we estimate in the following section—is our best estimate of erosion reduction that could be directly attributed to Conservation Compliance.

Some portion of other erosion reductions could be *indirectly* attributed to Conservation Compliance. Erosion reduction on some non-HEL cropland may be indirectly attributed to compliance if conservation systems were also adopted on non-HEL cropland within the complying farm. For example,

[9] While some HEL land was shifted into crop production, more was shifted out of crop production.

Figure 3

Erosion reduction and Conservation Compliance, 1982-97



Source: ERS analysis of 1997 NRI and 1997 ARMS data.

conservation tillage may have reduced costs for some producers, prompting its use on non-HEL cropland as well. Even though compliance requirements were designed to keep compliance costs low, some producers may have opted to convert land to grass or forest to avoid these costs. The extent to which these erosion reductions can be attributed to compliance is unknown.

There is also evidence to suggest Sodbuster sanctions may have deterred some producers from initiating crop production on HEL not previously cropped. Unlike Conservation Compliance, Sodbuster requires that producers apply basic conservation systems—which achieve the T standard—on previously uncropped land, regardless of cost. Claassen et al. (2000) show that, depending on the level of commodity price expectations, between 7 and 14 million HEL acres that were not cropped in 1992 are located near existing cropland and have inherent soil productivity high enough to make crop production profitable in the absence of Sodbuster.

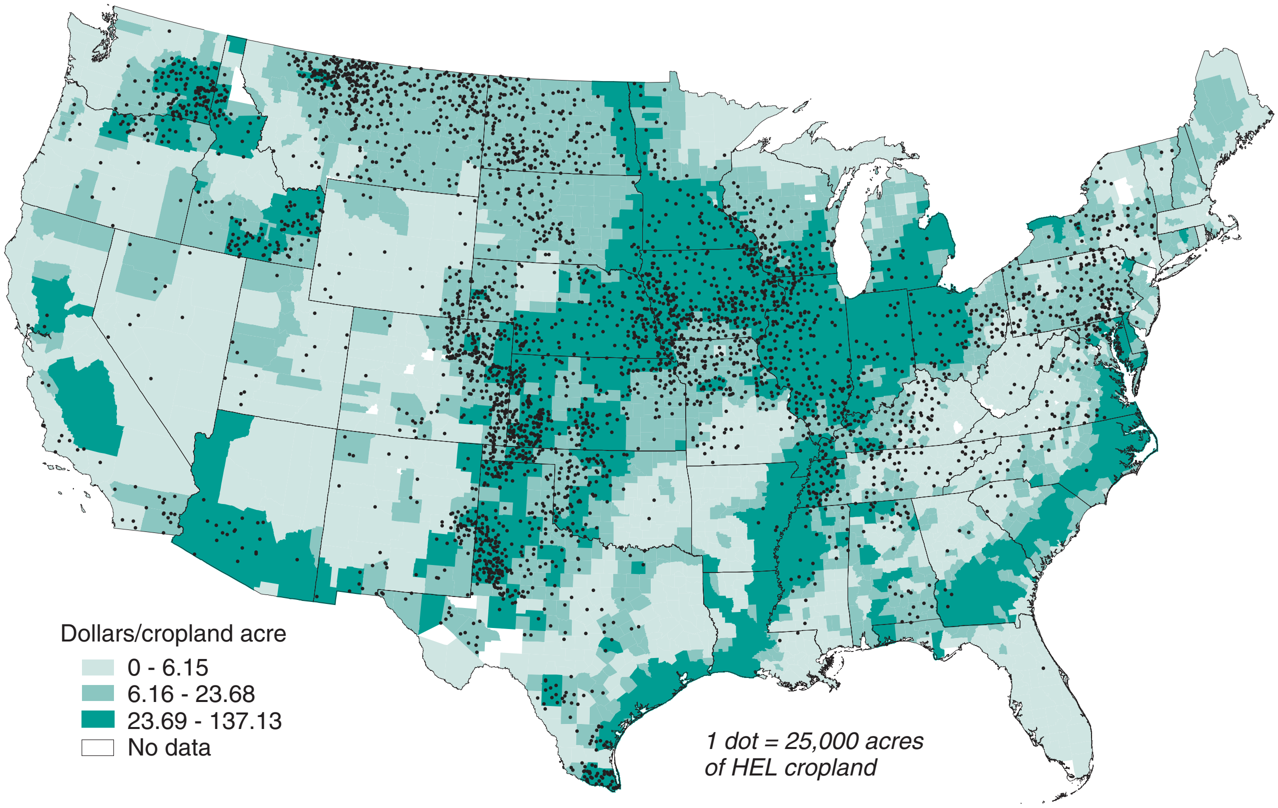
Erosion Reduction and Farm Program Participation

Soil erosion reduction that *could be* directly attributed to Conservation Compliance is the reduction in excess erosion on HEL that was cropped in both 1982 and 1997 (331 million tons) *and* is located on farms that receive government payments. A simple overlay of HEL cropland data with data on government payments suggests that most HEL cropland is located in areas with at least a moderate level of government payments (fig. 4). In this section, we go beyond the simple overlay to estimate the number of HEL acres on farms with and without government payments, as well as the reduction in excess erosion on farms with and without payments.

To provide an estimate of the overlap between farms receiving government payments and HEL cropland, we combined environmental and resource data

Figure 4

Distribution of commodity program payments and highly erodible cropland, 1998



Source: Farm Service Agency and NRI.

from the NRI with production and financial data (including data on government payments received) from ARMS (see Appendix 1). This analysis defines government payments as farm commodity program payments, disaster payments, and conservation payments from the CRP, WRP, and EQIP. These payments account for roughly 98 percent of direct payments potentially subject to compliance mechanisms. We use 1997 payments to match available environmental data from the 1997 NRI. Although total payments subject to compliance have been much higher in years since 1997, their spatial distribution has remained relatively constant over these years.

We estimate that more than 83 percent of HEL cropland is located on farms that receive farm commodity program, disaster, or conservation payments (fig. 5). Of cropland that is highly erodible due to wind, 92 percent is located on farms receiving payments, while about 75 percent of cropland that is highly erodible due to water is located on farms receiving payments. Results vary across regions[10] (fig. 6) and farm types (fig. 7). HEL cropland on farms not receiving payments is estimated to account for more than 50 percent of HEL acreage in only two regions—the Eastern Uplands and Southern Seaboard—regions with a high proportion of livestock-oriented farms. In other regions, 65-95 percent of HEL cropland is estimated to be located on farms that receive payments.

While the large majority of HEL cropland is located on farms receiving payments, payments are not distributed evenly across HEL acres. A large share of

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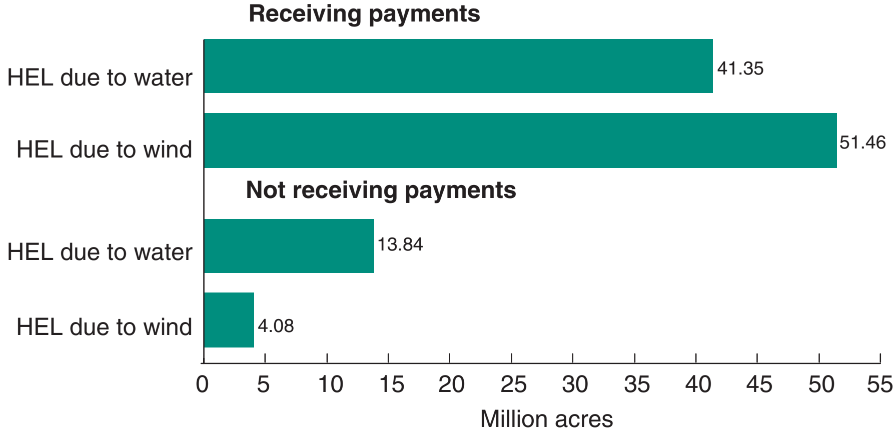
[10] For ERS Farm Resource Regions, see figure 8.

Figure 5

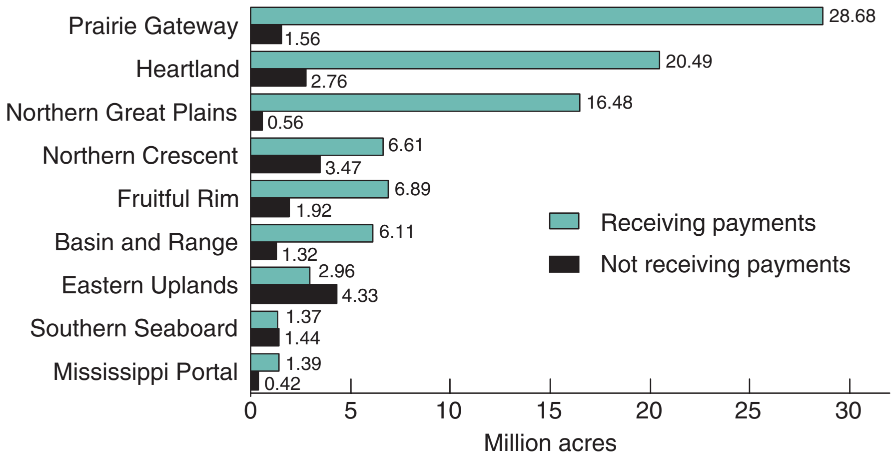
Highly erodible cropland acreage subject to Conservation Compliance on farms receiving and not receiving farm program payments, 1997



Source: ERS analysis of 1997 NRI and 1997 ARMS data.

Figure 6

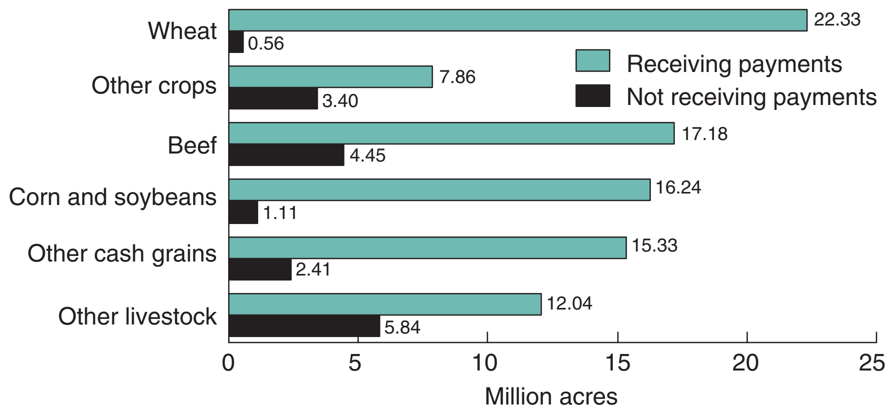
Highly erodible cropland on farms receiving and not receiving payments, by ERS Farm Resource Region, 1997



Source: ERS analysis of 1997 NRI and 1997 ARMS data.

Figure 7

Highly erodible cropland acres on farms receiving and not receiving payments, by commodity specialization, 1997



Source: ERS analysis of 1997 NRI and 1997 ARMS data.

payments go to farms that have little or no HEL cropland, while many farms with large acreage of HEL cropland receive relatively modest government payments. We estimate that roughly 28 percent of HEL cropland is located on farms that received total government payments of less than $15 per HEL acre in 1997, and nearly 50 percent is on farms that received less than $30 per HEL acre (fig. 9). Note, once again, that payments have been higher in more recent years (table 2). Low violation rates imply that most producers who received only modest payments are fulfilling Compliance requirements. If true, the net benefit of program participation to these producers exceeds the cost of compliance, whatever the level of payments per HEL acre.

We estimate that reduction in excess wind and water erosion on land cropped in both 1982 and 1997 has been larger on farms receiving payments than on farms not receiving payments (fig. 10). For wind erosion, the difference is large. Excess wind erosion declined by 30.7 percent on farms receiving payments while declining only 14.2 percent on farms not receiving payments. For water erosion, the difference is somewhat smaller. Excess water erosion dropped by 46.7 percent on HEL cropland on farms receiving payments while the decrease was 40.5 percent on farms not receiving payments. Overall, an erosion reduction of 294.6 million tons per year could be directly attributed to Conservation Compliance—about 89 percent of the 331 million tons of excess erosion reduction on HEL cropland cropped in 1982 and 1997 and 25 percent of all erosion reduction (fig. 3).

In summary, cropland erosion reduction between 1982 and 1997 was widespread. Erosion was reduced on land that is clearly not subject to compliance (e.g., non-HEL cropland) as well as land that probably is. About 89 percent of the reduction in excess erosion on HEL cropped in both 1982 and 1997—land subject to compliance—occurred on farms receiving payments, which accounted for roughly 83 percent of all HEL cropland. The difference was much greater for wind-erodible soils than for water-erodible soils. Substantial water quality, air quality, and soil productivity benefits are likely to have resulted from these erosion reductions (Canning, 1994; Hyberg, 1997).

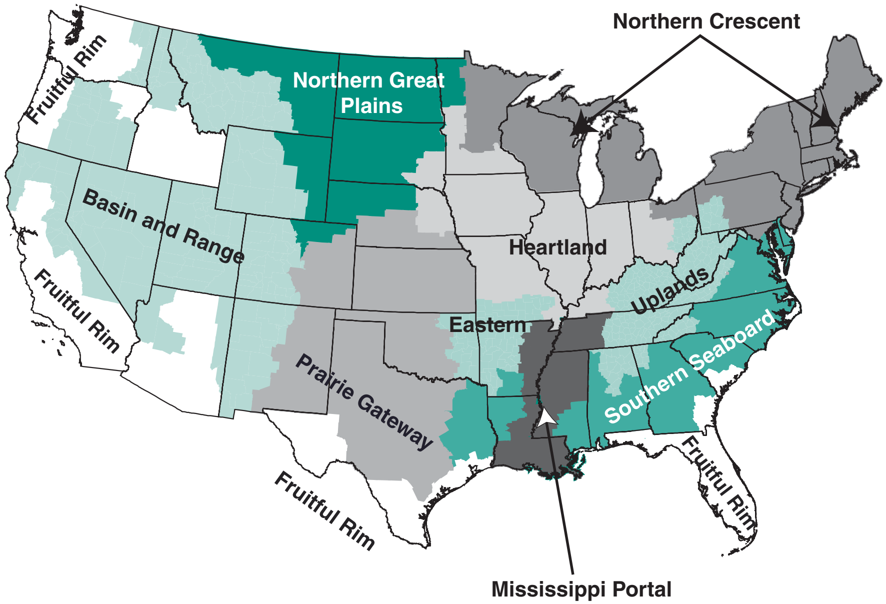
Compliance Costs

The above analysis suggests that many producers are in compliance even though program benefits per acre of HEL cropland are modest for some farms. This result is not surprising, because a flexible standard helped to keep costs low. The result also suggests that practices that are widely used in compliance systems are inexpensive. More than half of all conservation systems are some combination of conservation tillage, conservation cropping, and seasonal crop residue management.

Conservation tillage systems leave at least 30 percent of the soil surface covered with crop residue at planting time. While conservation tillage systems have the potential to reduce production costs, the evidence is mixed—labor, fuel, and capital costs may decline while herbicide or fertilizer costs may increase in many situations (Sandretto, 1997). Climate and soil conditions also play a role. Soils that are not tilled or tilled less may warm up and dry out more slowly than with conventional tillage. McBride (1999) notes that per-bushel cost advantages to conservation tillage in corn may be greatest in the

Figure 8

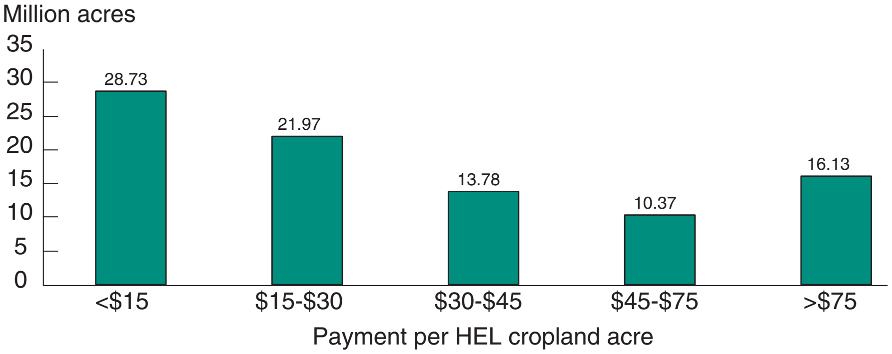
ERS Farm Resource Regions



Source: ERS.

Figure 9

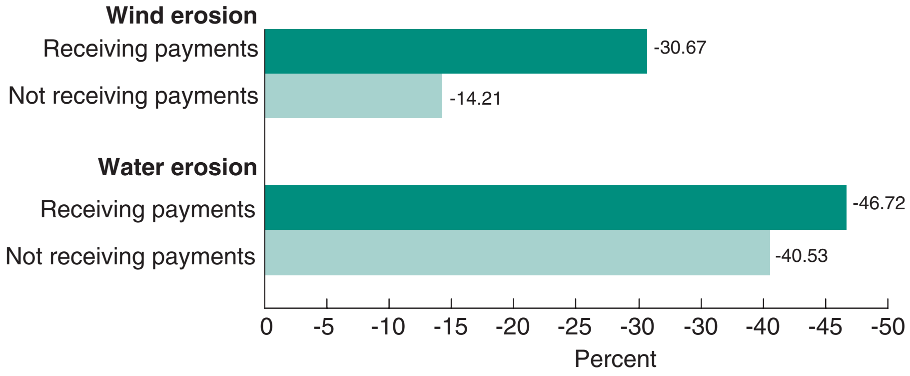
Highly erodible cropland acreage by payment per acre, 1997



Source: ERS analysis of 1997 NRI and 1997 ARMS data.

Figure 10

Percent change in excess erosion on highly erodible cropland on farms receiving and not receiving payments, 1982-97



Source: ERS analysis of 1997 NRI and 1997 ARMS data.

Plains States where reduced tillage can conserve moisture and help boost yields. Wet, cold conditions can lead to emergence problems and slow early-season plant growth, which can reduce yields (Griffith et al., 1988). *Seasonal crop residue management* differs from conservation tillage in that the seedbed is clean-tilled, but the previous year's crop residue is allowed to remain on the surface longer to protect the soil. Tillage costs are not reduced, but the period available for tillage is decreased, increasing the potential for delayed planting due to weather. *Conservation cropping* may include production of less profitable crops or the cost of establishing cover crops for a portion of the season.

One source of national data on the potential cost of conservation practices is the Environmental Quality Incentives Program (EQIP) database. EQIP payments do not directly represent estimates of cost. Payments indicate what some producers were *willing to accept* to implement land management conservation practices. Since EQIP is a voluntary program, we assume that payments cover at least the producer's cost, less any potential benefit that the producer can capture (e.g., lower fertilizer costs under nutrient management). For structural practices, such as filter strips, the payment is a cost-share (up to 75 percent in EQIP). For land management practices typical in Conservation Compliance systems, the EQIP payment could exceed producer costs. Incentive payments are provided for up to 3 years to smooth the transition to new production practices.

Nationally, the average incentive payment for producers adopting conservation cropping is $6.82 per acre annually for 3 years, and 95 percent of enrolled producers received $10.00 *or less* per acre annually for 3 years. Because incentive payments last only 3 years, we assume that the net present value of the payments covers the cost of practice adoption. Using a 4-percent rate of discount, the net present value (NPV) of 3 years worth of the average conservation cropping payment would be $18.92, while 95 percent of producers would receive payments with a NPV of less than $27.75 (table 5). For conservation tillage (not including no-till), the average incentive is $20.36 per acre (NPV over 3 years), while 95 percent of producers received $33.40 or less. EQIP participants adopting crop residue use techniques received $14.58 on average, and 95 percent received $27.75 or less.

Average payments for specific conservation practices vary regionally (table 6). The average NPV of EQIP incentive payments for conservation cropping ranges from $10.36 in the Prairie Gateway to $26.74 in the Southern Seaboard. For conservation tillage, the average incentive payment varies from $18.89 to $31.77, with the lowest payments in the Prairie Gateway (where moisture conservation is an issue, so that the private benefits of adopting conservation tillage may be highest) and the highest payments in the Eastern Uplands. Finally, for crop residue use, average NPV of EQIP payments range from $8.53 to $20.48.

The net present value of government payments that leverage Conservation Compliance is generally larger than these payments for conservation practice adoption. Among farm program participants with HEL cropland, two-thirds of HEL acres were on farms that received $15 *or more* in overall government payments per HEL acre in 1997 (fig. 9). The current farm bill extends payments for 6 years. Discounted at 4 percent, the NPV of a $15-

per-acre annual payment, made over a 6-year period, would be $78.75. Moreover, producers may expect that income support payments will be extended indefinitely. The NPV of a $15-per-acre annual payment over 20 years would be $204—more than enough to leverage the adoption of one or more conservation practices.

As expected, the cost of complying (as measured by willingness to accept EQIP payments) is generally lower than the benefits of farm program participation (the value of program payments). Actual costs are unlikely to be higher than producer willingness to accept but can be lower. These findings are consistent with a high rate of compliance. Low costs may also help explain the fact that, for the period analyzed, erosion reduction was widespread, occurring on land that is not subject to compliance, as well as land that is.

Analysis of Swampbuster

Unlike highly erodible land conservation, wetland conservation provisions interact significantly with both Federal and State regulatory requirements and apply largely to land that is not currently in crop production. We focus our analysis on the potential for wetland conversion without Swampbuster sanctions and on the implication of changing Federal wetland regulations.

Roughly 92 million acres of wetland are potentially subject to Swampbuster (Claassen et al., 1998). Between 1986 and 1997, a total of 26,597 acres of wetland were drained in violation of Swampbuster by 1,136 producers

Table 5—Average and 95th percentile EQIP incentive payments for selected conservation practices

Conservation practice	Average annual	95th percentile	3-year NPV of average annual	3-year NPV of 95th percentile	Number of contracts
	Dollars per acre				
Conservation cropping	6.82	10.00	18.92	27.75	3,386
No tillage	11.90	20.00	33.02	55.50	7,664
Conservation tillage*	7.34	12.04	20.36	33.40	3,523
Crop residue use	5.25	10.00	14.58	27.75	4,309

*Practice 329b, "Mulch Till" in the NRCS Field Office Technical Guide.

Source: ERS analysis of EQIP database (NRCS).

Table 6—Average EQIP incentive payments for selected conservation practices, by region

	Average annual payment			Net present value over 3 years		
ERS Farm Resource Region	Conservation cropping	Conservation tillage*	Residue mgmt. (seasonal)	Conservation cropping	Conservation tillage*	Residue mgmt. (seasonal)
	Dollars per acre					
Heartland	6.44	9.10	7.09	17.86	25.26	18.60
Northern Crescent	6.94	9.26	7.33	19.25	25.68	19.24
Northern Great Plains	5.13	10.88	4.98	14.23	30.18	13.08
Prairie Gateway	3.73	6.81	4.29	10.36	18.89	11.26
Eastern Uplands	8.84	11.45	7.56	24.53	31.77	19.85
Southern Seaboard	9.64	6.94	7.44	26.74	19.25	19.52
Fruitful Rim	7.16	8.32	7.80	19.87	23.10	20.48
Basin and Range	8.20	7.23	3.25	22.74	20.07	8.53
Mississippi Portal	5.35	10.28	4.91	14.86	28.54	12.87

*Practice 329b, "Mulch Till" in the NRCS Field Office Technical Guide.

Source: ERS analysis of EQIP database (NRCS).

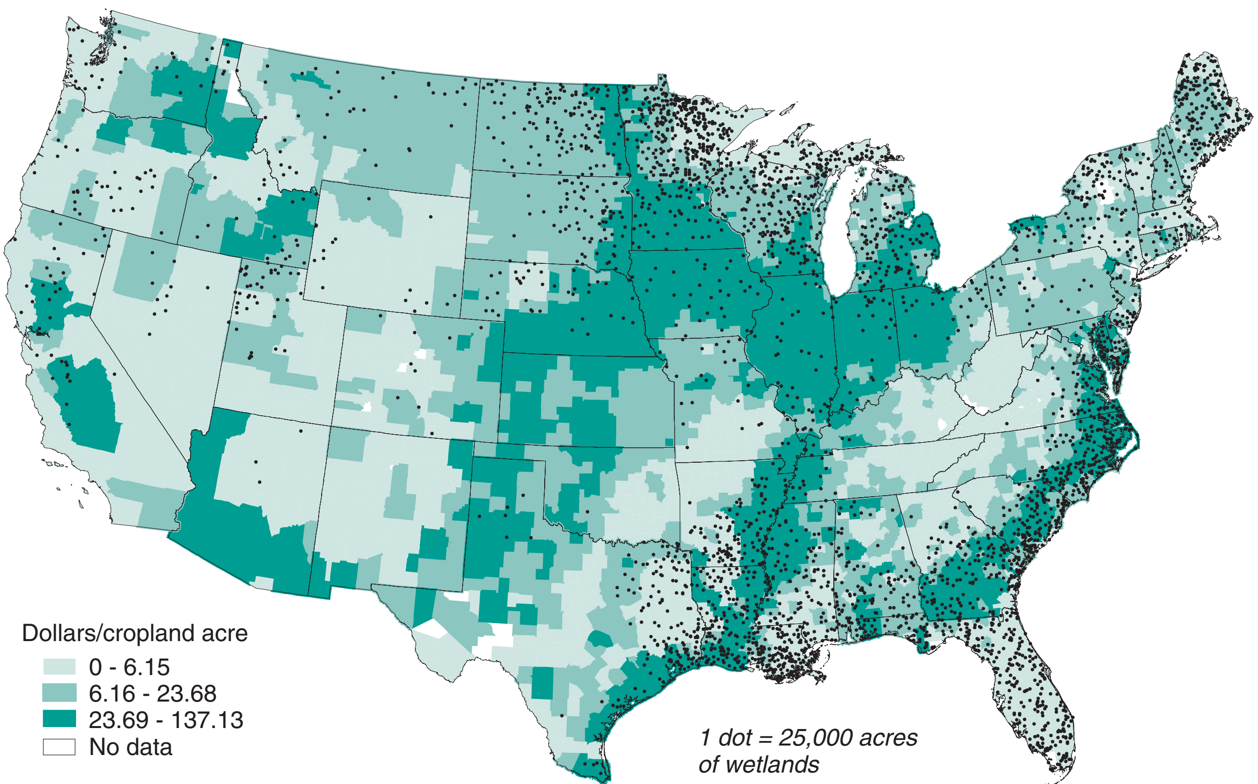
resulting in the loss of $12.3 million in Federal farm program benefits (Claassen et al., 2000). In recent decades, wetland conversion for agricultural production has decreased steadily, a trend older than Swampbuster (1985) or the Tax Reform Act of 1986. Conversion of wetland for crop production averaged 593,000 acres per year in 1954-74 (Frayer et al., 1983), dropping to 235,000 acres for 1974-84 (Dahl and Johnson, 1991), 31,000 acres per year between 1982 and 1992, and 26,000 acres per year between 1992 and 1997 (USDA-NRCS, 2002a).

Evidence on the role of policy change in reducing wetland conversion for agriculture is mixed (see Heimlich et al.,1998, for a full survey). Swampbuster penalties will constrain wetland conversion only when: (1) wetlands are located on farms that participate in Federal programs subject to Swampbuster; (2) those wetlands could be profitably converted to crop production in the absence of Swampbuster; and (3) other policies (e.g., Section 404 of the Clean Water Act) are not applicable or not effective in deterring wetland conversion.

First, Swampbuster will constrain wetland conversion only if wetlands are located on farms that receive government payments. The spatial distribution of government payments and wetland acreage subject to Swampbuster, shown in figure 11, suggests that many wetlands are located in areas that receive only modest payments per cropland acre. Many of these wetlands, however, are located in remote areas and are unlikely to be converted to cropland because they cannot be easily incorporated into an existing farm-

Figure 11

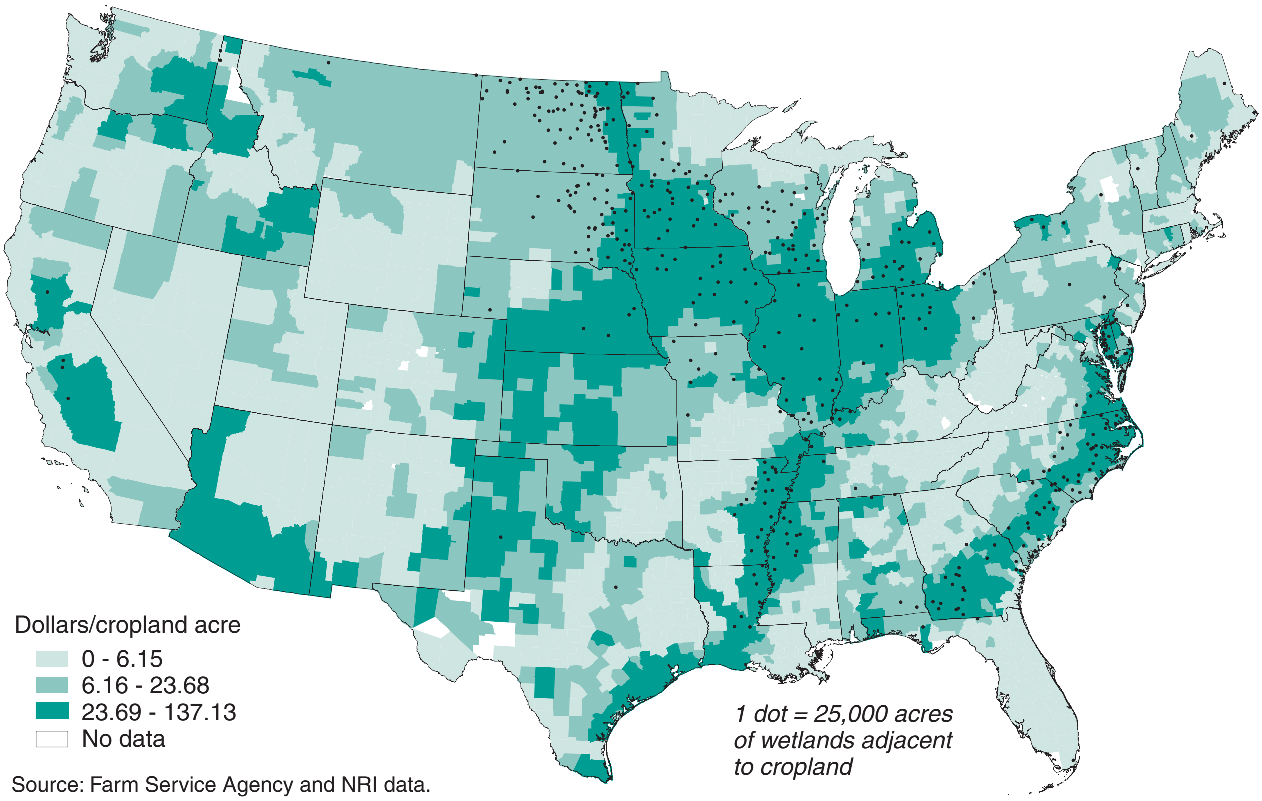
Distribution of commodity program payments and wetlands, 1998



Source: Farm Service Agency and NRI data.

Figure 12

Distribution of commodity program payments and wetlands adjacent to existing cropland, 1998



Source: Farm Service Agency and NRI data.

ing operation. We estimate that only 12.9 million wetland acres are directly adjacent to existing cropland[11] (fig. 12). As might be expected, these wetlands are much more likely to be located in areas that receive larger government payments, increasing the likelihood that these wetlands are, in fact, located on or near farms that receive government payments.

Of course, the fact that wetlands are adjacent to cropland does not imply that they can be *profitably* converted to crop production. Some researchers have questioned whether wetland conversion for crop production is profitable even without Swampbuster (Tolman, 1997; Kramer and Shabman, 1993). Profitability depends on a variety of factors, including crop prices and production costs, soil productivity, and the feasibility and cost of land clearing and drainage. Roughly half of all wetlands in the conterminous United States in 1780 have already been drained (Dahl, 1990), and remaining wetlands may be more difficult or expensive to convert or may be less productive once converted.

Using more detailed data on the potential productivity of wetland soils, other research suggests that there are wetlands that could be profitably converted to crops in the absence of policy constraints. Assuming that only those wetlands that are adjacent to cropland are vulnerable to conversion, Claassen et al. (2000) estimate that between 1.5 and 3.3 million acres of wetlands have sufficiently high productivity to be converted to crop production, depending on producer price expectations. Also, profitability of crop

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[11] We used the *habitat composition* variables in the NRI data to determine whether a wetland point is near cropland. We considered NRI points classified as wetland to be “adjacent” to cropland if some cropland occurred along any one of four 500 foot-long transects that extend NW, NE, SE, and SW from the NRI point, as indicated by the *habitat composition* variables.

production on the converted land is not the only consideration in the decision to drain wetland. Wetlands are sometimes drained to increase the efficiency of field operations on existing cropland by eliminating wetland areas that producers must farm around. Roughly 5 million acres of wetland are dry enough in some years for crop production. Although producers may continue to farm these wetlands in their current condition without violating Swampbuster, these wetlands may be particularly vulnerable to additional drainage that would improve production and make field operation more efficient.

Even if wetland conversion potential is, in fact, quite modest, these conversions could significantly undercut wetland restoration efforts. By the end of fiscal year 2002, about 1.275 million acres had been restored through the Wetlands Reserve Program (USDA-NRCS, 2002b). Another 1.6 million wetland acres have been restored through the Conservation Reserve Program (USDA-FSA, 2003). Thus, the total USDA wetland restoration effort since 1990 is less than 3 million acres.

Finally, other laws and regulations that can stop or discourage wetland drainage include Section 404 of the Clean Water Act (CWA) and numerous State and local laws. However, these laws and regulations do not completely protect all wetlands. Section 404 is limited in geographic scope following a recent Supreme Court decision that excludes many isolated wetlands from CWA regulation. In *Solid Waste Agency of Northern Cook County (SWANCC) v. United States Army Corps of Engineers (USACE)*, the Court ruled that USACE could no longer claim jurisdiction over isolated, non-navigable, intrastate ponds on grounds that they are used by economically important species of birds migrating across State lines (National Wetlands Newsletter, 2001). Known as the migratory bird rule, this rationale has often been used to assert CWA jurisdiction over isolated wetlands. The exact extent of wetlands thus excluded from CWA regulation is yet to be determined and will probably be decided by the courts. A patchwork of State and local regulations continues, but provides little or no wetland protection in many States (Kusler, 2001). State wetland regulations exist in the Northeast, States surrounding the Great Lakes, Atlantic Coast States in the South, and along the West Coast (Petrie et al., 2001). Many heavily agricultural Midwestern and Plains States have little, if any, State wetland regulation. In these areas, Swampbuster is the only remaining policy disincentive to draining isolated wetlands.

Potential for Extending Compliance: Nutrient Management in Crop Production

At present, compliance mechanisms are used only to encourage soil and wetland conservation, although agricultural production can result in a wider range of environmental damages (Claassen et al., 2001). In this section, we look at the potential for extending compliance to a third agri-environmental issue: reducing nutrient runoff and leaching from land in crop production.

Runoff and leaching from fertilizer application and animal manure are major sources of remaining U.S. water quality problems (USEPA and USDA, 1998). Nitrogen leaching into groundwater used for drinking can be a health hazard to infants and may pose a cancer risk for adults. Excess nutrients in surface water can lead to eutrophication, reducing the quality of water for recreation and habitat. Eutrophication results from excess algae growth which leads to high concentrations of bacteria (to break down dead algae), which, in turn, leads to accumulation of bacterial waste and oxygen depletion. Water becomes murky and develops an odor. In severe cases, aquatic plants and fish are damaged by the lack of sunlight and oxygen.

Nitrate nitrogen is highly soluble and is transported in both ground and surface water. In surface waters, nitrogen can be transported long distances, polluting estuaries throughout the Nation (Bricker et al., 1999). Nitrogen flowing into the Gulf of Mexico, largely from the Mississippi River, is the suspected cause of a large zone of oxygen-depleted (hypoxic) waters (Goolsby, 1999), creating a “dead zone” largely devoid of marine life. Phosphorus is far less soluble and is most often transported to water along with sediment (USGS, 1999). Excess phosphorus runoff from agriculture may have contributed to outbreaks of waterborne pathogens, including *pfiesteria piscicida* (Mlot, 1997).

To determine the potential of a compliance mechanism to mitigate runoff and leaching of agricultural nutrients, we consider three key questions:

- To what extent is nutrient application—either commercial fertilizer or manure—to land in crop production a source of nutrient runoff or leaching?
- To what extent do crop producers who have the greatest potential for reducing nutrient runoff and leaching also participate in farm programs?
- Are government payments large enough to encourage broad adoption of practices that could reduce nutrient runoff and leaching?

Nutrient Loss and Crop Producers

While a comprehensive solution to agricultural nutrient runoff and leaching must involve crop and livestock producers, compliance incentives are largest for farms with a significant area of land in program crop production. Crop producers—regardless of whether they are also livestock producers—will play a central role in managing nutrients and reducing nutrient runoff from agriculture. Available evidence suggests that the application of commercial fertilizer has, in the past, accounted for a significant share of agricultural nutrient runoff and leaching. Thus, crop producers can play a significant role in reducing nutrient runoff and leaching, independent of livestock producers. Moreover, as livestock production becomes increasingly concentrated on large, specialized farms, an increasing proportion of livestock is raised on farms with too little land to spread nutrients at agronomically sound rates (Kellogg et al., 2000), indicating that management of livestock waste will necessarily involve crop producers who do not raise livestock (Ribaudo et al., 2003).

In the past, commercial fertilizer has accounted for roughly 90 percent of nitrogen applied in agricultural production. Just over 12 million tons of nitrogen fertilizer was applied in 1997 (Daberkow et al., 2000). Only 1.2 million tons of nitrogen is recoverable from manure nutrients produced on U.S. farms with confined livestock (Gollehon et al., 2001), although not all of these manure nutrients are actually used in crop production.[12] Evidence also suggests that fertilizers are routinely applied in amounts that exceed crop needs. Roughly 70 percent of corn acres and 60 percent of winter wheat and cotton acres had high[13] excess nitrogen balances in 1995, while high excess phosphorus balances were estimated to exist on roughly 40 percent of corn, cotton, and wheat acres (Daberkow et al., 2000). Nutrients applied in excess of or well in advance of crop needs are particularly vulnerable to runoff and leaching.

U.S. Geological Survey (USGS) estimates also indicate that, in the past, commercial fertilizer has accounted for a significant share of nitrogen runoff to surface water. Fertilizer application accounts, on average, for more than 48 percent of all nitrogen loads to surface water in areas where nitrogen runoff per unit of land area is high (greater than 1,000 kg/km^2 annually) and more than 20 percent, on average, where runoff is low (less than 500 kg/km^2 annually) (Smith et al., 1997). Livestock waste production is estimated to account for 15 and 12 percent of nitrogen reaching surface water in high- and low-runoff areas, respectively. Where nitrogen loads are low, runoff from nonagricultural land is a relatively important source of nitrogen loading (Smith et al., 1997).

Phosphorus runoff to surface water is much more likely to be the result of livestock waste or nonagricultural, nonpoint sources. In areas where USGS researchers estimate that phosphorus surface-water concentrations exceed the Environmental Protection Agency (EPA) suggested water quality goal of 0.1 mg/L, fertilizer is estimated to account, on average, for 21 percent of phosphorus loading while livestock waste and nonagricultural land are estimated to account for 38 and 33 percent, respectively (Smith et al., 1997). As noted above, however, many cropland acres carry excess phosphorus balances. Thus, non-waste phosphorus management on cropland may still be important to reducing phosphorus damage to surface water, particularly in areas where livestock production is less prevalent and commercial phosphorus fertilizer is applied.

Nutrient Runoff and Farm Program Participation

While nutrient application in crop production contributes significantly to the runoff and leaching of nutrients to water, the potential for nutrient loss may vary across producers. If so, to what extent do producers who have significant potential for nutrient loss also participate in farm programs? To gauge

[12] While almost all manure is eventually disposed of through landspreading, it is not clear that all recoverable manure nutrients are applied to agricultural land as fertilizer. Increasing concentration in livestock production has resulted in concentrations of animal waste that often exceed the nutrient needs of crops grown on the farm. Manure may be stockpiled for extended periods, in which case much of the recoverable nutrient is lost to the environment. In some cases, transportation costs preclude full utilization of livestock manure as fertilizer (Gollehon et al., 2001; Ribaudo et al., 2003).

[13] A “high” excess nutrient balance is defined as available nutrients exceeding crop nutrient use by 25 percent or more.

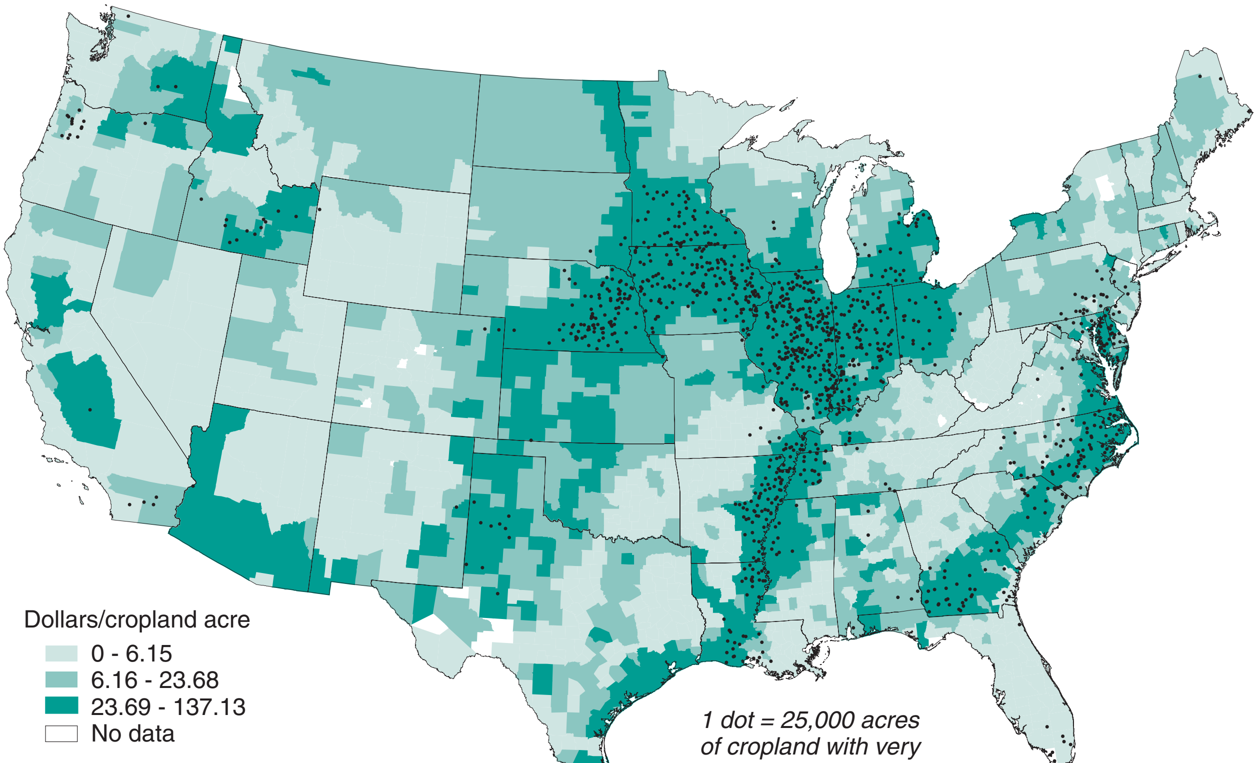
runoff potential, we use indices for potential nitrogen runoff, phosphorus runoff, and nitrogen leaching to groundwater developed by Lemunyon and Gilbert (1993), Sharpley et al., (1994) and Gburek et al. (2000). The indices are calculated for each NRI data point using NRI and other data and account for soil factors, climate, and production management decisions that affect runoff and leaching (see Appendix 2).

Using these indices, we divided cropland acres into five equal (by land area) categories by overall potential for nitrogen runoff, phosphorus runoff, and nitrogen leaching (we label these very low, low, medium, high, very high). We overlaid data on the 20 percent of cropland acres with very high potential for nitrogen and phosphorus runoff or nitrogen leaching with data on government payments (figs. 13, 14, and 15). Results suggest that acres with the highest potential for nutrient runoff and leaching are located mostly in areas with relatively high government payments. Unlike highly erodible cropland acres, which often occur in more (economically) marginal agricultural areas, nutrient runoff and leaching appear to be most problematic where crop production is the principal agricultural land use and soils are highly productive.

Using methods detailed in Appendix 1, we estimate that 75 percent or more of cropland acres with medium, high, or very high potential for phosphorus runoff, nitrogen leaching, or nitrogen runoff are located on farms that receive government payments (fig. 16). The average annual payment

Figure 13

Distribution of commodity program payments and very high nitrogen runoff potential, 1998

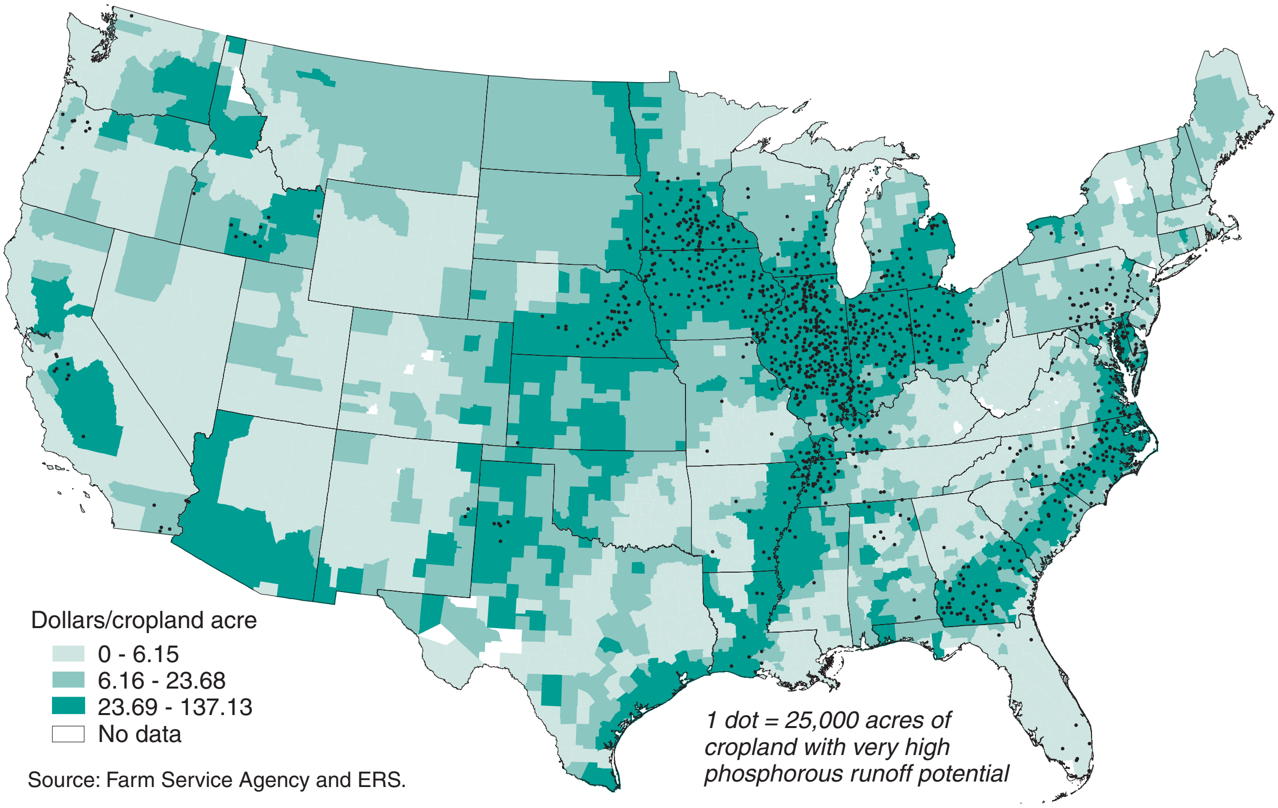


1 dot = 25,000 acres of cropland with very high nitrogen runoff potential

Source: Farm Service Agency and ERS.

Figure 14

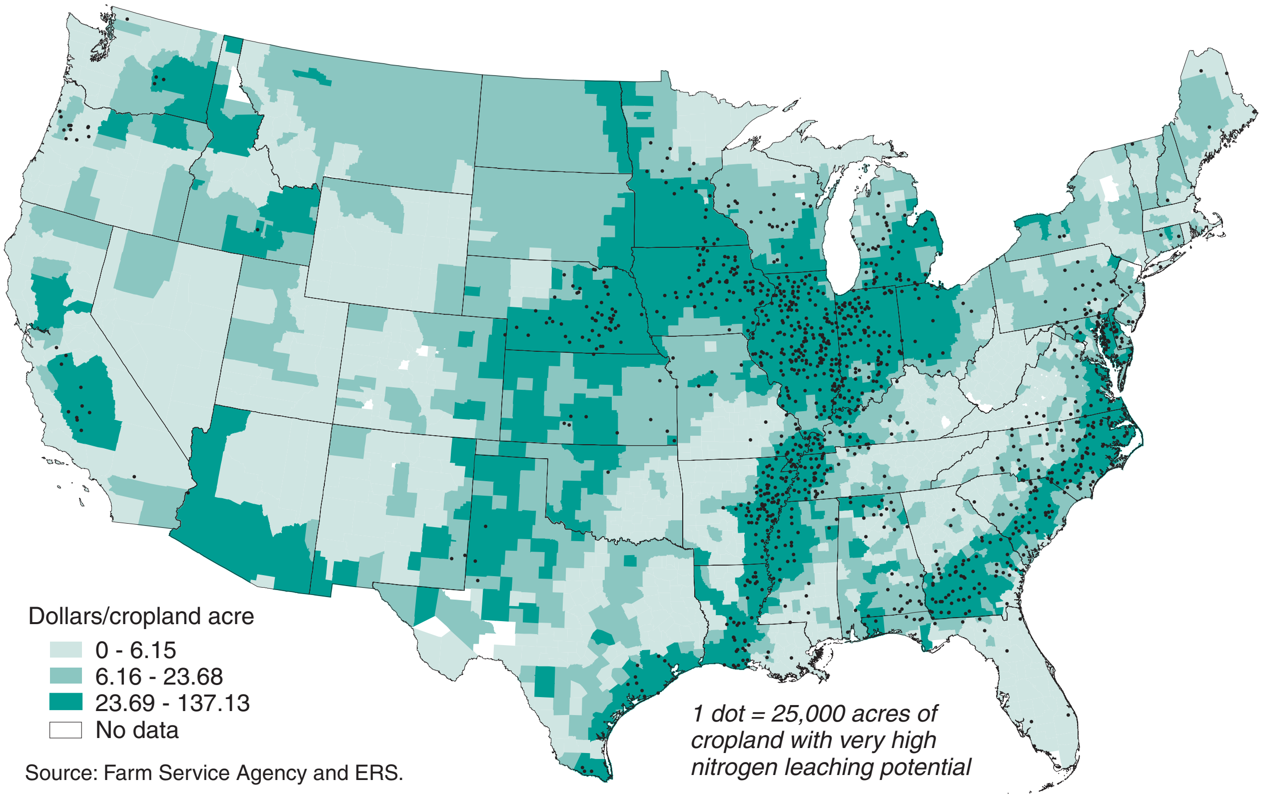
Distribution of commodity program payments and very high phosphorus runoff potential, 1998



Source: Farm Service Agency and ERS.

Figure 15

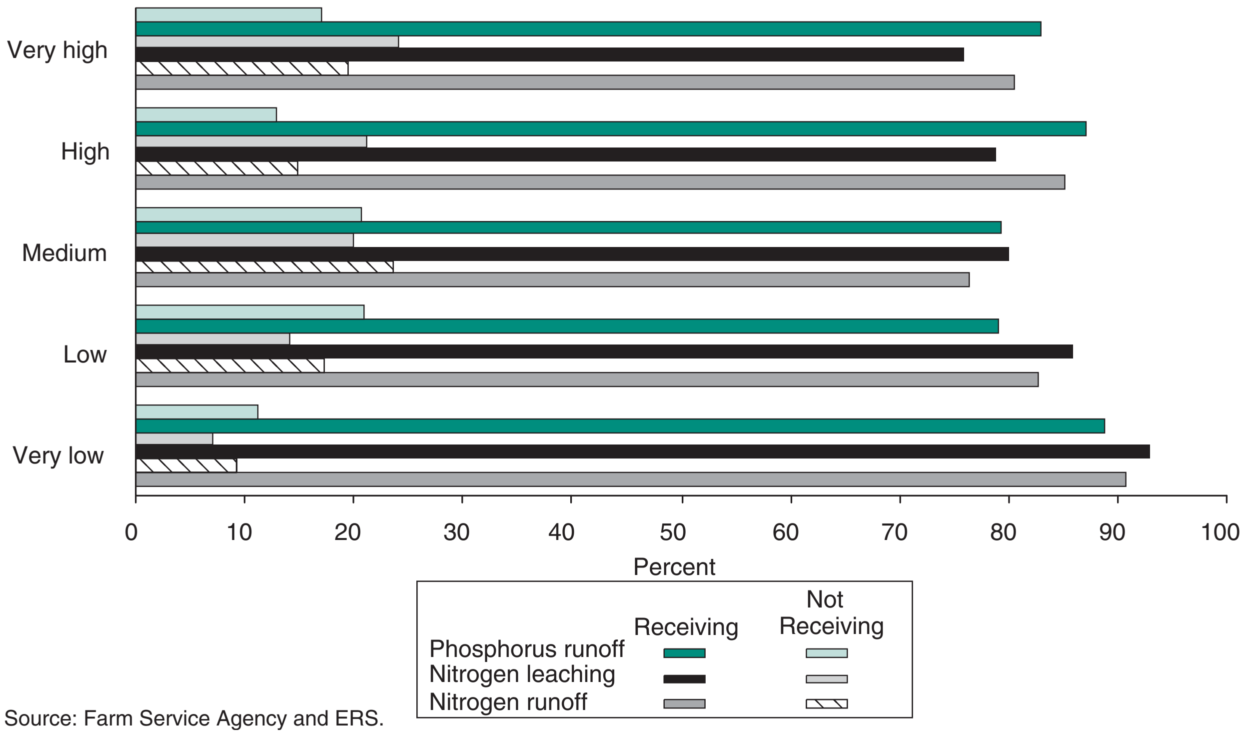
Distribution of commodity program payments and very high nitrogen leaching potential, 1998



Source: Farm Service Agency and ERS.

Figure 16

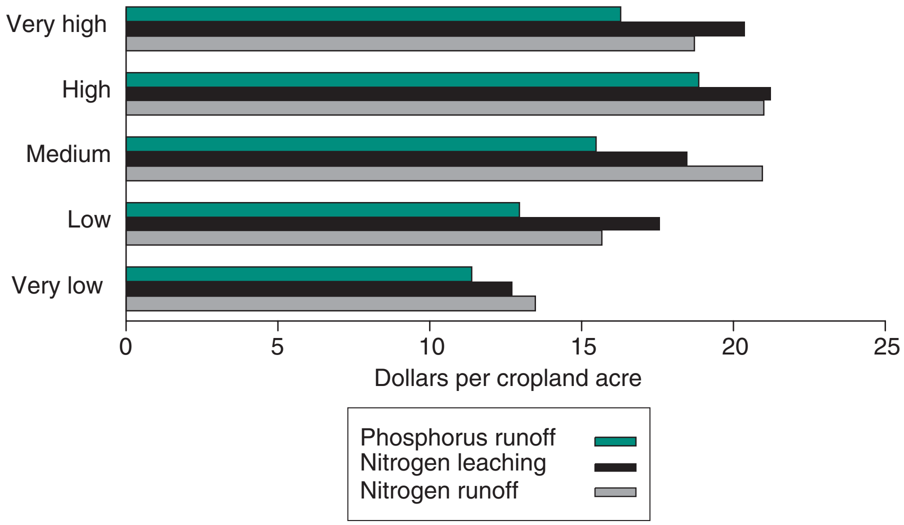
Percent of cropland acres on farms receiving and not receiving payments, by potential nutrient loss to water, 1997



Source: Farm Service Agency and ERS.

Figure 17

Average farm program payment per acre of cropland, by potential nutrient loss to water, 1997



Source: Farm Service Agency and ERS.

exceeds $15 per cropland acre on farms with medium to very high nutrient loss potential for all three nutrient loss indicators, exceeding $20 per acre in several cases (fig. 17). Thus, farms with the highest nutrient loss potential tend to participate heavily in farm programs and receive larger-than-average per-acre payments. Note, again, that the payment data used in this study are from 1997, a year of low payments relative to spending in more recent years and projected spending under the 2002 Farm Security and Rural Investment (FSRI) Act. Whether these payments are large enough to leverage actions that would produce significant reductions in nutrient runoff and leaching depends on the techniques available to reduce nutrient runoff and the cost of implementing them.

Reducing Nutrient Runoff: Nutrient Management and Buffer Practices

Our results to this point suggest that (1) nutrient application by crop producers is a large source of agricultural nutrient runoff and leaching, and (2) producers with medium to very high potential for nutrient loss also participate heavily in farm programs. Next, we consider practices for reducing nutrient runoff and leaching. Are these practices effective and enforceable? Are government payments large enough to encourage widespread adoption if program eligibility was contingent on the application of these practices?

One way to reduce nutrient loss from cropland is to encourage crop producers to manage nutrients more carefully. The objective of nutrient management is to match nutrient application rates, timing, and placement to plant needs (accounting for nutrients already available in the soil), thereby minimizing the level of "excess" nutrient (nutrient in excess of crop uptake) in the soil at any given time. Excess nutrients are most vulnerable to loss. Nutrient management is actually a collection of practices designed to help farmers match nutrient applications to nutrient needs (e.g., soil testing, split fertilizer application, legume crediting, reasonable yield goals, etc.).

Because it is a collection of practices that can be combined in many ways, nutrient management is flexible and can be tailored to each farm's unique circumstances, making it a potentially cost-effective way to reduce excess nutrients in the soil. However, because nutrient application rates, methods, and timing are very difficult to observe, enforcement could be difficult and expensive (Malik, 1993; Amacher and Malik, 1996, 1998; Johansson, 2002). Nor is it guaranteed that nutrient management will reduce runoff and leaching to levels consistent with significantly improved water quality. If heavy rains fall just after fertilizer application, significant runoff and leaching can still occur, even if application is timed to better coincide with plant needs.

A second way to address nutrient runoff is through the use of buffer practices, such as filter strips, grassed waterways, or restored wetlands to intercept nutrients before they leave the field or farm. Buffer practices can remove a substantial proportion of the sediment and nutrients from field runoff. A recent survey article (Dosskey, 2001) shows that, on average, filter strips remove 50-90 percent of nitrogen and phosphorus from runoff. Unlike nutrient management, buffer practices are easily enforceable because their existence and effectiveness are readily observed. Buffers can be more expensive to implement because some cropland is taken out of production, and will be ineffective where nitrogen leaches to ground water or reaches water bodies through subsurface flow.

Cost of Nutrient Management[14]

If nutrient management became a condition of eligibility for farm programs, use of nutrient management would increase only if nutrient management costs were lower than the net benefits of farm program participation (prior to the addition of the nutrient management requirement), and if the requirements were effectively enforced. As with soil conservation practices, the cost of nutrient management is likely to vary significantly among producers, and may depend on cropping patterns, soils, climate, management skill, and producers' risk preferences. Nutrient management plans typically include a variety of practices or management decisions that affect the overall amount of nutrient applied, the timing of fertilizer applications, and the method of application. For some producers, nutrient management could lower fertilizer bills. For others, lower fertilizer bills might be more than offset by the cost of soil and plant tissue testing, increased cost of fertilizer application, or increased risk of delayed application that can decrease crop yields.

Determining the appropriate level of nutrient application involves testing the soil to determine available nutrients, and, in cases where nutrients are applied to a growing crop (side dressing), other tests (such as plant tissue testing) to determine plant needs. Sample collection and testing can be time-consuming and costly. Even with soil and plant tissue tests, uncertainty about the relationship between nutrient application and crop yields can expose producers to the risk of low yields as they attempt to match nutrient application to plant needs. Research shows that assumptions about the relationship between nutrient uptake and crop yields can significantly affect calculation of an optimal fertilizer application rate (Grimm et al., 1987; Larsen et al., 1996), possibly leading to overfertilization or lower-than-expected crop yields. Year-to-year variation in growing conditions may also encourage overapplication of nutrients. Because crop nutrient needs are higher in years with good growing conditions, it may be profitable to use more fertilizer in anticipation of getting peak yields in particularly good years (Babcock, 1992; Dai et al., 1993).

Timing fertilizer applications to coincide with plant nutrient demand can also expose producers to higher cost and risk. Fertilizer prices tend to be lower in the fall, well in advance of planting (Huang et al., 1994), possibly making fall or early spring application less costly, even if more fertilizer is needed to make up for the runoff and leaching losses. Higher application costs are incurred in the use of "split" application, where fertilizer is applied at planting and during the growing season when plant needs are high. Moreover, delaying fertilizer application exposes producers to the risk of weather-related delays when plant needs are high. Some producers may rely on early application to reduce this risk (Huang et al., 1994; Feinerman et al., 1990). Better fertilizer placement can also reduce fertilizer use, but may increase application costs. For example, planter-mounted application attachments allow fertilizer to be placed directly in the root zone, increasing plant uptake. Fertilizer savings, however, must be considered against the cost of additional equipment.

Again, we use the EQIP database to provide a sense of the range of potential costs for nutrient management. Bear in mind that EQIP data represent

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[14] The authors greatfully acknowledge the contribution of Glen Sheriff to the development of this section.

Table 7—Average and 95th percentile EQIP incentive payments for nutrient management

ERS Farm Resource Region	Average annual	95th percentile	3-year NPV of average annual	3-year NPV of 95th percentile	Number of contracts
	Dollars per acre				
Heartland	7.07	12.00	19.61	33.29	9,819
Northern Crescent	5.96	11.99	16.55	33.28	7,728
Northern Great Plains	7.30	13.67	20.26	37.93	847
Prairie Gateway	6.60	17.25	18.32	47.87	6,460
Eastern Uplands	8.51	10.29	23.63	28.55	2,546
Southern Seaboard	8.45	10.00	23.44	27.75	14,787
Fruitful Rim	9.66	20.00	26.80	55.50	2,922
Basin and Range	7.13	25.00	19.79	69.38	950
Mississippi Portal	4.62	5.06	12.82	14.03	3,361
U.S.	7.31	15.00	20.29	41.63	49,420

Source: ERS analysis of EQIP data.

the level of payments some producers were willing to accept (WTA) for undertaking nutrient management—not necessarily the actual out-of-pocket cost of the practices. For some practices, producer WTA may be higher than out-of-pocket costs. For example, the cost of soil sample testing may be small compared with the opportunity cost of the time required to collect soil samples. On the other hand, fertilizer cost savings could offset some portion of these costs.

Nationally, EQIP participants adopting nutrient management in crop production received an average of $7.30 per acre, while 95 percent of these producers received $15 or less. Given a 3-year payment period and a 4-percent rate of discount, the net present value (NPV) of the average payment is $19.20 with 95 percent of producers receiving $39.45 or less. By region, the NPV of average incentive payments ranges from $12.82 in the Mississippi Portal, where 95 percent of participants received $14.03 or less, up to an average of $26.80 in the Fruitful Rim, where 95 percent of participants received $55.50 or less (table 7). A $20-per-acre annual commodity program payment would translate into $95 over 6 years and $212 over 20 years—substantially more than EQIP participants in any region of the country are willing to accept for undertaking nutrient management.

Cost of Buffer Practices

The term “buffer practices” refers to a range of practices that are designed to intercept sediment and nutrients at the edge of the field or farm. For example, practices eligible for continuous signup in the Conservation Reserve Program (CRP) that are particularly relevant for nutrient runoff include riparian buffers, filter strips, grassed waterways, and contour grass strips. The cost of buffer practices may include the establishment of vegetative cover, land shaping, and the retirement of productive cropland, although only a small amount of land is required. In the case of filter strips, for example, only 1-3 percent of the area drained through a filter strip is needed in the filter.[15]

One source of information on producers’ willingness to accept payment for installing buffer practices is the CRP continuous signup for high-priority practices. High-priority practices include filter strips, grassed waterways,

[15] For filter strips, minimum area depends on two factors. First, the ratio of drainage area to filter strip size depends on the RUSLE (Revised Universal Soil Loss Equation) R-factor. For R-factors of 0-35, a field-to-filter strip area ratio of 70:1 is appropriate, 60:1 is required for R-factors of 35-175, and 50:1 is needed for R-factors greater than 175. Second, filter strips must have a minimum flow length (width) of 30 feet. Depending on the size and shape of the field, this requirement may result in a larger field-to-filter strip area ratio than otherwise required. For more information, see USDA-NRCS, 2002c.

contour grass strips, and other buffer practices. Nationally, continuous signup acres receive an average payment of $92 per acre per year, more than double the average payment for land in general CRP signup ($43 per acre per year) (Barbarika, 2001). Up to 50 percent cost sharing is also provided for practice installation. Cost-share amounts for some common buffer practices include $59 per acre for contour grass strips, $69 for grass filter strips, and $209 for riparian buffers. Because buffer practices generally involve only a small proportion of cropland acres, the overall cost per cropland acre is modest.

As an example, consider installation of a grass filter strip. Assume that $92 per acre represents foregone annual returns, per acre establishment costs are twice the average cost share listed above (50 percent of cost is shared in CRP), and 2.5 percent of cropland is needed. Capitalizing forgone revenue at 4 percent, a grass filter strip would cost roughly $2.50 per cropland acre per year. This is well below the average program payment of $15-20 per acre (or more in recent years) on farms with the most serious nutrient loss potential.

Wetland restoration could also be used to intercept nitrogen runoff before it contaminates surface water. Ribaudo et al. (2001) compare nitrogen use reduction to wetland restoration strategies for reducing nitrogen flows from the Mississippi Basin to the Gulf of Mexico. For nitrogen runoff reductions of up to 26 percent, they found that reducing nitrogen use was the less expensive strategy, while wetland restoration would be more cost-effective in achieving larger runoff reductions. Wetland restoration can be more expensive than other buffer practices ($50-$800 per wetland acre in the Ribaudo study), in addition to the opportunity cost of ending crop production, and will not be appropriate for all locations. Nonetheless, wetland restoration could play a role in reducing nitrogen runoff to water.

Assuming payments will continue indefinitely, compliance could provide sufficient leverage for widespread adoption of either nutrient management to reduce the potential for nutrient loss or conservation buffers to intercept nutrient runoff. While this new compliance requirement could be leveraged with existing program payments, some producers who would be subject to the new requirement are already bearing the cost of existing compliance requirements. Figure 18 shows the potential for overlap between existing compliance requirements and a potential nutrient-related requirement. Map colors indicate land subject to existing compliance requirements—non-cropped wetland and highly erodible land (HEL) near existing cropland and HEL cropland—as a proportion of total cropland. The darker the color, the larger the potential impact of existing compliance mechanisms. The dots represent land with high or very high potential for nutrient runoff and leaching—those acres most likely to be affected by a nutrient requirement.

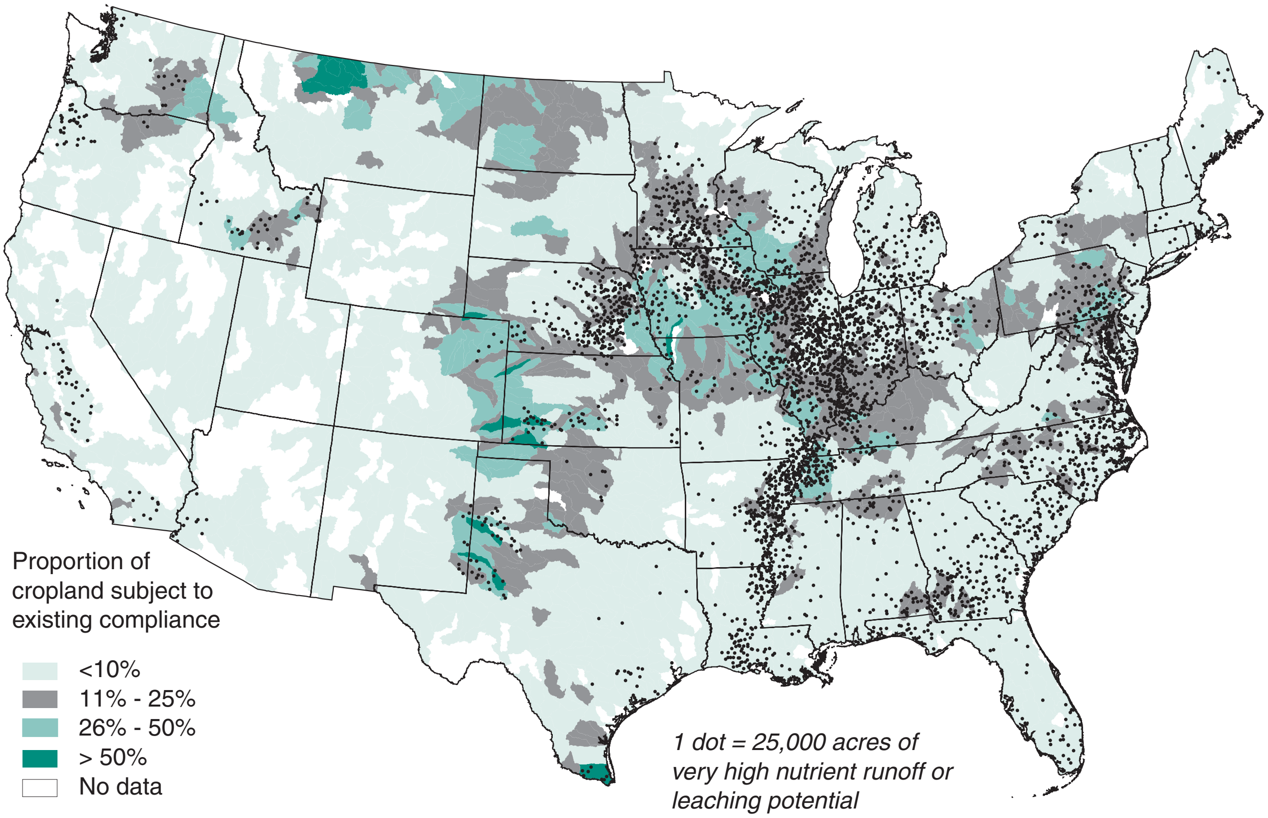
The greatest potential for overlap between the potential nutrient requirement and existing compliance requirements appears to be in the Heartland and the Mississippi Portal, particularly northern portions in Arkansas and Tennessee. Significant overlap may also occur in Eastern Pennsylvania and Maryland.

In the Corn Belt and Mississippi River Delta, crop production is a predominant agricultural enterprise and related farm program payments are relatively large. In 1997, farm program payments in most counties in these areas averaged more than $23 per acre (represented by the darkest shaded areas in fig. 1). Over the 6-year life of the farm bill, the net present value of a $23 stream of annual payments would be $109.63 per acre. Keep in mind that commodity program payments were relatively low in 1997 and that farm commodity programs are likely to continue past the end of the current farm bill.

Meanwhile, regional average costs for soil conservation and nutrient management practices are at or near national averages (see tables 5, 6, and 7). In areas where the overlap is most likely, moreover, nutrient management costs may be lower than the cost of addressing soil erosion. Because the cost of erosion reduction is modest, the combined cost of erosion reduction and nutrient management is unlikely to exceed (or even come close to) the value of farm program payments. In the Mississippi Portal region, the total cost for making a transition to the use of soil conservation practices is larger for each of the most commonly used practices. Producer willingness to accept (WTA) payments for conservation cropping, conservation tillage, and seasonal residue management are $14.86, $28.54, and $12.87 per acre, respectively, while WTA for nutrient management averaged $12.80 (see tables 5, 6, and 7). In the Heartland region, WTA for conservation cropping, conservation tillage, and seasonal residue management is $17.86, $25.26, and $18.60 per acre, respectively, while WTA for nutrient management averages

Figure 18

Potential for overlap between existing compliance requirements and nutrient requirement



Source: ERS and NRI data.

$19.60. Nonetheless, a new nutrient-related compliance requirement could cause financial stress for some producers. Specific cases of hardship could be addressed through variances (as under existing policy).

In Pennsylvania and Maryland, crop production is significant but nutrient problems are more likely to be driven by livestock waste. In most counties in these areas, nitrogen and phosphorus in livestock waste already exceed the assimilative capacity of cropland and pasture land (Kellogg et al., 2000). Farm program payments are not as uniformly high as they are in the Heartland and the Mississippi Portal, so the compliance requirement may be less effective overall. However, recently promulgated Clean Water Act regulations require comprehensive nutrient management on large livestock operations. Also, changes in EQIP eligibility requirements and funding levels will assist livestock producers in reducing environmental damage from excess nutrients. In this context, the compliance requirement may be a useful part of the overall mix of policies designed to reduce nutrient loss to the environment.

Conclusions

Compliance mechanisms were enacted primarily as a method of removing inconsistencies between farm income support and conservation programs. However, compliance mechanisms are also unique policy tools that, when used in conjunction with existing commodity programs, possess some desirable economic properties. Compliance mechanisms are less likely than subsidies to produce unintended consequences and may be effective when subsidy programs can be especially difficult or costly to use. Because compliance mechanisms depend on other programs, however, their effectiveness is limited. Problems associated largely with program crop production, such as soil erosion and nutrient runoff from fertilizer application, are good candidates for a compliance requirement. The design of the compliance requirement (i.e., environmental standards or practice requirements) will determine the cost and enforceability of the compliance requirement.

While USDA's Compliance Status Review process appears to have flaws, it is also likely that compliance rates are high and that significant erosion reduction has been achieved on land subject to Conservation Compliance. Our analysis shows that most highly erodible cropland (HEL), particularly wind-erodible cropland, is located on farms that receive government payments. More important, reduction in excess erosion on HEL cropland—the erosion specifically targeted by Conservation Compliance—has been larger on farms receiving payments (farms subject to compliance) than on farms not receiving payments, particularly for wind-erodible soils. Placing compliance in a larger context, however, we find that soil erosion rates have declined on both HEL and non-HEL cropland, in all regions of the country, and on farms receiving program payments as well as those not receiving program payments.

These results could be consistent with more than one hypothesis about the role of Conservation Compliance in reducing soil erosion. Compliance could be viewed as prompting the adoption of soil conservation practices. On the other hand, one could argue that practices like conservation tillage would eventually have been adopted where they are cost-effective, regardless of Conservation Compliance. In other words, the compliance requirement happened to coincide with a period of technical change favorable to soil erosion reduction. Finally, Conservation Compliance may have accelerated the adoption of low- or no-cost practices. For example, conservation tillage may have spread more rapidly in areas where it was shown to be cost-effective by producers who adopted it in response to compliance.

Likewise, evidence suggests that Swampbuster was only one factor among several that could have explained the rapid drop in wetland conversion for agricultural production. A dwindling number of easily convertible wetland acres and long-term declines in real prices for agricultural commodities may also be contributing to reductions in wetland drainage for crop production. In the aftermath of the Supreme Court's decision in *Solid Waste Agency of Northern Cook County (SWANCC) v. United States Army Corps of Engineers*, however, Swampbuster may be a more important component of U.S. wetland conservation policy.

Extending compliance to address nutrient runoff and leaching from land in crop production, whether through management of nutrient application or interception of nutrients with buffer practices (or both), could provide some additional environmental benefits. Farms where nutrient runoff to water is high are quite likely to receive substantial government payments. Moreover, our analysis shows that the value of government payments will generally exceed the cost of addressing nutrient loss through either nutrient management or buffer practices, suggesting that a compliance mechanism could be effective in leveraging the adoption of practices designed to reduce nutrient runoff. It is important to note that some producers who are already bearing the cost of HEL or wetland conservation requirements are also located in areas where nutrient-related compliance requirements would likely be most significant. Where crop production is predominant (the Heartland and Mississippi Portal regions), farm program payments are also large and would likely provide ample incentive for the additional requirement. Where much of the excess nutrient is generated by livestock production (Pennsylvania and Maryland), compliance alone might be less effective, but could complement other policies designed to reduce nutrient loss to the environment.

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Appendix 1. Linking Environmental Indicators to Farm-Level Data

Environmental indicators are linked spatially to farm-level economic data using a Geographic Information System (GIS). GIS techniques are used to create "surfaces" of environmental indicator values. Farm-level data are then linked to indicators by locating the farm on the environmental indicator surface and assigning the surface value at that location. Results are then aggregated to the national or ERS Farm Resource Region level. This spatial association is valid to the extent that spatial variations in climate, land resources (e.g., soil productivity and erodibility), and farms (e.g., variation in crops and production practices) are interrelated. ERS Farm Resource Regions are, in fact, based on identification of areas with relatively uniform farms, soils, and climate. The regions are based in part on a cluster analysis of U.S. farm characteristics (Sommer and Hines, 1991) and on USDA land resource regions (USDA-SCS, 1981).

Environmental indicators are based largely on data from the National Resources Inventory (NRI). NRI point data files are collected and maintained by the USDA's Natural Resources Conservation Service (NRCS) and contain detailed data on land use and condition for each of more than 800,000 points nationwide, including estimates of water (sheet and rill) and wind erosion on cropland. Surfaces for highly erodible land, acres with excess erosion, and the change in excess erosion are derived from NRI. Data from other sources are combined with NRI to create the nitrogen and phosphorus runoff and nitrogen leaching indices described in Appendix 2.

The surfacing technique employed is the Average Shifted Histogram (ASH) estimator, which is a non-parametric regression procedure designed to assess the density of certain characteristics in the overall land base, e.g., the prevalence of highly erodible land. Indicator surface values are developed on a per-cropland-acre basis to facilitate combining these measures with ARMS data. For HEL cropland, for example, the surface value is the proportion of cropland acres that are highly erodible.

The distribution of farms by commodity specialization and program payments is derived from the 1997 Agricultural Resource Management Survey (ARMS). ARMS is an annual sample survey of farms and agricultural commodities conducted to obtain information about the status of farmers' finances; production practices for specific commodities; use of natural, physical, and financial resources; and household economic well-being. Sponsored jointly by ERS and USDA’s National Agricultural Statistics Service (NASS), ARMS began in 1996 as a synthesis of the former USDA cropping practice, chemical use, and farm costs and returns surveys, which dated back to 1975. Of particular interest for our application, agricultural producers[16] are asked about land use, cropping patterns, and government program participation.

[16] Defined as "all establishments except institutional farms that sold or would normally have sold at least $1,000 of agricultural products during the year" in the 48 contiguous States. For more information, see www.ers.usda.gov\Briefing\ARMS.

Regional or national estimates of acreage with specific environmental characteristics (e.g., the number of HEL cropland acres) on farm with payments are calculated as:

$$A_i = \sum_{k \in K} \gamma_k A_k^{ARMS} \rho_{ik}$$

where γ_k is a zero-one indicator of whether farm *k* receives farm program payments that would make it subject to conservation compliance; A_k^{ARMS} is the cropland acreage in farm *k* in Phase III of ARMS; and ρ_{ik} is the value per acre of indicator *i* in the area where farm *k* is located. The variable ρ_{ik} is constructed using the surfacing techniques described above. Because farms surveyed in Phase III of ARMS are located only at the county level, values for ρ_{ik} are assigned at the center of the county (the county centroid).

This procedure provides estimates that are often quite close to the original NRI estimates. Appendix table 1 provides estimates reported in the text (derived using the procedure detailed above) and estimates derived directly from NRI. National estimates of the extent of land that is highly erodible due to the potential for water (sheet and rill) erosion are extremely close to NRI estimates. Using the ARMS-NRI merged data, we estimate that 55.19 million acres are highly erodible due to water, less than 1 percent higher than the 54.69-million-acre estimate obtained directly from NRI. For wind erosion, the ARMS-NRI merged data indicate 55.54 million acres are highly erodible, about 7 percent higher than the 51.61-million-acre estimate obtained directly from NRI.

Appendix table 1—Acreage estimates using indictor surfaces and ARMS versus acreage estimates directly from NRI

	Estimate	NRI estimate	Difference
	million acres		*percent*
HEL cropland, wind	55.54	51.61	7.61
HEL cropland, water	55.19	54.69	0.91
Total HEL cropland, by region			
Prairie Gateway	30.24	26.67	13.39
Heartland	23.25	23.24	0.04
Northern Great Plains	17.04	18.49	-7.84
Northern Crescent	10.08	9.77	3.17
Fruitful Rim	8.81	7.31	20.52
Basin and Range	7.43	6.54	13.61
Eastern Uplands	7.29	5.77	26.34
Southern Seaboard	2.81	3.63	-22.59
Mississippi Portal	1.80	2.31	-22.08
HEL cropland, wind, erosion>T*	25.38	22.26	14.02
HEL cropland, water, erosion>T*	34.71	34.95	-0.69

*T is the soil loss tolerance, the maximum rate of soil loss that can be sustained indefinitely without productivity damage.

Source: ERS analysis of NRI and ARMS data.

Appendix 2. Methodology for Constructing Nutrient Loss Indices

Nitrogen and Phosphorus Runoff Index

The Nitrogen and Phosphorus Runoff Indexes are based upon "The modified P index system to rate the potential P loss in runoff from site characteristics" found in *A Conceptual Approach for Integrating Phosphorus and Nitrogen Management at Watershed Scales* by Heathwaite et al., 2000.

The indexes consist of four transport factors and two source factors. Index scores, based on the factors described below, are computed as:

> **Nitrogen score** = (soil erosion index score * runoff index score * irrigation index score * distance to water index score) * (commercial nitrogen application + manure nitrogen application)
>
> **Phosphorus score** = (soil erosion index score * runoff index score * irrigation index score * distance to water index score) * (commercial phosphorus application + manure phosphorus application)

The indexes are calculated for each cropland data point in the 1997 National Resources Inventory (NRI) database, excluding land in aquaculture and horticultural crops. The NRI point data files are collected and maintained by USDA's Natural Resources Conservation Service (NRCS) and contain detailed information on land use and condition for more than 800,000 points nationwide. A variety of other data sources are used to calculate some of the individual factors.

Transport Factors

The *soil erosion* index score is based on estimated sheet and rill erosion reported in the 1997 NRI. Erosion rate estimates, in tons per acre per year, were made using the Universal Soil Loss Equation (USLE; see Wischmeier and Smith, 1978). Erosion rate estimates are used to classify cropland into five categories of roughly equal size, by acreage. Each of the five groups was then given a score, from lowest to highest, of 0.6, 0.7, 0.8, 0.9, or 1.0, respectively.

The *irrigation erosion* index score is based on the existence of irrigation and land slope, both of which are reported in the NRI. Land without irrigation was assigned an irrigation erosion value of 0.6. Land slope was used to classify irrigated cropland into four categories of roughly equal size, by acreage. Each of the four groups was then given a score, from lowest to highest, of 0.7, 0.8, 0.9, or 1.0, respectively.

The *runoff* index score is based on the methodology used by Kellogg (1997). Average annual precipitation was computed for each NRI point using various sources of weather data and methods of interpolation. Runoff was then estimated using a runoff curve value taken from the NRCS runoff curve table.[17] The runoff curve value depends on cropping type, conservation management, and soil hydrologic group. Cropping type was determined by land use as shown in appendix table 2. On highly erodible land, conservation management was considered good if erosion was less that twice the soil loss tolerance

[17] See http://abe.www.ecn.purdue.edu/~engelb/agen526/Runoff/cn_table.html

Appendix table 2—Runoff curve table based on NRI land use

NRI land-use designation values	Runoff curve cropping type
11 – 20	Row crops
111-116	Small grains
141 - 143	Meadow
170 - 180	Used most recent land-use designation from cropping history.

Source: National Engineering Handbook, USDA-NRCS.

or "T" factor. On non-highly erodible land, conservation management was considered good if erosion was less than T. The soil hydrologic group was taken from the Soil Interpretive Record (SIR) database associated with the NRI. The runoff estimates were used to classify cropland into five categories of roughly equal size, by acreage. Each of the five groups was then given a score, from lowest to highest, of 0.6, 0.7, 0.8, 0.9, or 1.0, respectively.

The *contributing distance or distance to water* index score is based on distance to water available in the 1997 NRI database. The values for distance to water were placed into the five groups as described in Heathwaite et al., 2000.

Source Factors

Commercial nitrogen and phosphorus application rates are computed at the county level. Each NRI point in a given county is assigned the county application rates. The values were derived from commercial fertilizer expenses from the 1997 Census of Agriculture.

Manure nitrogen and phosphorus application rates are computed at the county level. Each NRI point in a given county is assigned the county average application rates.

Nitrogen Leaching Index

The Nitrogen Leaching Index is based upon "The N index system to rate the potential loss in leaching from site characteristics determining source and transport factors" found in *A Conceptual Approach for Integrating Phosphorus and Nitrogen Management at Watershed Scales* by Heathwaite et al., 2000.

The index consists of two transport factors and two source factors. Index scores, based on the factors described below, are computed as:

> **Nitrogen score** = (soil texture index score * permeability index score) * (commercial nitrogen application + manure nitrogen application)

The index is calculated for each cropland data point in the 1997 NRI database, excluding land in aquaculture and horticultural crops. A variety of data sources were used to compile the individual factors. Nitrogen source factors are as described above.

Transport Factors

The *soil texture* index score was assigned following Heathwaite et al., 2000.[18] Data on soil texture data is from the 1997 NRI point database.

The permeability index score is based on a formula developed by Williams, Jones, and Dyke (1984). The formula uses data on precipitation, irrigation, and soil hydrologic group. Average annual and monthly precipitation was computed for each NRI point using various weather data sources and interpolation methods. The presence of irrigation was determined using NRI data. The soil hydrologic group was taken from the SIR database. The permeability estimates were used to classify cropland into five categories of roughly equal size, by acreage. Each of the five groups was then given a score, from lowest to highest, of 0, 1, 2, 4, or 8, respectively.

[18] A few soil texture categories that did not appear in this publication were assigned index scores by the authors.