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Flexible Conservation Measures on Working Land

What Challenges Lie Ahead?

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Abstract

From 1985 to 2002, most Federal conservation dollars going to farm operators have been to retire land from crop production. Yet most U.S. farmland (850 million acres) remains in active production. The Farm Security and Rural Investment (FSRI) Act of 2002 sharply increased conservation funding and earmarked most of the increase for working-land payment programs (WLPPs). The design and implementation of WLPPs will largely determine the extent to which environmental goals are achieved and whether they are cost effective. We simulate potential environmental gains as well as adjustments in agricultural production, price, and income associated with various WLPP features to illustrate tradeoffs arising from WLPP design and implementation. Competitive bidding with the use of environmental indices to rank producers for enrollment is most cost effective. Payments based on past conservation will help support farm incomes, but limit the amount of additional environmental benefit that can be generated under a fixed budget.

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Summary

Agricultural production can have damaging environmental impacts. Although past conservation efforts—particularly land retirement—have helped, agri-environmental problems remain. Because most agricultural land (850 million acres) remains in production, and many agri-environmental problems are the result of small contributions from many widely dispersed farms, improving environmental performance on "working lands" is an important next step.

What Is the Issue?

The 2002 Farm Security and Rural Investment Act, or the 2002 farm bill, shifted U.S. agri-environmental policy from land retirement to conservation on working lands—land used primarily for crop production and grazing. Spending for conservation programs was increased by 80 percent over the previous farm bill, with much of that going to the Environmental Quality Incentives Program (EQIP) and the Conservation Security Program (CSP). While actual funding of these working-land payment programs (WLPPs) is unlikely to reach authorized levels, the scope of working-land conservation is nevertheless expanding.

Whether this trend continues in subsequent legislation is uncertain. However, effective design of agri-environmental programs can help stretch the available budget, whatever it might be, in terms of environmental gains or other program goals. But because of the complexity of farm household decisionmaking and the nonpoint source and site-specific nature of agri-environmental problems, forecasting the benefits of agri-environmental conservation programs is data-demanding and technically challenging.

What Did the Study Find?

Once a working land payment program has been designed—before any producers are enrolled or any contracts are signed—most of what can be done to ensure that program objectives are achieved is locked in place. If funding is limited, program goals are likely to be achieved only if program decisionmakers can anticipate the effect of enrolling a given producer.

Producers will apply for participation when the benefits they receive outweigh their costs, which will depend on program details. Program decisionmakers may apply enrollment screening criteria to determine which applicants are enrolled. Participation patterns then determine the environmental and economic outcomes of the program. The trick is to (1) develop a request for proposals that is attractive to producers who can contribute to achieving program goals and (2) develop enrollment screening criteria that use information provided by the applicants to select those best suited for the job. Policymakers and program managers may sometimes need to balance conflicting goals of fiscal conservatism versus conservation coverage, acknowledgment of ongoing stewardship versus reward for all-new efforts, or even resource concerns themselves (managing nutrient runoff, say, versus maintaining soil productivity).

Environmental cost-effectiveness. Programs best designed to maximize environmental gain from a limited budget will:

- Structure the application/enrollment process as a "request for proposals," which can then be accepted or rejected. This allows program decision-makers to glean valuable information before committing to a pool of program applicants.
- Rank proposals by benefit-cost criteria. Given a pool of willing participants, information on the practices to be adopted—soil quality in fields to be enrolled, farms' proximity to surface water, etc.—can be used to assess potential environmental benefits. Contract costs can be gleaned directly from the proposal. Environmental indices, like the Environmental Benefits Index (EBI) in the Conservation Reserve Program, can then be used to rank proposals.
- Promote bidding on financial assistance. In a competitive enrollment program, bidding on the level of financial assistance (e.g., the cost-share rate) can stretch budgets by reducing the cost of individual contracts. For a fixed budget, environmental performance on working lands may be increased by 25 percent with bidding provisions versus payments based on an (index-based) estimate of potential environmental benefits.

Stewardship payments. Only policymakers can decide the appropriate level of a good-stewardship reward. However, rewarding past performance could mean that there will be less program budget to encourage new conservation efforts. This tradeoff becomes more apparent when new and old practices are eligible for similar payments and when budgets are relatively small. In such a program, eligible stewards will have a greater incentive to accept a given payment for a particular practice they have already implemented than would eligible producers who would be newly adopting the same practice. Given that the number of eligible stewards is the same regardless of the budget level, the proportion of the budget allocated to stewardship payments will increase as the size of the budget decreases. Alternatively, program managers could decide to set aside a fixed proportion of the budget to reward stewards and another portion to encourage new adoption.

- Simulation results indicate that when budgets are capped at $500 million, a program that provides equal payments for both new and existing practices may achieve only one-fourth as much environmental gain as a program that focuses exclusively on new conservation activities. At lower budgets, given that the number of eligible stewards is still the same, a greater share of the budget goes toward stewardship payments and a smaller share is available to encourage new conservation efforts. A $250-million program that provides equal payments for new and existing practices may achieve less than one-twelfth as much environmental gain as a program that pays only for new practices.
- Payments designed to reward producers who are already good environmental stewards will limit the cost-effectiveness of achieving new environmental benefits, but may complement other programs that target regions or producers with a high potential for environmental improvement.

Alternative resource concerns. Environmental and economic outcomes of WLPPs depend on which agri-environmental problems are emphasized in the establishment of program incentives or enrollment criteria. These emphases are implicit in the environmental indices used to rank and select program participants. In the past, conservation practices that maintain and enhance soil productivity have been heavily weighted. We find that the environmental impacts of deviating from this paradigm are minimal because many conservation practices address multiple resource concerns.

How Was the Study Conducted?

A conceptual framework describes the effect of program design decisions on producer application, program enrollment, and, ultimately environmental gain and economic outcomes (e.g., farm income effects). We describe a range of design options available to policymakers and discuss each in terms of environmental gain and equity considerations. We estimate the magnitude—regarding public spending, environmental gain, and change in farm income—for several specific designs using the U.S. Agriculture Mathematical Programming (USMP) model.

USMP and environmental simulation models linked to it are used to quantify the potential environmental and economic tradeoffs in selecting among program objectives and design features. The report uses cost-effectiveness to measure program success and compare alternative program designs; i.e., how much environmental gain was achieved by each alternative design for a given level of public expenditure?

Chapter 1
Setting the Stage

Farmers make choices daily about which land to use for crops or grazing and how to manage that land. Decisions with potentially important environmental implications include what to produce, how much fertilizer and pesticide to use, which tillage practice to employ, and whether to install conservation measures like grassed waterways. Conservation programs aim to improve the environmental performance of agriculture by influencing those decisions.

What Has Worked . . . To a Point

Policymakers can choose from a wide range of agri-environmental policy instruments, but rely heavily on voluntary participation payment programs (see box, "Major USDA Conservation Programs"). For most of the two decades preceding 2002, most USDA financial assistance for conservation was for land retirement under the Conservation Reserve Program (CRP) and the Wetlands Reserve Program (WRP). These two programs accounted for nearly four-fifths of such financial assistance in the 1990s, with spending of $1.5 billion or more annually.

But land retirement programs, despite environmental gains, are costly and do not address problems on the vast area of land that remains in agricultural production. During these same years (before 2002), Federal financial assistance for working-land programs was modest. Such programs include the Environmental Quality Incentives Program (EQIP), Wildlife Habitat Incentives Program (WHIP), and CRP's continuous signup that encourages installation of buffer practices such as filter strips and grassed waterways. Nonfinancial assistance programs include Conservation Technical Assistance (CTA), which provides in-kind technical support to producers who want to install or adopt conservation practices without Federal cost-sharing or incentives. Conservation compliance, meanwhile, requires farmers to adopt soil-conserving practices on highly erodible cropland or risk loss of Federal farm program benefits. While these efforts have helped promote conservation on working lands, our focus is on voluntary, financial assistance programs—working-land payment programs (WLPPs).

Although land retirement will continue to be an important part of U.S. agri-environmental policy, it appears that programs directed at working land conservation are growing. Many resource concerns—such as nutrient and pesticide runoff—may be more cost-effectively addressed on the 850 million acres of active cropland and grazing land than on idled land. Much of the 80-percent boost in conservation funding outlined by the Farm Security and Rural Investment Act of 2002 is slated for conservation efforts on working lands (fig. 1.1).

In many instances, WLPPs could achieve environmental benefits at a lower cost per acre under land retirement programs because land remains in production and farmers are able to sell commodities. Also, pressing agri-

Agricultural Land Preservation and Other Programs

Land Retirement Programs

- The ***Conservation Reserve Program (CRP)*** and the ***Conservation Reserve Enhancement Program (CREP)*** offer annual payments and cost-sharing to establish long-term, resource-conserving cover, usually grass or trees, on environmentally sensitive land.
- The ***Wetlands Reserve Program (WRP)*** provides cost-sharing and/or long-term or permanent easements for restoration of wetlands on agricultural land.

Working-Land Payment Programs

- The ***Environmental Quality Incentives Program (EQIP)*** provides technical assistance and cost-sharing or incentive payments to assist livestock and crop producers with conservation and environmental improvements on working lands.
- The ***Conservation Reserve Program (CRP) Continuous Signup*** provides cost-sharing and annual payments to producers who establish "buffer" practices such as riparian buffers, filter strips, grassed waterways, and contour grass strips to intercept sediment and nutrients before they leave the field.
- The ***Wildlife Habitat Incentives Program (WHIP)*** provides cost-sharing to landowners and producers to develop and improve wildlife habitat.
- The ***Conservation Security Program (CSP)*** will reward demonstrated land stewards for implementing appropriate land-based practices on working lands that address one or more resources of concern, such as soil, water, or wildlife habitat.

Agricultural Land Preservation Programs

- The ***Farm and Ranch Lands Protection Program (FRPP)*** provides funds to State, tribal, or local governments and private organizations to help purchase development rights and keep productive farmland in agricultural use.
- The ***Grassland Reserve Program (GRP)*** is designed to preserve and improve native-grass grazing lands through long-term contracts and easements. While normal haying and grazing activities will be allowed under GRP, producers and landowners cannot crop the land and will be required to restore and maintain native grass and shrub species.

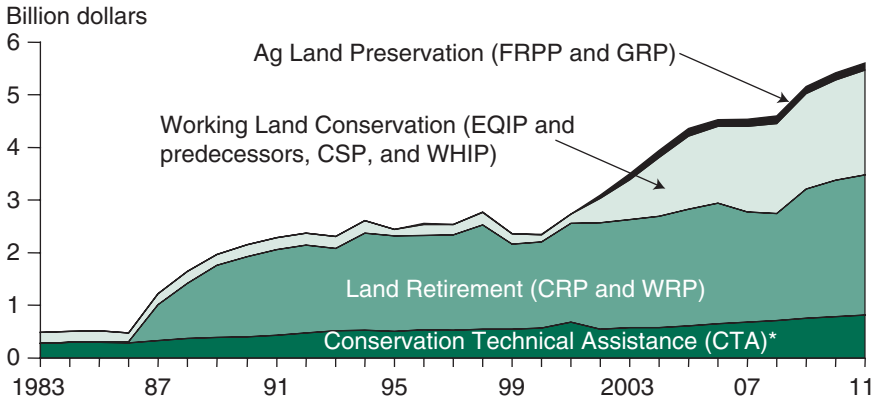
Technical Assistance

- The ***Conservation Technical Assistance (CTA) Program*** has been providing conservation technical assistance for planning and implementation of conservation systems since 1935.

Compliance Mechanisms

- ***Conservation Compliance, Sodbuster, and Swampbuster*** are provisions that tie the receipt of farm payments to management of highly erodible land and wetlands.

Figure 1.1
Conservation emphasis appears to be shifting from land retirement to working land



*Expenditures on CTA estimated for 2005-2011 using 22-year trend.
Sources: Compiled by Economic Rsearch Service, UDSA using data from Office of Budget and Policy Analysis, USDA, and the Congressional Budget Office.

environmental problems like soil, pesticide, and nutrient runoff from farmed land, can be more fully addressed. Maximizing the benefits of WLPPs presents considerable challenges. Which producers apply for enrollment in the program, what land they offer, and what practices they employ will depend largely on the level of payment producers are offered. Which of these producer offers is ultimately accepted will depend on the rules or procedures the government uses to decide which applications to accept. These decisions, together, will determine the economic and environmental effects of the WLPP.

Program performance—both economic and environmental—depends critically on *program design*. Design decisions that will influence participation include eligibility criteria, payment rates for conservation practices, and methods used to rank program applicants (see Claassen et al., 2001).

The design challenge is compounded by the diversity of farm types, crops, farming practices, and environmental concerns. This is especially complicated for WLPPs because these programs would fund a broader range of practices on a wider range of land types than land retirement programs have generally done. For many funded practices, environmental effectiveness and adoption cost will vary significantly across farms and—for practices like nutrient management—implementation will be difficult to monitor and enforcement costly. Finally, the coexistence of major land retirement and working land programs will heighten the need for coordination to avoid inconsistencies and duplication of effort.

In general, it is difficult to accurately predict which producers will participate and what land and practices they will offer in response to a given set of participation incentives. Before a program is implemented, program decisionmakers may have only a general sense of potential benefits or costs of inducing sufficient producer participation. Programs that collect site-specific data on contract offers may help in determining which applications to accept for program enrollment.

We address a broad range of issues concerning the design and implementation of WLPPs and the potential economic and environmental implications of alternative policy designs. Discussions are illustrated using examples from existing working land programs, including the Environmental Quality Incentives Program (EQIP) and the newer Conservation Security Program (CSP). Illustrations are also drawn from the CRP.

Specifically, this report seeks to address the following questions:

1) How can program design be used to help shape the pool of applicants who are willing to participate in working land payment programs?

2) How can program design be used to enroll producers who could make a particularly valuable contribution to program objectives?

3) What impact do the design criteria have on performance in terms of cost-effectiveness, environmental efficiency, and equity objectives?

Chapter 2
Designing Voluntary Incentive Payments for Working Land Conservation

Water quality, air quality, abundant wildlife, and open space are among the issues addressed by agri-environmental policy. Agri-environmental programs may also have secondary goals like helping farmers comply with environmental regulation, supporting farm incomes, and ensuring an equitable distribution of payments across regions. To design a cost-effective WLPP (see box, "What Is Environmental Cost-Effectiveness?"), it is necessary to (1) identify those producers, land, and practices that are most likely to secure program objectives at least cost; and (2) devise eligibility criteria, incentives, and enrollment screening criteria that will attract those producers, land, and practices.

Benefits from WLPPs Contingent on Design

Agri-environmental incentives, when offered to farmers, trigger a sequence of events that includes producer bids, program enrollment, the application of conservation practices, the disbursement of payments, and ultimately environmental and economic outcomes. Once enrollment decisions are made—well before any of the contracted practices have been adopted or installed—most of what can be done to ensure that program objectives are achieved will already have been done. Thus, designing a cost-effective

What Is Environmental Cost-Effectiveness?

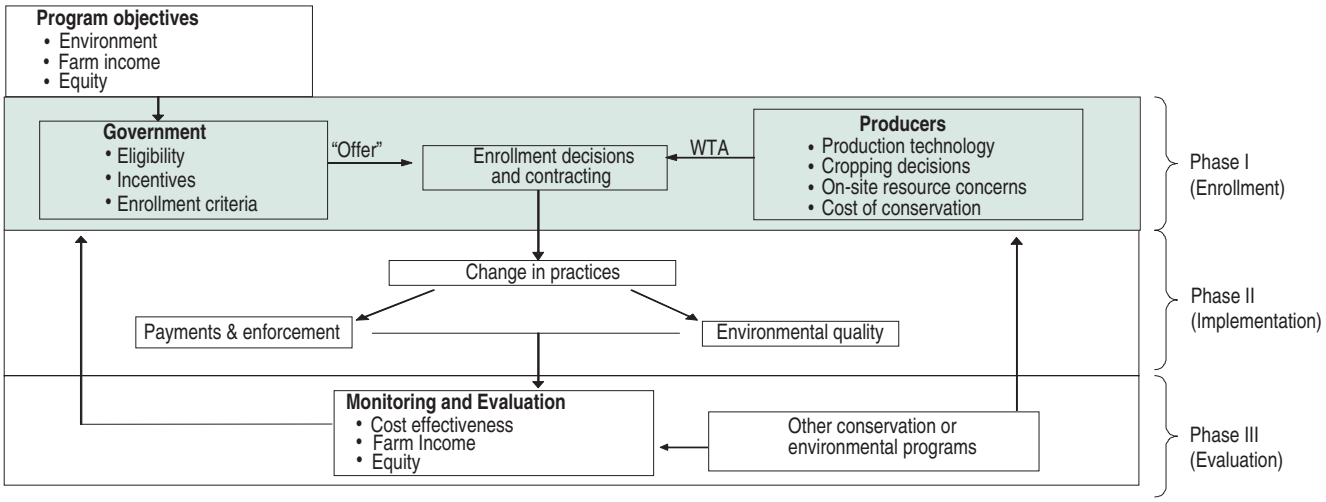
Environmental cost-effectiveness is achieved when an environmental goal or objective is attained at the lowest possible cost to society as a whole. Note that "cost" is not necessarily equal to government expenditure. Costs include the full (private and public) cost of adopting or installing and maintaining beneficial conservation practices, including federally provided technical assistance, and transaction costs. If government payments and technical support exceed producer conservation costs, the amount exceeding cost is a transfer payment to the producer. Because the transfer payment is simultaneously a cost to taxpayers and a benefit to the producer, these costs and benefits cancel one another for society as a whole. When program expenditure is limited by a budget (e.g., EQIP) or acreage allocation (e.g., CRP), an alternate formulation of the cost-effectiveness criterion can be used: maximize environmental gain given the available budget. The budget-constrained cost-effectiveness criterion is not a precise mirror image of the standard cost-effectiveness criterion. To maximize environmental gain subject to a budget constraint, both the economic cost of environmental gains (just as in the standard cost-effectiveness criterion) and transfer payments must be minimized. In contrast to the standard cost-effectiveness criterion where transfer payments are a wash, transfer payments are an issue in the budget-constrained case because they use up budget resources that could be devoted to further reducing environmental damage. As a result, budget-constrained cost-effectiveness is more difficult to achieve than standard cost-effectiveness.

program—regardless of objectives—places a premium on the ability of program decisionmakers to anticipate program outcomes.

To anticipate outcomes, it is necessary to anticipate how producers will react to the offer of payments and how their changed practices would affect the environment. The way government structures an agri-environmental program—effectively its "offer" to producers—will largely determine what information can be gleaned from the application process and how it can be used to determine program enrollment (Phase I, fig. 2.1). Broadly speaking, all existing U.S. agri-environmental payment programs use one of two basic structures:

- ***Request for proposal.*** In most agri-environmental programs, the government's offer is, in fact, a request for proposals from producers. The government's offer generally indicates who can submit proposals (i.e., who is eligible), minimum requirements in terms of conservation action, how much producers can expect to be paid (or, for some programs, the maximum bid that could be acceptable), and the criteria by which proposals will be assessed. Participants are then selected on the basis of the specific environmental benefits they offer and costs they incur, or another set of criteria that reflect policymaker objectives. A producer's offer typically specifies the land to be enrolled, what resource concerns will be addressed, what practices will be adopted or installed, and, in some programs, the level of payment the producer is willing to accept for taking the specified actions.
- ***Payment offer***. In some programs (e.g., continuous signup for CRP), the government offers producers a given payment (usually based on conservation cost or land rents) for taking a given action and allows them to choose to participate without further assessment by the government. If necessary, budget or other limits can be enforced by withdrawing the offer when the limit is reached (i.e., first-come, first served). In the special case of an entitlement program—where eligible, willing producers cannot be denied enrollment, regardless of budgetary consequences—spending would be determined by the extent of participation (e.g., how much land, which practices).

Figure 2.1
Framework for a voluntary working-land payment program



The difference between these two approaches is in the extent of final review by the government. This process, which we call enrollment screening, allows program decisionmakers to gather farm- or field-specific data (e.g., location, soil types, topography, proposed practice changes) that can be very helpful in assessing potential environmental benefits. This information can be used to better weigh the potential environmental benefits against contract costs for specific proposals.

Meanwhile, a producer's attitude toward a given program can be summarized in a single question: "Am I willing to take the specified actions in exchange for the payment offered?" What producers are willing to accept (WTA) will depend on factors like their cost of adopting conservation practices, attitudes about and awareness of conservation problems, wealth, and level of aversion to the risk of trying new practices (see box, "Producers' Willingness To Accept Payments"). By definition, producers are willing to participate so long as the incentive offered meets or exceeds their WTA. For example, if a producer is willing to adopt conservation tillage for a payment of $5 per acre, he will be willing to participate in any program where he is offered $5 or more per acre for conservation tillage adoption. While producers' WTAs are generally unknown, a program implementation process that includes competitive bids for financial assistance may induce producers to reveal their WTAs—which can lower program costs *if* program decisionmakers use this information in determining which producer applications to accept.

Decisions about eligibility, participation incentives, and enrollment screening must be made simultaneously, particularly when the program budget is limited. For example, broad eligibility and large participation incentives will yield a large pool of program applicants, which can then be narrowed using an enrollment screen. A broad pool of applicants may be environmentally cost-effective because it is more likely to include those producers who can make the most profound contributions to achieving program goals. The risk in this approach is that many applications will be reviewed only to be rejected, possibly straining administrative resources and/or discouraging producers from again applying for agri-environmental programs.

In an entitlement program, enrollment screening is moot—those producers who meet eligibility requirements and are willing to accept the payment offered must be enrolled. As a consequence, achieving cost-effectiveness requires that eligibility requirements and incentives be designed to attract producers best suited to making a cost-effective contribution to program objectives. This goal can be accomplished, but only at a cost (in terms of program expenditure) that is higher than may be necessary if an enrollment screen was used.

The need to make program provisions work together is not limited to decisions about a single program. WLPPs are likely to interact with other agricultural and environmental programs. Accounting for that interaction in program design can help avoid conflict or duplication between programs (see chapter 4 for more details).

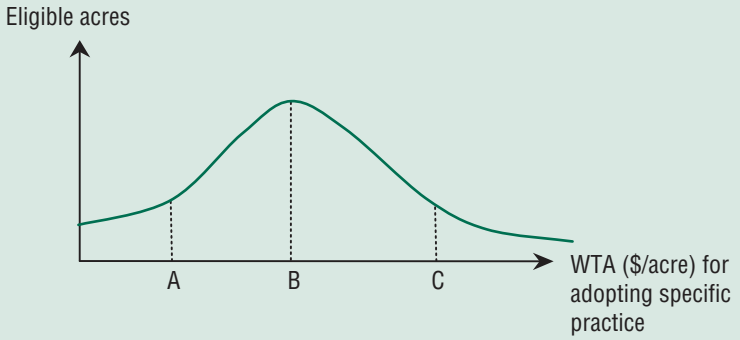
Producers' Willingness To Accept Payments (WTA)

Producers may consider a variety of issues in deciding whether to apply for any voluntary agri-environmental program. These factors can be summarized in a single question, "Am I willing to take the specified actions in exchange for the payment offered?" Because many agri-environmental programs allow producers to propose which portion(s) of the farm would be enrolled and which practice(s) would be adopted or installed, the question may also be formulated as, "What am I willing to offer, given the level of payment that is potentially available?"

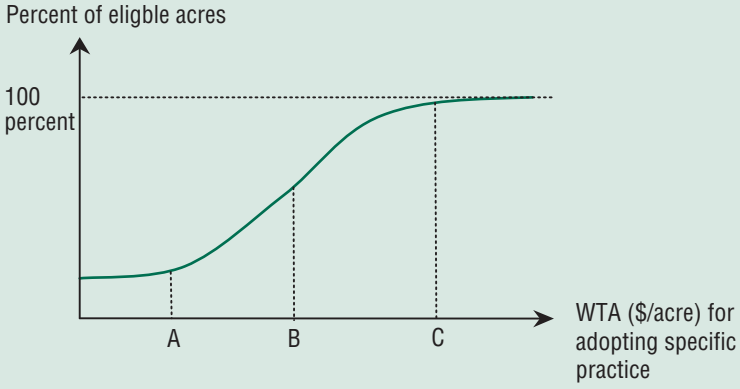
In either case, the level of payment the producer is willing to accept (WTA) for undertaking any conservation practice or activity reflects a variety of costs and benefits to the producer. Most obvious (and most easily measured) are the out-of-pocket costs to adopt or install conservation practices. These include earthworks to build terraces or waterways and machinery upgrades needed to practice reduced- or no-till farming. Other obvious (but less easily measured) costs are from adoption or installation of management practices. For example, producers adopting nutrient management may save on fertilizer but could also risk reductions in yield.

For some producers, the transaction costs associated with program signup can be considerable. These costs can include time and travel required to meet with USDA staff and develop conservation plans in conjunction with technical experts (provided by USDA). Likewise, risk aversion may increase WTA as risk-averse producers require greater payment for making changes perceived as risky. Finally, WTA may also reflect other factors like wealth, education and attitudes about environmental quality, and participation in government programs.

Because the factors that underlie WTA can vary widely among producers, WTA can also vary widely among different producers who install or adopt the same practice or address the same resource concern. Understanding the likely distribution of WTA among producers is important because it can help policymakers assess the proportion of producers to adopt certain practices or address certain resource concerns for a given level of payment. This variation in WTA can be depicted by a bell-shaped or normal curve. To depict the bell-shaped curve in a way that is directly relevant to agri-environmental program participation, we graph the proportion of acres controlled by producers with WTA of a specific level or less. This type of curve is known as a probability density function or PDF. The more (less) variation in WTA for adoption of any given practice, the smaller (larger) the "peak" in the bell curve and the less (more) pronounced the "S" shape of the cumulative distribution function (CDF).



A bell-shaped PDF, or "normal" curve, is used to represent the distribution of WTA. Average WTA is represented by point B. Relatively few acres are owned/farmed by producers who have WTA significantly less than the average level (point A) or significantly higher than average (point C). Some acreage has a zero WTA because the practice has already been adopted.



This s-shaped CDF formulation shows the proportion of acres with WTA at or less than a given level. On only a handful of acres (where the practice is not already adopted), WTA is less than or equal to A. In contrast, WTA is less than or equal to C on almost all acres. A payment of $A would result in enrollment of only a handful of producers, while a payment of $C would send enrollment to nearly 100 percent.

After the enrollment phase, contracts are signed, technical assistance is provided, conservation practices are adopted, and incentive payments are disbursed (Phase II, fig. 2.1). However, compliance is not assured. Given the wide range of practices typically available in a WLPP, checking that practices are actually adopted as specified in the contracts is difficult—more so for management practices than for structural practices (Johansson, 2002). For example, the existence of terraces or grassed waterways—as well as the appropriateness of their design and the extent to which they have been maintained—can be observed directly. But it is very difficult to confirm that nutrient management plans are being fully implemented in the field.

Finally, although monitoring of agri-environmental outcomes (Phase III, fig. 2.1) has been used only sparingly in agri-environmental programs, information gained from monitoring could be used to adjust program design to better meet policy objectives. This type of ex-post evaluation could help improve cost-effectiveness by honing environmental indices and other "tools" used in program implementation.

Attracting the Right Participants: Program Design Alternatives

Policymakers have a number of tools that can be used to influence WLPP participation. In particular, eligibility criteria, payment incentives, and enrollment screens can be used to direct resources toward producers, land, and practices that are most likely to achieve program objectives. Cost-effectiveness depends largely on how these tools are used and how they are combined into an overall program design.

Before these tools can be applied, however, it is important to be clear about what the program is expected to achieve, environmentally and otherwise (see box, "Defining Program Objectives"). Broad directives, aimed at general resource concerns, such as "improve water quality" or "increase wildlife habitat" are not specific enough for effective program design. To establish a practical agri-environmental program, environmental indicators that measure the need for action and progress toward addressing resource concerns are also important. The selection of indicators is effectively the selection of a more specific set of program objectives. When programs seek to address multiple objectives, moreover, some method of weighing objectives (indicators) against each other is needed when, inevitably, conflicts arise. Once these decisions are made, program decisionmakers can proceed effectively with all other aspects of program design: eligibility criteria, payment incentives, and enrollment screens.

Eligibility is often used as a broad "first cut" in defining participation because it determines who can apply for enrollment and what practices they can use. EQIP, for example, sponsors a wide range of practices on many different land types—virtually any type of farm, any type of agricultural land, and any practice found in the NRCS *National Conservation Practice Handbook* can be funded. Because eligibility has been so broad, program decisionmakers have used other means (e.g., enrollment screening) to select participants on the basis of environmental benefits and costs.

Defining Program Objectives

Practical agri-environmental objectives can be formulated in a number of ways. One way is to meet a specific, definable standard for a specific resource. For example, a water quality objective may be defined as meeting a specific maximum concentration of nutrients or other pollutants in a lake or along a stream. Many nonagricultural environmental programs use this method for defining goals. Under the Clean Water Act, for example, the Total Maximum Daily Load provisions require States to identify impaired water bodies where controls on municipal and industrial discharges will not achieve water quality standards. The State must define the maximum load of the problem pollutant that the water body can absorb and still achieve water quality standards. Load allocations are then assigned to both point- and nonpoint-source dischargers in the watershed so that the maximum load is not exceeded.

However, most agri-environmental payment programs have multiple environmental objectives. To weigh the environmental objectives against one another, multi-objective programs often use environmental indices. Both CRP and EQIP use indices to rank producer-proposed contracts by their potential to generate environmental benefits. In budget- or acreage-limited programs, environmental indices, used together with information on contract cost, can help program decisionmakers determine which contracts to accept.

When an environmental index is used, the proportion of total points allocated to various resource concerns defines objectives, implicitly. In the CRP, for example, addressing water quality concerns on a parcel of land is allotted a maximum of 100 points, while a maximum of 35 points can be assigned for addressing air quality concerns. The difference reflects program decisionmaker perceptions as to environmental value or urgency. Decisionmakers may use location, soils, practices to be adopted, and other information to determine how many points to assign for each resource concern. Variation reflects diversity of environmental problems faced by producers and variation in their ability to address them.

Nonenvironmental objectives, such as income support, may be an explicit or implicit consideration in the formulation of agri-environmental programs. Equity is often an issue. While any definition of equity is subjective, objective economic analysis can help policymakers understand the effect of program design decisions on different groups within the farm sector and society at large. For example, policymakers may be concerned with the distribution of payments among farms and their effect on farm income. In the 2002 farm bill, regional equity emerged as an issue in the distribution of agri-environmental payments. Special preferences may also be given to limited-resource farmers or beginning farmers. Equity concerns have been raised on behalf of "good actors"—producers who have already reached a high level of environmental performance.

Eligibility, however, need not be broad. In CRP's continuous signup, only a narrow group of "buffer practices"—shown to significantly reduce sediment and nutrient losses to surface water (Dosskey, 2001)—is eligible for enrollment. The pool of potential applicants is narrowed in CSP by requiring producers to demonstrate past stewardship before they are eligible for program enrollment. Only those producers who have already addressed soil quality and water quality concerns on at least a part of their farm are eligible, and only those portions of the farm where these resource concerns have been addressed can be enrolled.

Table 2.1—Agri-environmental program design options

Program feature	Options		Potential effects
Budget	Continuously variable; allocations may reflect concern about regional equity		As budget increases, so does program scope; may significantly affect decisions on screening, eligibility, and incentives.
Eligibility	Can be based on wide range of factors: farm type, land type, practices, past stewardship, geographic area, etc.		Can be used to focus program implementation on producers, land, and practices most likely to cost-effectively produce environmental benefits.
Enrollment screens	Performance-based		Selection of participants based on ability to meet program objectives. If based on environmental benefits and cost, can promote environmental cost-effectiveness.
	Allocative		Budget can be allocated in ways considered to be fair, e.g., equal allocation among producers; first-come, first-served. Ensures spending stays within budget.
Participation incentives	New conservation incentive	Performance-based	Producers are paid according to the (estimated) value of their conservation actions. Can encourage environmental cost-effectiveness by directing greatest participation incentive to high-benefit, low-WTA (willingness to accept) producers. However, these incentives can also be costly in terms of budget.
		Fixed, cost-based	Payments are proportional to actual cost (as in cost-sharing for structural practices) or an estimate of cost (as in incentive payments for management practices). Environmental cost-effectiveness can be improved by using performance-based screen.
		Bid-based	Payments are based on bids that, ideally, reveal the minimum payment producers are willing to accept for taking conservation actions. Maximum acceptable rates are often specified. When used in conjunction with a performance-based enrollment screen, an environmentally cost-effective outcome is possible.
	Stewardship		Likely to ensure continued maintenance of existing practices, but direct environmental gain will be small. Indirectly, may reduce producer hesitance to adopt conservation practices without program support because they will not be frozen out of opportunity for future payments
	Payment limits can be applied annually, to overall contracts, etc.		May restrict participation of large farms; ensure that participation is more widespread. Effect on cost-effectiveness is unclear.
Implementation	Information costs		Good planning and technical assistance can improve cost-effectiveness, but it can be expensive. Information can also improve cost-effectiveness by leading to more accurate and detailed payment schedules or enrollment screens. But how much information and analysis can be justified on a benefit-cost basis?
	Enforcement		Greater monitoring effort increases likelihood that violation will be detected; greater penalties increase the potential loss if violation is detected; both increase incentives to comply.
Program coordination	Not a specific program provision, but may affect specification of other provisions		Can improve environmental cost-effectiveness by reducing conflict and/or duplication with other programs.

Incentives and Enrollment Screens Can Work Together

In most programs, where eligibility criteria are broad, most of the work in selecting participants is done through a combination of payment incentives and enrollment screening. In general, higher payment rates will lead to broader program application, but exactly how many producers will apply and what actions they will offer to take depends largely on how the incentives are designed. It can be very difficult (or very expensive) to design payment incentives so that the pool of applicants contains only those producers, land, and practices that can (1) most cost-effectively meet program objectives and (2) be funded within the program budget. Consequently, many programs use enrollment screens to help select participants and make sure that budget limits are not breached (see box, "Enrollment Screening and Budgets").[1]

[1]Appendix 1 contains a graphical analysis exploring these tradeoffs in more depth.

Existing enrollment screens are generally **performance-based**. The term "performance" refers to *estimated* physical effects of adopting conservation practices (e.g., reduced erosion and sediment delivery to water) and the potential benefits that society derives from them (e.g., lower water treatment costs, enhanced water-based recreation). One of the best-known examples of a performance-based screen is the Environmental Benefits Index (EBI) used to select CRP participants. Producers offer specific tracts of land (with specific environmental characteristics), identify what type of cover they will establish (e.g., grass or trees), and what level of cost-sharing and annual payment they are willing to accept. Program managers can also obtain tract-specific information from existing databases (e.g., soil survey information), and so score proposed contracts by benefit-cost criteria using the EBI. Contracts with EBI scores above a cutoff level are accepted.[2]

[2]Producers are unlikely to be aware of the level of environmental benefit they can produce, given that many benefits will accrue offsite (e.g., downstream).

But enrollment screening need not be performance-based. Any method of allocating a limited budget can be used as an enrollment screen. For example, producers may be enrolled on a first-come, first-served basis until the program budget (or other limit) is exhausted. CRP's continuous signup for high-priority practices follows this method. On eligible land, buffer practices such as filter strips or grassed waterways are eligible without the competitive review process that accompanies regular signup. Because eligibility is limited to a few practices with profound environmental benefits, a competitive process is waived.

Of course, the extent to which screening is needed depends considerably on the level and type of payments available to producers. Payments for the adoption/installation of new practices can generally be grouped into three categories: fixed-rate payments, performance-based payments, and bid-based payments. Payments can also be based on stewardship, i.e., ongoing conservation effort.

New Practices: Fixed-Rate Payments. Fixed rate refers to a fixed incentive payment (dollars per acre or per practice) or, in the case of cost sharing, a fixed cost-share rate, e.g., 75 percent. Cost sharing reimburses farmers for part of the cost of installing structural (or vegetative) practices such as terraces and grassed waterways. The actual cost of installation can be deter-

Enrollment Screening and Budgets

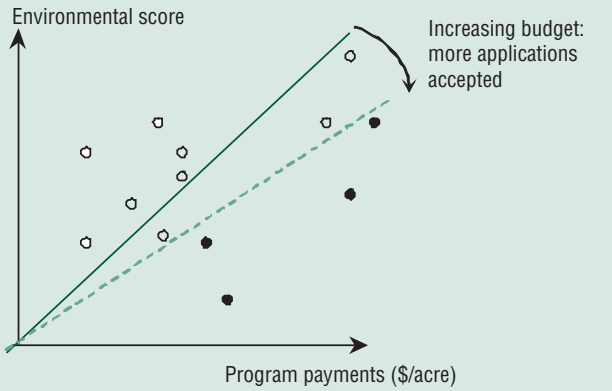
Evaluation of applications hinges on the criteria adopted to rank eligible applicants. Here, several possibilities are presented using 13 hypothetical applicants plotted according to their environmental score and per-acre cost to the government. Black points represent applications that would not be accepted; white points represent applications that would.

This first approach (A), which coincides with how EQIP functioned until 2002, enrolls applications based on their benefit/cost ratio. The evaluation process can be portrayed by rotating clockwise a "cutoff" line: applications above the line are accepted, those below are rejected. How far the line is rotated depends on the available budget. The advantage of this approach is that the largest number of acres will be accepted into the program (short of evaluating applications based exclusively on cost). The disadvantage is that some acres may be accepted simply because the conservation measures to be adopted are very cheap, and as a result, provide only minimal environmental benefits.

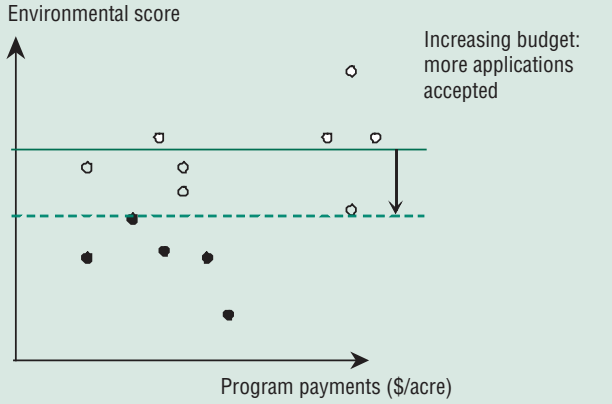
Another approach (B) is to accept applications with the highest environmental scores until the funds are exhausted. This approach excludes all cost considerations from the evaluation procedure. The drawback is that it could reject an application with an environmental score that is just below cutoff but would be less costly to fund than some that are accepted. When cost is excluded, some applications that are rejected may be more environmentally cost-effective than the applications that are accepted. Many States adopted this method in 2002 when the U.S. Congress passed EQIP legislation that discourages cost considerations in the evaluation procedure.

An intermediate approach (C) assigns additional points to applications for cost-effectiveness. This can be portrayed as a sloped cutoff line. The more cost-effectiveness is emphasized, the steeper the slope of the line. States following this approach are Colorado, Kansas, Massachusetts, Minnesota, Nebraska, North Dakota, South Carolina, South Dakota, Utah, and Wyoming.

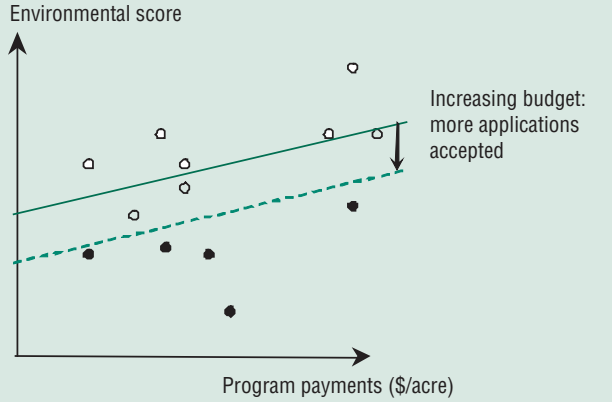
A. Maximize environmental score per dollar of program expenditure



B. Maximize environmental score



C. Maximize environmental score considering cost-effectiveness



mined from receipts for earthwork, seed, and other necessary inputs and services. Incentive payments encourage adoption of management changes where cost is not easily defined. For example, conservation tillage may save on labor and fuel but increase herbicide costs. In EQIP, for example, incentive payments are made to encourage the adoption of management practices, but are not tied to the producer's cost of adopting these practices.

There is no guarantee that producers who apply for payments will be able to make environmental contributions that are more cost-effective than those who choose not to apply. If environmental benefits are typically high when producer WTA is low (i.e., benefits and WTA are negatively correlated), fixed-rate payment arrangements can produce a relatively cost-effective outcome. In other words, producers willing to participate with low payments are also those with relatively high benefits to offer. This is not very likely (see box, "Correlating Costs, Benefits, and Rental Rates"). With performance-based screening, however, program decisionmakers can select producers who can produce relatively large environmental benefits relative to costs. Using a screen in conjunction with fixed payments can significantly improve cost-effectiveness.

Of course, fixed-rate payments need not be based on the cost (real or estimated) of adopting, installing, or maintaining conservation practices. For example, policymakers seeking to direct income support through these programs may want to reimburse producers above conservation costs. However, funds intended as income support may direct participation away from producers who can deliver high environmental benefits at a low cost, because the income support-related payment is not necessarily positively correlated with environmental benefits or negatively correlated with conservation costs. In a budget-limited program, moreover, these additional payments would divert funds from leveraging additional environmental gains.

New Practices: Performance-Based Payments. Performance-based payments compensate farmers based on actual or estimated environmental benefits from their actions. For example, the Soil Condition Index, developed by NRCS, helps determine the CSP payment rate for practices designed to improve soil quality, with measurements both before and after the approved practice is adopted.

When payments are based on (estimated) performance, producers will apply if their WTA is less than or equal to the (estimated) value of their actions.[3] Those whose estimated performance is high, but who can adopt practices designed to achieve that performance at low cost, are most motivated to and most likely to apply. Consequently, the pool of applicants is likely to include largely the same producers who would have been selected using a performance-based enrollment screen, assuming the same performance measures are used in both cases.

However, providing the payment incentives that make this self-selection process work can be costly. When a producer's payment exceeds his WTA, that producer receives some surplus over the minimum amount he or she would have been willing to accept, and money is diverted from other conservation efforts. Without proper safeguards, moreover, these additional

[3]Producers may not know the environmental potential of their actions. Providing this information can improve the cost-effectiveness of the program because it equips producers to respond effectively to the offer of incentive payments. In short, performance-based programs are most effective when producers are fully aware of the environmental impact of their actions.

Correlating Costs, Benefits, and Rental Rates

The table below shows the correlation coefficient between environmental benefits, conservation costs, and land rental rates for seven combinations of resource concern and land type. The correlation coefficient is a measure of linear association that can have values between -1 and 1. When the correlation coefficient is -1, variables are perfectly negatively correlated. In other words, when one variable is high, the other is low. Likewise, a correlation coefficient of 1 indicates perfect positive correlation, while a coefficient equal to zero indicates no correlation.

Benefit	Land type	Average benefits	Correlation coefficient	
		$/acre	Conservation cost	Rental rate
Water quality	Nonirrigated cropland	20.4	0.14	-0.07
Air quality	Nonirrigated cropland	3.02	0.07	-0.064
Soil productivity—water erosion	Nonirrigated cropland	3.74	0.08	0.31
Soil productivity—wind erosion	Nonirrigated cropland	3.53	-0.14	0.58
Wildlife habitat	Nonirrigated cropland	18.41	0.36	0.37
Wildlife habitat	Grazing land	7.86	0.16	0.2

Note: County CRP rates are used for cropland, Grassland Reserve Program (GRP) rates for grazing land.

Sources: ERS analysis of NRCS and FSA data. See Web Appendix C (www.ers.usda.gov/publications/err5) for a detailed discussion.

Only one resource concern/land type combination—soil productivity damage due to wind erosion—shows negative correlation between potential benefits (damage reduction) and cost and positive correlation between potential benefits and land rental rates. The correlation between benefits and costs is low. Moreover, the potential soil productivity benefit of reducing wind erosion is modest. In all other cases, benefits are positively correlated with costs. Benefits are negatively correlated with rental rates in some cases and positively correlated in others. For water quality, where potential benefits are particularly high, benefits are positively correlated with costs and negatively correlated with rental rates. These results indicate that benefit-cost targeting could likely improve the environmental cost effectiveness of a program, using cost-based or rental rate-based payments.

For a more extensive, technical discussion of these issues see Babcock et al. (1997) and Wu et al. (2001). These authors focus on land retirement but find that targeting on the basis of cost is equivalent to benefit-cost targeting only when costs and benefits are negatively and highly correlated.

funds may encourage producers to bid up the value of eligible land or make changes in land use that could undercut program goals (see chapter 4). Furthermore, any program in which (1) conservation payments exceed conservation costs and (2) payments are tied to agricultural land could inflate land values and ultimately intensify land use, depending on the size of the payments and whether they are viewed as long term.

New Practices: Bid-Based Payments. Program decisionmakers can encourage producers to reveal their specific WTA through competitive bidding on cost-share or incentive payment rates. Generally, a maximum bid is established (e.g., 75 percent cost-share in pre-2002 EQIP), but producers are otherwise free to bid as they wish. Bids would encompass a statement of which parcels of land will be enrolled, what practices will be adopted or installed on that land, and the level of financial assistance the producer would accept for taking the specified actions.

As with fixed-rate payments, bid-based payments will not automatically attract producers able to make environmental contributions that are relatively cost-effective. When paired with a performance-based enrollment screen, however, bid-based payments can produce a cost-effective outcome.[4] If bidding is competitive, incentive payments will approximate producers' WTAs and government payments will be minimized (see box, "Bidding and Budgets," p. 17, and Appendix 1). Thus, the risk of unintended consequences is quite low. Bidding may also facilitate participation of producers with relatively high WTA but who could, nonetheless, produce benefits large enough to make a cost-effective contribution. Of course, bid-based payments provide little, if any, boost to farm income. If bidding is competitive, and producers do bid their WTA, there will be no surplus left over to supplement farm income.

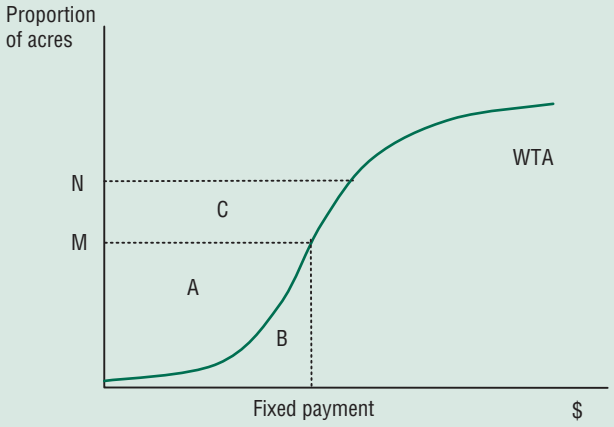
Stewardship Payments. Finally, unlike most agri-environmental programs that extend payments based only on practices that were to be adopted, stewardship payments are based on past conservation efforts. For example, under CSP, producers may qualify for payments based on practices that were adopted or installed before enrollment. In other words, so-called "good actors"—those producers who have already adopted or installed environmentally beneficial practices—can be rewarded with program payments.

Proponents argue that stewardship payments address a fundamental inequity in current programs—that good stewards will no longer be excluded from agri-environmental payment programs just because they have taken the initiative in addressing resource concerns on their farms. They criticize traditional U.S. agri-environmental payment programs for rewarding those who have done little to maintain or enhance environmental quality while good stewards have done so without payment. Some are concerned that producers will be reluctant to address resource concerns outside the context of a payment program for fear of being frozen out of current or future programs. There is also some concern that good stewards could find themselves at a competitive disadvantage and may subsequently abandon conservation practices or fail to maintain them in the absence of ongoing payments.

[4]Evidence suggests that policymakers have been successful in designing cost-effective programs using environmental indices and bid-based payments. In the CRP, policymakers have done both. The 1990 farm bill mandated a change in CRP enrollment procedures, from what was effectively a fixed payment without performance-based enrollment screening to a system with bid-based payments and performance-based screening (the Environmental Benefits Index). A 1999 study of the CRP (Feather et al.) found that use the use of EBI and bidding significantly improved the cost-effectiveness of that program. The study also noted that additional gains were possible through further refinement of the EBI.

Bidding and Budgets

Competitive bidding on conservation payments can help stretch a limited budget to achieve more agri-environmental gain than is possible using a fixed payment. In the figure, the "S"-shaped curve represents the distribution of the minimum payment producers would be willing to accept (WTA) in exchange for installing a practice or taking some other conservation-related action. The higher the payment rate (on the horizontal axis), the larger the proportion of land producers are willing to enroll in the program (see "Producer Willingness To Accept Payments," p. 8, for more details on WTA). When the payment rate is fixed across producers, the proportion of acres enrolled is represented by point M and program expenditure is represented by area A + area B. When producers bid for payments, a lower bid increases the likelihood of being enrolled in the program. If bidding is competitive and producers are unsure about the level of bid that will be accepted, they have an incentive to submit bids that equal their WTA. If so, the cost of funding conservation action on the proportion of acres represented by point M is reduced from A+B to A. The change frees some of the budget to fund additional acres up to point N. Area C, the cost of funding additional producers, is equal to area B, the savings from instituting a bidding system.



Savings due to bidding can be large. In the Environmental Quality Incentives Program (EQIP), where competition for enrollment has been very strong, cost-sharing and incentive payment rates were much lower than maximum rates when bidding was allowed (1996-2002). The average bid on cost-sharing for structural practices was 35 percent of cost, compared with a maximum of 75 percent. For management practices, bids averaged 43 percent of the maximum rate (generally established by practice and by county).

Finally, note that bidding alone does not make a program cost effective. Bidding generates a range of payment rates for practices. However, to create an environmentally cost-effective program, bidding can be used in conjunction with a performance-based enrollment screen to ensure that producers who do receive higher payments can also produce a higher level of environmental gain.

However, stewardship payments may do little to encourage new environmental gains. Opponents of stewardship payments argue that they divert funds from practice installation or adoption in budget-limited programs. Moreover, unless stewardship payments are positively correlated with potential for achieving environmental benefits and negatively correlated with producer WTA for taking the necessary action, they do little to encourage participation among producers who could (in addition to a history of good stewardship) take additional actions to improve environmental quality. As presently configured in the CSP, stewardship payments are based on land rental rates, which are unrelated to either environmental benefits or conservation costs (see box, "Correlating Costs, Benefits, and Rental Rates").

Payment Limitations. Regardless of payment mechanism, program payments can be limited on an annual basis or over a period of years. In terms of equity, payment limitations can ensure broader access to an agri-environmental program. However, farms large enough to be constrained by the payment limit may scale back their own participation or avoid the programs altogether. For example, large farms may register only a portion of their total operation or elect to install less expensive practices, even when other practices would be more environmentally effective.

Costs of Conservation Programs Include Administration and Monitoring

Environmental cost-effectiveness is not determined exclusively by the costs and benefits of establishing conservation practices on the ground. In the program implementation process, applicants fill out forms, administrators process them, and program managers monitor sites. *Transaction costs* include the government's cost of formulating the program (e.g., establishing payment rates), the producer's cost of submitting an application, the government's cost of assessing producer applications, and the government's cost of monitoring and enforcement.

Increased emphasis on working land conservation may increase the overall flexibility of U.S. agri-environmental policy as more producers have access to more programs. In theory, producers who seek to address resource concerns can select the lowest cost approach from a number of environmentally effective alternatives. However, environmental benefits and the cost of implementing a given conservation practice can vary widely by climate, soils, location (e.g., proximity to water), cropping patterns, and management skills. If program decisionmakers are to improve their ability to weigh contract offers using benefits and costs, additional research and/or data may be needed. The cost of information gathering increases as program managers seek to adjust program parameters to better differentiate applicants. The gains in cost-effectiveness need to be weighed against increasing transaction costs.

Environmental benefits are achieved only when producers comply with contract requirements, which require monitoring. Many irregularities are inadvertent and can be corrected with the cooperation of the producer. In some cases, however, penalties may be required. For some, the incentive to fulfill all contract requirements will partially depend on the likelihood that a contract will be selected for inspection, the likelihood that a penalty will be assessed once a violation is detected, and the potential size of the penalty.

Program managers may choose to monitor intensively, visiting many enrolled farms and thereby maximizing adherence. But this is costly: monitoring efforts will entail onfarm visits by qualified personnel who could otherwise be engaged in conservation planning or technical assistance. On the other hand, program managers may choose to minimize monitoring, visiting only a few farms or when there is reason to suspect irregularities. To a certain degree, it is possible to compensate for a minimal monitoring effort by increasing both the size and certainty of penalties. Even if detection is unlikely, the prospect of stiff sanctions may encourage careful compliance with contract requirements. Of course, stiff penalties may be unpopular with producers and inadvertent errors are more likely to go uncorrected with less monitoring.

In either case, it is important to consider the difficulty of monitoring in determining practice eligibility, practice-specific payment rates, and the role of specific practices in contract acceptance criteria. The extent to which practice implementation and maintenance can be observed varies widely. Consider the potential tradeoff between nutrient management and conservation buffers in

reducing nutrient runoff from cropland. Many nutrient management practices, including reduced application rates and better application timing, are difficult or impossible to monitor (Johansson, 2002). But nutrient runoff can also be intercepted before it leaves the field or enters a stream through filter strips, grassed waterways, or riparian buffers. The existence, adequacy of design, and maintenance of these buffer practices can be observed more easily than compliance with nutrient management plans. In both cases, the benefits of specific practices need to be weighed against their full costs.

Working-Land Payment Programs in Practice: EQIP and CSP

The Environmental Quality Incentives Program (EQIP) and the Conservation Security Program (CSP) are, at present, the largest U.S. WLPPs. EQIP and CSP are designed to address similar environmental problems on working lands, but various program design decisions have largely distinguished CSP from EQIP, so that these programs now represent the broad diversity of program designs that can be encompassed within the definition of the WLPP (table 2.2).

On one hand, EQIP is similar to previous conservation programs in that eligibility is broad. Payment incentives (cost-sharing or incentive payments) are based on the installation or adoption of new conservation practices that meet existing NRCS standards (the "non-degradation" standard) (see box, "Environmental Quality Incentives Program"). Producers need not reach any specific level of conservation effort or stewardship before becoming eligible, and there is no incentive for whole-farm conservation effort. Enrollment screening is based on an index that incorporates environmental benefits and costs. EQIP is heavily focused on livestock-related resource concerns and, since 2002, is often used to help large livestock operations comply with new Clean Water Act regulations on waste discharge.

On the other hand, CSP has introduced a number of nontraditional concepts into the agri-environmental policy debate (see box, "Conservation Security Program"). Unlike EQIP, CSP eligibility requires a substantial level of stewardship, and participation incentives encourage whole-farm conservation effort. Soil quality and water quality must be addressed (to existing NRCS standards) before land can be enrolled in CSP. Stewardship payments are available based on past conservation efforts. CSP also provides significant payments for "enhancements," which, to some extent, encourage producers to transcend existing conservation standards. Enrollment screening is also based largely on stewardship and the willingness to pursue conservation effort beyond minimum program requirements. While many livestock-related practices can be eligible for CSP, livestock waste management structures and handling equipment are specifically excluded. Finally, CSP is available nationally, but only in selected watersheds for any given signup. All 2,100 U.S. watersheds are to be eligible once over an 8-year period (2004-2012).

Table 2.2—EQIP and CSP designs

Program feature	EQIP	CSP
Budget	2004 contract obligations totaled $903 million. A total of $5.8 billion is authorized for 2002-2007.	2004 contract obligations totaled $35.2 million. A total of $6 billion is authorized for 2002-2011.
Conservation standard	Producers must address resource concerns to standards in existing NRCS handbook (referred to as “non-degradation”).	Standards in existing handbook ("non-degradation") are minimum. Through enhancement payments, CSP can encourage producers to go beyond this standard.
Eligibility	• Both crop and livestock production (in 2003, 33% to crop-related practices; 67% to livestock practices). • Emphasis on assisting livestock operations to comply with new Clean Water Act regulation. • No previous conservation effort required. • Only newly installed practices can be funded. • Available nationally.	• All agricultural land (in 2004, 67% to cropland; 33% to range and pasture land). • Animal waste storage or treatment facilities are not eligible. • Soil and water quality concerns must be addressed before land can be enrolled in CSP. • Existing practices eligible for payments. • Available nationally, but only in selected watersheds for any given signup. All 2,100 U.S. watersheds to be eligible once during 8-year period.
Enrollment screen	Performance-based “offer index.”	“Category” system based on level of conservation effort above minimum requirement.
Participation incentives	Fixed payments: • Cost sharing (typically 50%) on structural and vegetative practices; • Incentive payments for management practices. No annual payment limitation. The sum of all EQIP payments to an individual or entity cannot exceed $450,000.	Fixed payments: • Stewardship and existing practice payment based on land rental rates. • Cost-sharing for new practices. Performance-based payments: • Enhancements based, in part, on environmental performance Payments limited by tier: Tier 1 = $20,000 max annual payment Tier 2 = $35,000 max annual payment Tier 3 = $40,000 max annual payment.

Environmental Quality Incentives Program (EQIP)

EQIP was established by the 1996 Federal Agricultural Improvement and Reform Act as an innovative voluntary conservation program to provide assistance to farmers who adopt conservation practices. Since its creation in 1996, EQIP has provided cost-share and incentive payments for conservation practices. EQIP contracts specify a conservation plan, which outlines what changes in farming practices are planned and how these changes address environmental concerns in the area.

Budget—The initial funding level of $200 million annually was insufficient to meet demand early on, with 65 to 70 percent of applications turned down in the first 2 years. This rejection rate discouraged subsequent farmers from applying, as indicated by a steady reduction in the number of applicants from 1997 to 2001.

The Farm Security and Rural Investment (FSRI) Act of 2002 authorized funding at a total of $5.8 billion from 2002 through 2007, nearly a five-fold increase in annual funding. The increased budget, combined with more inclusive eligibility criteria for practices and the allowance of contracts up to $450,000, attracted a broader pool of applicants than previously. Applications doubled from 2001 to 2002, maintaining the competitiveness of the enrollment process.

Eligibility—Both crop and livestock producers are eligible for EQIP. Currently, 60 percent of EQIP funds are designated to address livestock-related resource concerns. Over 250 acceptable conservation practices are eligible for EQIP funding. Such flexibility enables a more efficient addressing of resource concerns. If the set of eligible practices is limited, practices appropriate to some situations or regions may be excluded, leading to an outcome that is less cost effective.

As of 2002, EQIP no longer limits eligibility for funding of waste treatment structures to smaller animal feeding operations (fewer than 1,000 animal units). Water quality may benefit by allowing larger animal facilities to compete for program funds. Many of these larger facilities face new Federal water quality regulations, and EQIP funds may be used to help producers comply. (One of the objectives set out for EQIP in both the 1996 and 2002 Farm Acts is to provide assistance to "help farmers and ranchers meet Federal, State, Tribal, and local environmental requirements.")

Enrollment Screens—The enrollment screens used in EQIP have changed over the program's life. Initially (as stated in the 1996 FAIR Act), EQIP's principal objective was to achieve the greatest possible environmental benefits per dollar of program expenditure. Under the 1996 program, at least 65 percent of EQIP funds had to be allocated to specially targeted priority areas, with local workgroups determining priority resource concerns and allocating funds. Nearly 41 percent of all applicants within a priority area were accepted, versus 24 percent outside a priority area. Furthermore, an "offer index" was calculated by NRCS for each proposed conservation plan by considering the environmental benefits and the cost-share request for each practice. Applications were ranked according to this offer index. In 2002, Congress de-emphasized benefit-cost targeting by eliminating the requirement to "maximize net environmental benefits per dollar expended" and eliminated priority areas. The offer index was retained.

Participation Incentives—EQIP offers contracts ranging from 1 year (after the implementation of the last scheduled practices) to 10 years. These contracts provide fixed-rate payments (incentive payments and fixed cost-shares) to implement new conservation practices. By funding conservation practices yet to be introduced, all EQIP funds are meant to actively contribute to environmental improvement.

For structural and vegetative practices, farmers are reimbursed a share of their costs not to exceed 75 percent (90 percent for limited-resource and beginning farmers and ranchers). However, most practices will be cost-shared at 50 percent. Cost-shares between 50 and 75 percent require special approval by State conservationists, but can be provided on those practices deemed most effective at addressing local resource concerns.

For management practices, EQIP incentive payments may be provided for up to 3 years. These payments are set at the local or State level by considering the amount necessary to encourage producers to participate, given additional costs or risks incurred by the producer, including lost production.

The 2002 FSRI Act eliminated the "bid down" procedures, by which operators could improve the offer index of their applications by reducing the amount of payment they would accept. Between 1996 and 2002, when bidding procedures were in place, the overall national average cost share rate was 35 percent for structural practices and incentives payments were, on average, 43 percent of maximum rates. The elimination of bidding may increase the cost of individual EQIP contracts, reducing the level of conservation that can be funded with a given budget.

The FSRI Act also increased the flexibility of EQIP contract design. It increased the maximum payment to $450,000 for all contracts held by a producer through 2007, and eliminated the limitation on annual payments. The 2002 FSRI Act also allows for contracts to expire 1 year after the date of the installation of the last practice, even though practices have to be maintained. And rules now allow for more than one contract per tract. These changes allow more environmental concerns to be addressed, appeal to large-scale producers who may have felt that previous payments were insufficient, and reduce the risk of long-term contractual obligations.

Implementation—The EQIP competitive bidding process before 2002 may have induced some farmers to enter into an untenable agreement due to overcompetitive bidding. The potential remorse was compounded by the limited enforcement capabilities of the conservation authority to ensure that the contract was carried out in its entirety. In fact, 17 percent of the contracts were not being implemented in full due to structural problems with the program incentives (Cattaneo, 2003). These contract withdrawals often resulted in the loss of funds allocated to these practices. (Funds for canceled practices are now recycled by the program, so the negative impact of cancellations is more limited.)

Conservation Security Program (CSP)

The Conservation Security Program (CSP) may be the first in a new generation of conservation policy. As structured by Congress, CSP could fill the traditional role of conservation programs—providing incentives for improving the environmental performance of farms—and some not-so-traditional roles—such as providing ongoing rewards for good environmental performance. CSP will also stress "enhancements." Enhancements could be used for a number of purposes, including addressing local resource concerns. Unlike previous programs, however, some enhancement payments will encourage the adoption of practices or activities that go beyond minimum standards of addressing a specific resource concern (e.g., soil quality) as defined in the NRCS Field Office Technical Guide (USDA-NRCS, 2004a). To address a soil quality concern, for example, producers are required to reduce soil erosion to at least the soil loss tolerance ("T") level. Through enhancements, however, CSP could encourage producers to reduce erosion to even lower levels or in other ways improve the quality of their soils.

Budget—CSP was originally enacted as an entitlement, meaning that all eligible producers who wished to participate would be enrolled. However, CSP funding was capped at $41 million in fiscal year 2004, limiting implementation to 18 selected watersheds. In 2005, CSP funding is $202 million and signup will encompass 220 watersheds. Unless and until the budget cap is lifted, CSP enrollment is effectively a competitive program—producers' participation offers can be rejected.

Eligibility—CSP eligibility is broad in terms of producers and land types—cropland, pasture, and range—but is open only to producers who have already addressed soil quality and water quality concerns on at least part of their agricultural operations. Only those acres where these resource concerns have been addressed can be enrolled in CSP. For any given signup period, CSP eligibility is also limited to a set of selected watersheds. NRCS will enroll producers in 220 watersheds in 2005, with plans to make all 2,100 U.S. watersheds eligible for CSP enrollment once over the next 8 years. Both crop and livestock operations are eligible, but livestock waste management facilities are explicitly excluded from CSP.

Enrollment Screens—In CSP, applicants are ranked by categories based stewardship and on their willingness to take on additional conservation effort during the contract. In 2004, producers were placed in the lowest category (least likely to be enrolled) if they met only the basic requirements of the program (i.e., have addressed soil and water quality concerns). In the highest category, producers agreed to implement multiple enhancement practices and activities. The category system may or may not be used in any given signup, depending on the number of applicants and the CSP budget.

Participation Incentives—In CSP, eligible producers can participate in one of three CSP "tiers," based on the extent to which the entire farm and all associated resource concerns are addressed. Higher tiers require a greater minimum level of conservation effort but also offer higher payments. Minimum conservation requirements, by tier, include:

- In tier I, producers may enroll that portion of their farm on which soil and water quality concerns have been addressed at least to existing handbook standards. Tier I contracts are for 5 years and can be renewed only if the producer expands conservation efforts to a larger share of the farm or additional resource concerns.
- For tier II, producers must address soil and water quality concerns on their entire farm. Contracts are for 5-10 years and can be renewed without further action.
- In tier III, producers must address all resource concerns on all land in the farming operation. Tier III contracts are for 5-10 years and can be renewed without further action.

CSP offers several types of payment, some of which reward past stewardship and help producers maintain previously installed practices. "Stewardship" and "existing practice" payments are based, roughly, on a percentage of the county average rental rate for the specific type of land involved (rental rate data from several sources were combined by USDA, then adjusted to ensure consistency and equity at local and regional levels). For the 2005 CSP signup, stewardship payments are equal to 11.25 percent, 5.0 percent, and 1.25 percent of these rates for tier III, tier II, and tier I contracts, respectively. Where the CSP stewardship rate is $75 per acre, for example, the annual stewardship payments—paid in each year of the contract—would be $8.44, $5.63, and $0.94 per enrolled acre, for tiers III, II, and I. Existing practice payments, which are designed to ensure maintenance of previously installed practices, would be 25 percent of the stewardship payment.

New practices can be cost-shared through CSP at a rate of up to 50 percent. Limited resource farmers and beginning farmers may be eligible for higher cost-share rates. For example, producers may install or adopt new practices as part of a CSP contract in which they agree to move to a higher tier. These payments made up only a very small portion of overall CSP payments in 2004.

Finally, payments for environmental "enhancements" accounted for about two-thirds of all CSP payments in 2004. Enhancements address local resource concerns (e.g., resource concerns other than the nationally significant concerns of soil quality and water quality) and encourage practices or activities that improve or enhance resource quality beyond the minimum (non-degradation) standard. In a number of cases, enhancement payments are based not on cost but on environmental performance as measured by indices like the soil condition index. Payments are to be based on the improvement in index values, ensuring that payments reflect likely environmental gains.

Overall payments (stewardship, existing practice, and enhancements) are limited to $20,000 per year per farm in tier I, $35,000 in tier II, and $45,000 in tier III. Stewardship payments are also limited to $5,000 per year for farms in tier I, $10,500 in tier II, and $13,500 in tier III.

Chapter 3
Economic and Environmental Impacts of WLPPs

Recent implementation of working-land payment programs and new flexibility in their design raise many questions. To what degree can EQIP or CSP improve producers' environmental performance? What are the tradeoffs between improving the environment and supporting farm incomes? How might changes in these programs, such as budget levels or enrollment options, affect their outcomes? Very little data are available to assess the cost-effectiveness of programs such as EQIP or CSP. Instead, simulation models can illustrate the nature of tradeoffs implied by different program design decisions. Given the importance of these questions and the scarcity of data, this chapter uses empirical simulations to examine how alternative designs for working-land payment programs affect returns to agricultural production, consumer welfare, and the environmental performance of working croplands.

Measuring Environmental Performance

The process of cultivating crops generally results in the discharge of pollutants into water and air, which may cause human or ecological damage.[1] Working-land payment programs are designed to reduce the discharge of pollutants by encouraging use of "better" management techniques, such as conservation tillage and reduced fertilizer applications. Cost-effective WLPP design requires a measure of how these better practices affect the environment. Estimating one environmental impact is difficult by itself, but when the desire is to address multiple environmental criteria, administering program payments cost effectively becomes even more complicated. To measure overall changes to the environment resulting from WLPPs, we use an Aggregate Environmental Index (AEI). This index is similar to the Environmental Benefits Index used by USDA to assess CRP contracts.

[1]Although pasture and rangeland are also eligible for enrollment in existing WLPPs, we focus our analysis on cultivated cropland.

To construct the AEI, we link crop management practices and regional topography to estimate a cropping system's impact on the resource concerns deemed most harmful to regional ecosystems. We denote the cropping systems with a subscript "i," resource concern with a subscript "j," and region with a subscript "k." This impact factor is denoted I_{kji}. We consider nine resource concerns: nitrogen discharged to surface waters, nitrogen leached into ground water, phosphorus discharged into surface waters, pesticides discharged into surface waters, pesticides leached into ground water, sediment eroded into surface waters, soil eroded via the wind into the atmosphere, carbon emitted into the atmosphere, and loss in long-term soil productivity.[2] The individual impact factors are used to generate an Aggregate Environmental Index score, AEI_{ki}, reflecting the impact of that system on the environment as a whole: $AEI_{ki} = f(I_{kji})$. Several formats have been used in the past to construct such measures of environmental quality. This report uses a weighted sum of the individual environmental indicators:

[2]See Appendix B (www.ers.usda.gov/publications/err5) for more details.

$AEI_{ki} = \sum_j w_{kj} I_{kji}$, where w_{kj} are regional weights for the different resource concerns. Ideally, the weights chosen would reflect socio-economic preferences for mitigating the various pollutants (Heimlich, 1994). We construct several different weighting schemes (see box, "Weighting Multiple Environmental Criteria"), but for most of our analysis we use weights based on how EQIP contracts have valued different resource concerns in different regions.

Constructing Alternative WLPP Designs

We start with six hypothetical working-land payment programs (table 3.1). Each program contains one or more of the design features discussed in earlier chapters—whether previous conservation efforts are rewarded in or required for participation, whether incentives are based on practices or on performance, and whether farmers are screened according to the relative benefits and costs of their WLPP contract.

To compare alternative designs, we hold several program features constant. Each program design is simulated subject to a fixed budget. However, we

Weighting Multiple Environmental Criteria

Developing weights that reflect society's preference for different environmental benefits is difficult. Many studies ask respondents how much they are willing to pay for a reduction in their exposure to certain chemicals, such as nitrates in drinking water supplies (Crutchfield et al., 1997). Others determine how valuable variable recreation opportunities are to the public (e.g., Feather et al., 1999) or how asset values are affected by variable environmental quality (e.g., Kim et al., 2003).

However, in the absence of national or local surveys that can be applied across multiple environmental criteria, we use data about how policymakers have valued past efforts at addressing multiple environmental criteria. How public preferences translate into policymaker expenditures and mandates is well documented (Variyam and Jordan, 2001; Besley and Burgess, 2002; Dixit et al., 1997; Crémer and Palfrey, 2002). Looking explicitly at conservation programs Bastos and Lichtenberg (2001) noted that incentive payments are linked to public preferences for environmental quality. Moreover, while the link between policy expenditures for working-land payment programs, environmental standards, and public preferences may not be completely transparent, Reichelderfer and Boggess (1998) noted that policymakers could learn and improve the cost-effectiveness of conservation program controls.

Therefore, we use stated weights taken from the Conservation Reserve Program's Environmental Benefits Index and expenditure data from EQIP contracts to essentially "reveal the preference" of policymakers in reducing one pollutant vis-à-vis another. This method is appropriate for two reasons. First, it shows how multiple environmental criteria are valued under voluntary conservation programs. Second, CRP and EQIP do not weight actual physical measures of pollutant abatement, but weight management practices more or less depending upon how they are expected to result in environmental benefits, which is how we have constructed the Aggregate Environmental Index. See Web Appendix B (www.ers.usda.gov/publications/err5) for more details.

Table 3.1—Alternative program designs

Policies	WLPP policy options		
	Budget constraint	Stewardship payments	Performance screen
Practice-Based			
(1) Good-Act (ongoing and new practice adoption)	Regional	X	
(2) Practice (new practice adoption)	Regional		
Performance-Based			
(3) Performance (new performance standard)	National		
(4) Hurdle-Low (ongoing performance above low reference level)	National	X	
(5) Hurdle-High (ongoing performance above high reference level)	National	X	
(6) Bid (new performance standard)	National		X

run multiple simulations for each program at different budget levels in order to map aggregate payments to environmental performance. All cropland currently under production is assumed eligible for program participation, and this acreage is kept constant throughout our modeling horizon. Since this report examines working-land payment programs, we do not examine program payments for enhanced environmental performance on land retired from production. Also, CSP limits eligible cropland to land that had been cropped prior to enrollment. Our model does not incorporate pasture or rangeland, although we recognize that these lands can be enrolled in either EQIP or CSP.[3]

Practice-Based Policies. Practice-based payments are fixed-rate incentive payments to producers who implement eligible conservation practices. Producers who can implement such practices at least cost are likely to benefit most from these incentives, regardless of the amount of environmental benefits achieved. Payments for practices deemed environmentally beneficial are modeled under *Good-Act* (a program that rewards ongoing and new conservation efforts) and *Practice* (a program that rewards only new conservation efforts). Here, we model those management practices that are intended to reduce soil erosion and improve water quality. They include cropping systems that employ conservation tillage, nutrient management, and conservation rotations. Given a range of potential regional payments for these management practices, the practice-based programs are simulated under various regional budgets.[4]

Under the hypothetical *Good-Act* program, eligibility for program payments does not discriminate between past or new conservation. Eligibility is constrained to apply to only those cropland acres that have been in active production. Therefore, eligible stewards who essentially have a zero WTA for their practices will be the first to accept program payments, limited by a regional budget. Once all eligible old practices have received program payments, new eligible practices are considered for participation.

[3]See Web Appendix A *www.ers.usda.gov/publications/err5/* for additional details of policy simulations.

[4]These practices represent approximately 90 percent of the nonlivestock, nonstructural EQIP contracts between 1997 and 2000 (FSA-EQIP database). Because the practice-based programs are less flexible than are the performance-based programs (fewer ways for producers to earn program payments), a regional budget restriction is imposed on the distribution of payments to producers similar to the distributional allocations of the EQIP budget. This ensures program participation will occur across all regions, even at relatively low program budgets. We do not use regional budget constraints for the performance-based simulations. There, producers can receive payments for any improvement in environmental performance regardless of the practice adopted, so participation is less likely to favor one region over another. See Web Appendix A *www.ers.usda.gov/publications/err5/* for details.

Next, a practice-based program (*Practice*) without stewardship payments is simulated using the same program payments, where eligibility is strictly limited to new adoption of practices. Stricter eligibility is likely to improve environmental cost-effectiveness, but to the extent that the program payments (including stewardship payments) do not completely cover implementation costs, the program will not provide as much income support as *Good-Act*. As before, new production acres are not eligible for payments under this program. These depictions of two different practice-based programs illustrate the tradeoff between providing stewardship payments and providing payments for newly adopted practices.

Performance-Based Policies. Performance-based policies use either performance-based payments or bid-based payments in conjunction with performance-based screens to steer participation toward producers who can deliver environmental gain at low cost. For the performance-based scenarios, payments are based on changes to the environment as measured using the Aggregate Environmental Index; i.e., payments received by participants are modeled as a function of physical effects that will likely affect environmental performance. Under the first performance-based program (*Performance*), the policymaker establishes a fixed price for environmental performance and any producer is eligible for payments based on the degree to which environmental performance increases. There are no stewardship payments attached to these contracts.

The next performance-based program (*Bid*) steers participation toward the same producers as in *Performance*, but at a lower cost using competitive bidding and performance-based screens. In these scenarios, the simulation model mimics a program in which (1) producers submit bids that include both the actions to be undertaken and the level of payment they would accept, and (2) bids are accepted or rejected on the basis of projected environmental benefits (again measured by the AEI) and costs. Here, producers submit bids for financial assistance that are at or near their WTA, minimizing the program expenditure necessary to gain their participation. Those producers who can deliver the most environmental gain per dollar will be selected for participation, up to limits imposed by the program budget.

Another type of performance-based program combines performance-based payments with stewardship payments, but limits eligibility to producers who have already achieved environmental performance above a fixed "reference level" (see Claassen et al., 2001; Johansson et al., 2002). We examine two reference levels. The first reference level (measured using the AEI) is set relatively low (*Hurdle-L*), such that 33 percent of farms (38 percent of current acres) are eligible for program payments even if they do not engage in new conservation efforts. The second reference level (*Hurdle-H*) is set higher, such that only 25 percent of farms, representing 20 percent of current acres, are eligible to receive payments without implementing new conservation practices. Here, the program decisionmaker sets a given price for each AEI point generated above the reference level, and then opens the program for enrollment.

Simulating Producers' Adjustments to Policy. Our model simulates how different agri-environmental program designs can encourage farmers to alter

production and management practices, and how these changes may affect production and, as a result, commodity prices. An environmental process model estimates the environmental changes flowing from adjustments to cropping and management practices prompted by program payments. Linking production practices (such as crop rotation, irrigation, tillage, and fertilizer application rate) to an environmental model in this fashion illustrates how different WLPP designs result in different economic and environmental effects across sectors and regions (fig. 3.1).[5] We examine these effects in the medium run (e.g., 5-10 years), meaning that we model changes in price and production levels, but we assume that technology (e.g., types of cropping systems) and the resource base (e.g., the amount of land in crop production) are constant.

[5]For a more detailed description of the modeling, see Web Appendix A *www.ers.usda.gov/publications/err5/.*

You Get What You Pay For

For a given budget, the *Performance* and *Bid* programs achieve much greater improvements in environmental performance than the practice-based programs. Whereas practice-based payments provide fixed payments for eligible practices, performance-based programs link either payment amounts or the likelihood of participation to a practice's efficacy at, say, reducing soil erosion or pesticide leaching. In this manner, practices that most improve environmental performance will receive the highest payment or will be most likely to be enrolled, while those practices that marginally improve environmental performance will receive a lower payment or will be less likely to be enrolled.

Increasing Costs of Environmental Performance. At the national level, as producers improve environmental performance on cropland, it becomes more costly and requires more program payments for each additional unit of performance (fig. 3.2). Program designs do differ in the degree to which increasing environmental performance is associated with progressively higher

Figure 3.1
Simulation methodology

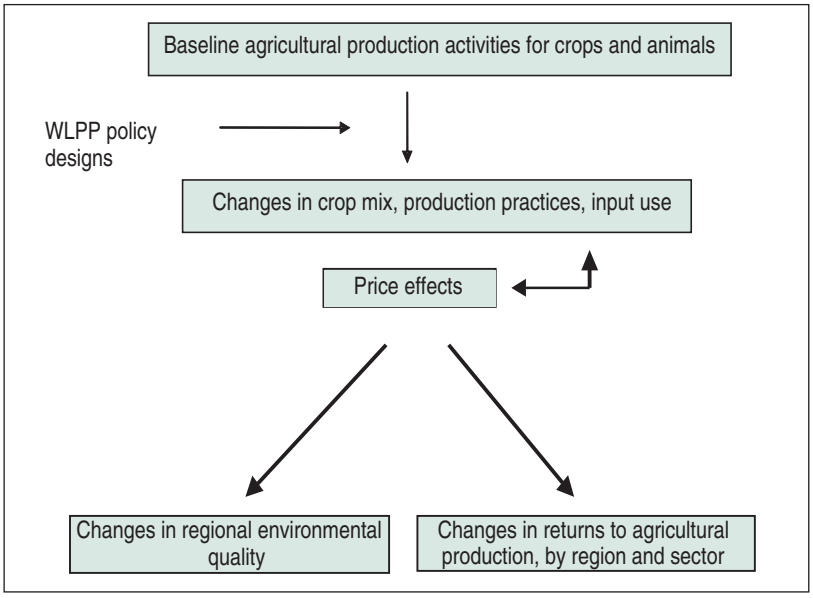
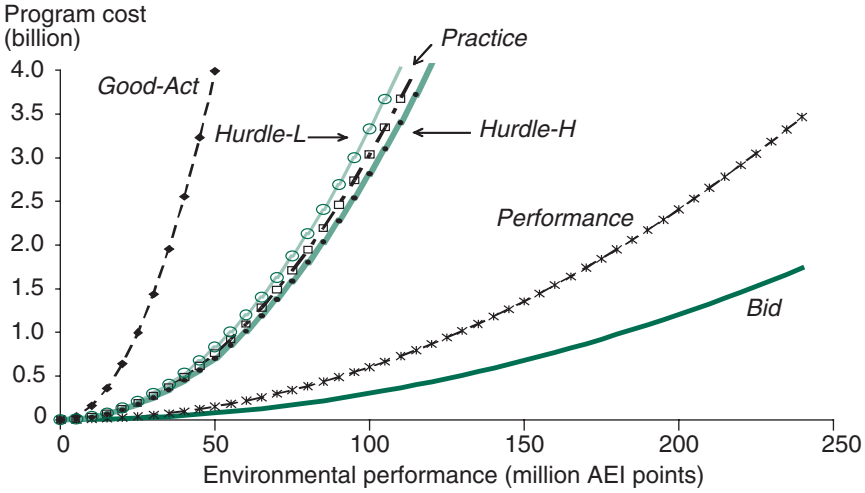


Figure 3.2
Enhancing aggregate environmental performance on working lands



program payments. For example, the more constrained payments are, the less likely they will be sufficient to cover producers' WTA for new practices. However, producers' WTA for old practices is essentially zero, which means the provision of stewardship payments increases the cost of the program per environmental increment if old and new practices compete for payments, especially at lower budget levels. Results show that at the $250-million level, *Practice* (where only new practices are eligible) achieves 12 times the improvements in environmental performance achieved by *Good-Act* (a program that rewards both new and old practices). At the $500-million level, *Practice* is still four times more cost effective than *Good-Act*. This illustrates that, under our depiction of stewardship payments, at lower budget levels a larger proportion of funds is devoted to rewarding past stewardship than is directed toward new conservation efforts. Under other designs, program decisionmakers might fix the percentage of the program budget that is to be set aside for stewardship payments and for new conservation efforts.

Unless stewardship payments are positively correlated with potential for achieving new environmental benefits and negatively correlated with producer WTA for taking the necessary action, they do little to encourage participation among producers who could (in addition to a history of good stewardship) take additional actions to improve environmental quality. As configured in our model and in the Conservation Security Program, stewardship payments are based on land rental rates, which may be unrelated to either environmental benefits or conservation costs.[6] Such payments differ from those of other working-land payment programs, which base payments primarily on practice installation or adoption cost. Because stewardship and existing-practice payments are tied directly to land rental rates, producers have the greatest incentive to participate when land rent is high and the cost of addressing resource concerns is low. Given this incentive structure, a CSP-type program will direct participation incentives toward high-benefit, low-cost producers, land, and practices *only* to the extent that environmental benefits are positively correlated with land rents used to establish the base payment and negatively correlated with conservation costs, which is unlikely (see "Correlating Costs, Benefits, and Rental Rates," p. 15).

[6]See Web Appendix C *www.ers.usda.gov/publications/err5/* for more discussion of correlating costs, benefits, and rental rates.

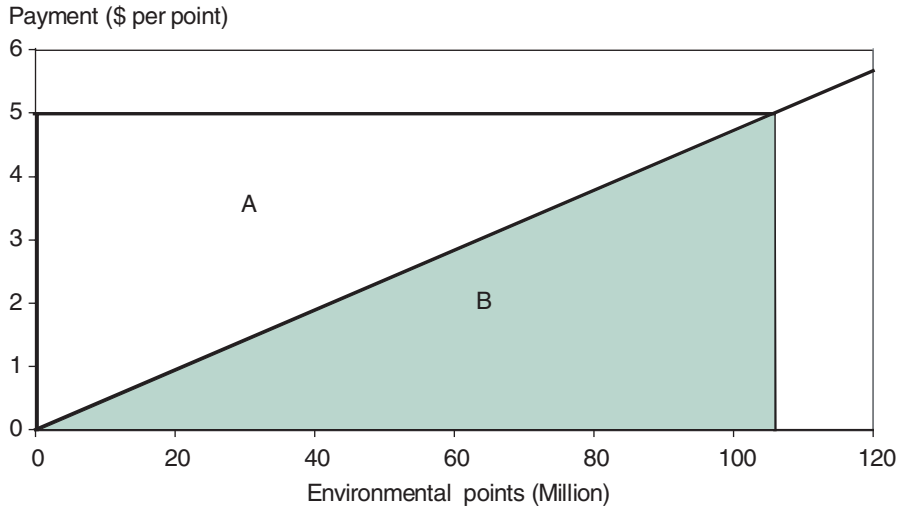
The performance-based, hurdle programs mimic a good-actor type of program by providing payments for cropping systems already performing above the reference level. The higher the reference level, the less likely producers will receive payments based on what they are already doing. However, the higher the reference level, the fewer ways there are for producers to reach the hurdle. This loss in flexibility will also inflate the cost of the program. Yet, because payments are based on performance, they are more cost-effective than *Good-Act*. They achieve improvements in environmental performance at costs similar to the *Practice* program.

Why Bidding Increases Cost-Effectiveness

By comparison, the performance-based programs, *Performance* and *Bid*, produce more environmental gain per dollar of program expenditure (i.e., flatter supply curves for environmental benefits—fig. 3.2) than the other program designs. Payments for *Performance* are equal to a fixed payment per point multiplied by the amount of environmental benefits generated by the contract, as measured by the AEI. For example, a *Performance* payment of $5 per AEI point would result in a 10-percent increase in environmental performance (or 110 million AEI points) from current levels (fig. 3.3). The annual program payments under *Performance* would be approximately $550 million (areas A+B in fig. 3.3). When producers bid for payments, they can increase the likelihood of being enrolled in the program by submitting a low bid. If program enrollment is competitive, producers have incentive to submit bids that equal their WTA. We take cost as a proxy for WTA, so that aggregate payments in *Bid* are equal to the area under the payment—marginal benefits curve, or the shaded triangle (B) in fig. 3.3, approximately $275 million.

Environmental Cost-Effectiveness. Another way to compare programs is to fix the budget and measure environmental cost-effectiveness (table 3.3). Holding the budget fixed at approximately $1 billion,[7] we see that a performance-based program with bid-down provisions (*Bid*) could improve

Figure 3.3
Payments and program costs—performance-based WLPP



[7]This is roughly equal to projected average annual EQIP expenditures between the years 2002-2007 (www.ers.usda.gov/Features/farmbill/titles/titleIIconservation.htm#working, 2003).

Table 3.3—Environmental performance at the $1-billion level

Region[1]	*Good-Act*	*Hurdle-L*	*Hurdle-H*	*Practice*	*Performance*	*Bid*
	% Increase in environmental performance					
Northeast	0.9	1.2	2.9	0.8	4.3	6.3
Lake States	0.0	0.3	1.0	4.1	8.7	15.4
Corn Belt	0.0	8.0	8.5	10.3	12.0	13.2
Northern Plains	0.5	0.8	2.3	2.2	12.4	17.4
Appalachia	0.0	2.4	4.0	6.4	11.5	13.9
Southeast	5.8	1.8	1.8	5.7	9.3	15.2
Delta States	5.8	2.4	2.4	5.8	15.5	19.9
Southern Plains	4.3	2.1	4.4	4.3	10.3	15.0
Mountain	2.1	1.3	2.1	2.0	14.8	20.9
Pacific	4.1	1.1	7.0	4.1	7.8	11.9
United States	1.3	3.3	4.4	5.6	11.7	15.5

[1]Northeast = CT, DE, MA, MD, ME, NH, NJ, NY, PN, RI, VT; Lake States = MI, MN, WI; Corn Belt = IA, IL, IN, MO, OH; Northern Plains = KS, ND, NE, SD; Appalachia = KY, NC, TN, VA, WV; Southeast = AL, FL, GA, SC; Delta States = AR, LA, MS; Southern Plains = OK, TX; Mountain = AZ, CO, ID, MT, NM, NV, UT, WY; Pacific = CA, OR, WA.

environmental performance (as measured by the AEI) by more than 15 percent over current production patterns. Without the bid-down provisions, such a program (*Performance*) could improve environmental performance by nearly 12 percent, relative to base production patterns. A practice-based program with good-actor payments (*Good-Act*) might increase environmental performance by about 1 percent. However, without stewardship payments, a practice-based working-lands program (*Practice*) might enhance environmental performance by about 5.6 percent.[8] Both of the hurdle programs (*Hurdle-H* and *Hurdle-L*) have lower environmental cost-effectiveness than Practice at this budget because they pay for already existing conservation practices.

This highlights the fact that, overall, programs that pay for practices already established are generally less cost-effective than those that do not. A performance-based program with bidding provisions achieves environmental improvements at an average cost of $6 per aggregate environmental point; without the bidding provision, the average cost of enhancing environmental performance by one point increases to $8. The average cost under a practice-based program without stewardship provisions more than doubles to $17 per point, and increases to $73 per point when "good actors" are eligible for payments based on past implementation of conservation practices.

These results also show how improvements in environmental performance vary across program designs and across regions. For example, under the *Bid* program, the Northern Plains, Mountain, and Delta regions improve environmental performance the most, whereas under *Good-Act*, the Southeast, Delta, and Southern Plains improve environmental performance most.

[8]Two additional policies were considered, whereby the constraints on the regional distribution of practice-based payments were dropped. Under the altered *Good-Act* program, there is no improvement in environmental performance; i.e., eligible good actors soak up the entire $1-billion budget. Under the altered Practice program, cost-effectiveness is marginally higher.

Equity Concerns May Limit Cost-Effectiveness

Payments under the two practice-based programs are subject to regional budget constraints based on historic EQIP payments (see Web Appendix A *www.ers.usda.gov/publications/err5/* for additional details). This ensures that all regions will have participants, even at low national budget levels. However, it also lowers the cost-effectiveness of these programs. For example, under *Good-Act*, when producers are eligible for stewardship payments, not all eligible acres are able to participate in the program at lower budgets (fig. 3.4). The regions with the highest demand for participation, given fixed regional budgets, are the Corn Belt and Lake State regions because there are already many producers using payment-eligible practices. Even at $1 billion, acres that are eligible for stewardship payments are unable to participate, which indicates that in these regions no new practices are being adopted. It is only at $1.5 billion in funding that all eligible acres in these regions are able to receive stewardship payments. When all producers receive payments for practices they are doing already, the program can start to encourage the adoption of new practices.

Also, practice-based payments are differentiated by region, but the ability of funded practices to produce environmental benefits is not homogenous within a region or across regions. Performance-based programs have more potential to increase environmental performance on working lands. By basing payments on estimated environmental performance rather than on practices, they account for dissimilarity in practices and regions. Therefore, certain regions will have lower costs of generating benefits than others. For example, under the *Performance* scenario, producers in the Northern Plains are able to improve environmental performance at least cost, whereas the costs of improvement are highest in the Northeast (fig. 3.5).

Figure 3.4
Percentage of eligible acres in the Lake States and Corn Belt that can participate in *Good-Act*

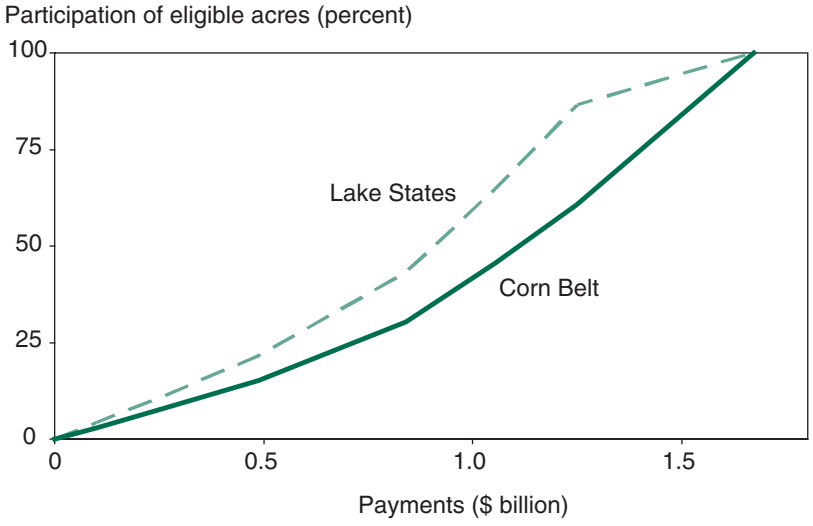
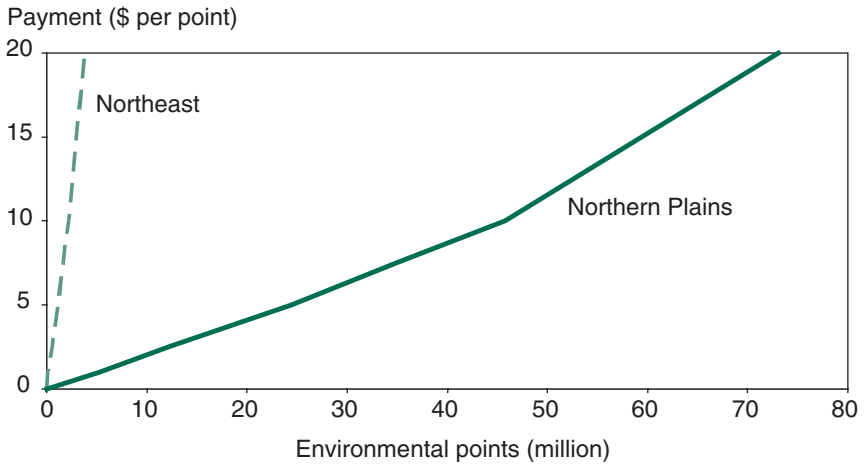


Figure 3.5
With regional EQIP weights, cost of improving environmental performance in the Northern Plains and Northeast under a performance-based program



Weights Matter to Outcomes

How the aggregate environmental index is created will also affect who participates in the performance-based programs. Until this point in our analysis, environmental performance has been measured using an AEI derived from regional EQIP weights. However, we devised five other weighting schemes for use in constructing the AEI to illustrate how environmental performance might be influenced by program decisionmakers' preferences across resource concerns (table 3.4). The first three schemes are derived from the CRP: national-level weights, regional weights incorporating environmental preferences, and regional weights without soil productivity. The fourth and fifth weighting schemes are derived from national and regional expenditures on EQIP contracts. The sixth scheme weights all environmental criteria equally across all regions.[9]

We compare these six weighting schemes under the *Performance* design holding the budget fixed at $1 billion (table 3.5). Under all weighting schemes, the improvements in environmental performance are quite similar when aggregated to the national level. However, the regional CRP weights (scheme 2) enhance environmental performance more than the national CRP weights (except for wind erosion). Thus, a national preference for reduced wind erosion may diminish the potential to address other resource concerns, at least in aggregate. However, with EQIP-derived weights (except for pesticide runoff), focusing on regional preferences may impair overall reductions at the national level.[10]

Some argue that soil productivity is not a resource concern because producers are self-motivated in that respect (Trimble and Crosson, 2000). What might result if soil productivity was not directly rewarded under such programs? One way to look at this is to give soil productivity loss a zero weight (scheme 3). Similarly, under a simple uniform weighting scheme (scheme 6), the weight on soil productivity is identical to those of the other indicators; i.e., it receives a lower weight than in four other weighting

[9]See box, "Weighting Multiple Environmental Criteria," p. 24, and Web Appendix B *www.ers.usda.gov/publications/err5/* for more details of these weights.

[10]These comparisons might not hold if the other practices that are eligible under EQIP, including those for livestock producers, were included in the analysis.

Table 3.4—Options for weighting multiple environmental criteria

Weighting schemes	Description
1	National-level weights taken from the Conservation Reserve Program's Environmental Benefits Index (EBI)
2	Regional-level weights generated by applying regional values for environmental benefits to the national-level EBI weights (above)
3	As above, with a zero weight on soil productivity
4	National-level weights derived from aggregate EQIP expenditures
5	Regional-level weights derived from regional EQIP expenditures
6	Uniform weights across regions and indicators

Table 3.5—Effect of weights on environmental indicators[1]

	Reductions under alternative weighting schemes[2]					
Environmental indicator	1	2	3	4	5	6
	Percent					
Sheet and rill erosion	15	17	11	17	17	16
Nitrogen to ground water	14	18	14	16	14	13
Nitrogen to surface waters	12	13	9	14	13	12
Phosphorus to surface waters	15	16	10	16	15	14
Loss in soil productivity	295	307	57	350	323	176
Wind erosion	21	19	16	21	21	17
Carbon emissions	8	8	6	8	7	7
Pesticides to surface waters	4	8	8	6	7	13
Pesticides to ground water	8	13	9	10	9	12

[1]Here, estimated levels of pollutants are compared to base levels. See appendix table B-1 for base levels of annual discharge, leaching, and emissions.

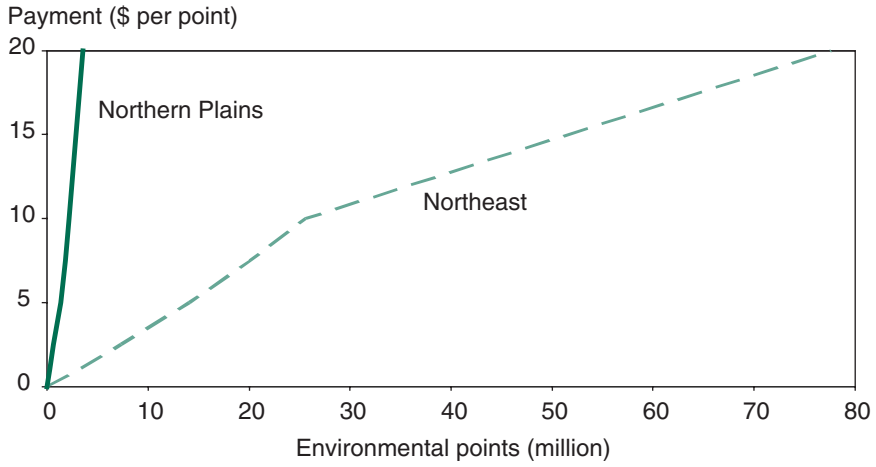
[2]No. 1 = national weights from the CRP; No. 2 = regional CRP weights; No. 3 = Regional CRP without soil productivity weight; No. 4 = national EQIP weights; No. 5 = regional EQIP weights; No. 6 = uniform weights.

schemes. As might be expected, reductions in soil productivity loss under these two weighting schemes are less than under the other weighting schemes, albeit still positive.[11]

Even though aggregate improvements in environmental performance are similar at the national level, regional results are more likely to depend upon the weights chosen. For example, if the weights chosen for environmental quality are developed using regional preferences for environmental quality, improvements in regions with higher population densities will be valued more than in regions with low population densities. This is evident in scheme 2, a performance-based program simulated using regional CRP weights (fig. 3.6). Under the assumption of population-based value, the Northeast is able to provide improvements in environmental performance at lowest cost; the highest cost regions are the Northern Plains and Southern Plains. The order of regional cost-effectiveness in achieving environmental improvements is essentially reversed, compared with regional EQIP weights

[11]When the percentage reduction in lost soil productivity exceeds 100, a soil productivity gain is indicated; i.e., when compared to baseline losses in long-term soil productivity, adjusted production patterns actually increased soil productivity.

Figure 3.6
With regional CRP weights, cost of improving environmental performance in the Northern Plains and Northeast under a performance-based program with regional CRP weights



(see fig. 3.5), which reflect regional **expenditures** on different resource concerns and not regional differences in the **value** of environmental quality improvement.

Different Programs Have Different Economic Impacts

Alternative program designs (including good-actor, hurdle rates, and bidding provisions) will affect returns to production, production levels, and prices differently. For example, programs that reward reduced soil erosion may also induce a change in residue management and the mix of crop rotations in a particular region, such as increased use of no-till cultivation. Such changes will affect crop yields and crop prices, and ultimately will result in a new equilibrium between crop and livestock supply and their demand across regions and sectors. We use our simulation model of regional agricultural production and consumption to examine the economic implications of new production and consumption patterns from different program designs.

Among the practice-based programs, *Good-Act* has smaller impacts on crop production than *Practice*, simply because most of the budget goes toward stewardship payments and no change in practices or production is required to receive program payments. On the other hand, bidding provisions should induce more crop adjustments than a fixed-rate performance-based program under equally funded programs. This is because the program payments are devoted entirely to paying producers' WTA for improvements in environmental performance. By contrast, under a fixed-rate, performance-based program such as *Performance*, producers can still receive payments that exceed their WTA (see fig. 3.3).

All WLPPs will influence returns to the livestock sector via their effects on feed crop supply and prices. Similarly, changes in commodity production will affect consumers' well-being; prices will change for commodities based on increasing or decreasing returns to agricultural production, and consumers

will end up paying more or less for foodstuffs. Moreover, taxpayers fund these programs, which is also an important element in the final calculus.

Because performance-based programs result in more changes to management practices, the economic impacts on all sectors are much more pronounced under the performance-based than practice-based programs (table 3.6) for a given budget ($1 billion). Under practice-based programs, higher returns to agricultural production result mainly from program payments (i.e., returns to crop production increase just above $1 billion), not from increased commodity prices, and thus cost taxpayers roughly the price of the working-land payment programs. That said, returns to agriculture increase under all the programs by more than the $1 billion in program payments. Still, not all sectors benefit from these programs. While crop producers benefit in general from practice- or performance-based programs, livestock producers and consumers do not.[12]

The returns to crop production under a $1-billion performance-based program would increase by nearly $2.6 billion. This includes the $1 billion in payments for conservation efforts, implying that an additional $1.6 billion accrues to crop producers based on changes in prices, production costs, and production levels. Livestock producers would face higher prices for their feed material, resulting in a decrease in overall returns by $400 million. This is partially due to a reduction in feed crop production[13] and higher feed prices for livestock and poultry producers. Returns to agricultural production increase by nearly $2.2 billion. Still, overall losses are $331 million, reflecting lost consumer surplus due to higher prices.

To calculate the net effect on society, that loss of $331 million must be weighed against the value of a 12-percent improvement in environmental performance on working cropland (see table 3.3). Underlying this 12-percent improvement in environmental performance is an estimated 17-percent reduction in sheet and rill erosion—about 36 million tons (table 3.5, column 5). A conservative estimate of the benefit of reducing sheet and rill erosion at the edge of the field is about $2 per ton.[14] The estimated 36-million-ton reduction to instream sediment loads from sheet and rill erosion results from reducing edge-of-field losses by approximately 166 million tons. Therefore, the value of reducing sheet and rill erosion alone could be as high as $332 million, which would offset the $331-million loss in overall surplus. Moreover, this does not incorporate the values of other environmental improvements attained simultaneously. In addition to the reductions in sheet and rill erosion, nitrogen leaching falls by 14 percent, nitrogen runoff by 13 percent, phosphorus runoff by 15 percent, soil productivity losses by more than 300 percent, wind erosion by 21 percent, carbon emissions by 7 percent, pesticide leaching by 9 percent, and pesticide runoff by 7 percent (table 3.5, column 5).

[12]This conclusion does not hold for working-land payment programs such as EQIP with specific livestock components.

[13]Under performance-based programs, farmers have an incentive to adopt less intensive management systems with lower overall crop yield and less environmental impact.

[14]Ribaudo et al. (1990) estimate the value of reducing soil erosion for recreational fishing to be $2 per ton ($2004). Other estimates include additional values, such as reduced dredging costs, reduced water treatment costs, and increased water-based recreation (e.g., $4 per ton—Hansen and Claassen, 2001).

Table 3.6—Economic impacts of stylized WLPPs (budget = $1 billion)

		Change[1]					
		Practice		Performance			
Sector	Base	Good-Act	Practice	Hurdle-L	Hurdle-H	Performance	Bid
				$ million			
Crop returns	32,744	1,059	1,273	1,205	1,210	2,560	3,182
Livestock returns	44,665	0	-80	-47	-42	-398	-570
Returns to agriculture	77,410	1,058	1,193	1,158	1,168	2,162	2,612
Overall gain/loss[2]	508,018	-79	-318	-186	-178	-331	-629
Change in environmental performance (percent)		1.3	5.6	3.3	4.4	11.7	15.5

[1] These changes are relative to the USDA baseline projections for the year 2010 (USDA, WAOB, 2001).
[2] Overall gains or losses include changes in returns to agricultural producers and changes in consumer surplus in addition to any deadweight losses associated with movement from the initial steady-state equilibrium. The value of the environmental benefits obtained under these scenarios is not included in the calculations.

Conclusion

The modest size of EQIP prior to 2002 and the implementation of CSP in 2004 means there are little data to assess their outcomes directly. But through simulation models, as undertaken in this chapter, unanswered questions can be explored over a range of program designs—i.e., budget levels, enrollment options, eligibility criteria—and across the heterogeneous landscape of U.S. agriculture.

- *To what extent can programs improve producers' environmental performance?* At funding of $1 billion, a performance-based program with bidding provisions achieves improvements at an average cost of $6 per AEI point. Without the bidding provision, the average cost of enhancing environmental performance by one AEI point increases to $8. The average cost under a practice-based program without stewardship provisions more than doubles to $17 per point, and increases to $73 per AEI point when producers are eligible for stewardship payments based on past conservation efforts.
- *What are the tradeoffs between improving the environment and supporting farm incomes?* If the objective of the program is simply to increase incomes of crop producers, performance-based programs are the most cost-effective. They result in higher returns to production than under the two practice-based programs. Returns to crop production increase by approximately $9 per acre and $8 per acre under *Bid* and *Performance*, at the $1-billion budget level. Incomes increase by just $4 per acre and $3 per acre under the *Practice* and *Good-Act* programs.

In general, WLPPs, as modeled here, increase returns to the agricultural sector overall, but consumers (who fund these programs) may pay more for less food depending on the program specifics. Overall, economic losses outweigh the gains under all programs modeled here. However, we have not included the value of the environmental gains—the impetus of these programs. Putting a price tag on all the relative environmental improvements is beyond the scope of this report, but evidence suggests that the value of these benefits could far exceed the lost surplus at the aggregate market level.

Chapter 4
WLPPs in a Broader Policy and Economic Context

Agri-environmental payments on working lands represent an opportunity to address negative environmental impacts associated with agriculture **and** perhaps benefit agriculture economically. Given the diversity of U.S. agriculture, maximizing program performance would require that program contracts be tailored to the specific circumstances of individual farms. Creating that kind of flexibility in a "one size fits all" set of program guidelines is not easy. Policymakers face a myriad of decisions, any one of which could have important implications for program performance.

From the government's point of view, enrolling producers in WLPPs is a lot like hiring a contractor. The program, as first encountered by producers, is more like a "request for proposals" than a simple offer to pay for services. Through the request for proposals, program decisionmakers gather information about the conservation actions producers are willing to take and the level of payment they are willing to accept. The government, in turn, awards contracts based on an assessment of the producer's ability to generate environmental benefits (or achieve other program goals) and the cost of the contract. The trick, then, is to develop a request for proposals that is attractive to those producers who are best suited for the job, and to let the proposal process itself do the job of sorting the best from the rest.

This report uses a conceptual framework and simulation analysis to isolate individual policy design decisions and assess the effect of each on program performance. The truth is, however, that design decisions can rarely be made independently of one another. Moreover, previous chapters focused on issues relating to agri-environmental program design without considering the broader economic, policy, and research contexts. Programs often have impacts that are different or broader—temporally, geographically, or throughout the economy—than originally intended. WLPPs also interact with other programs, including other agri-environmental programs, commodity programs, and some nonagricultural programs. We revisit some of the key lessons of previous chapters, focusing on their inter-relatedness, and raise some of these broader questions here because their answers, ultimately, will be part of the story surrounding WLPP design.

Designing WLPPs involves a suite of interrelated decisions. The basic elements of policy design—budget levels, eligibility rules, enrollment screening mechanisms, and participation incentives—can be combined in many ways to establish an agri-environmental program. Design decisions interact on at least three levels:

- If the budget is limited—as it is in all existing agri-environmental programs—eligibility rules, enrollment screening, and participation incentives must be coordinated at least to the extent that spending limits are not exceeded.

- In the case of multiple objectives, program decisions made in service of one objective may preclude achieving another objective.
    - Stewardship payments likely reduce the level of new conservation effort that can be achieved (i.e., new practices that can be installed/adopted) given budget limitations.
    - Bidding on financial assistance—if it is truly competitive—will stretch conservation budgets by lowering the cost of individual contracts, but the resulting payments are unlikely to provide much in the way of direct support for farm income.
    - Environmental objectives can complement or conflict with each other—reduced runoff of nutrients to surface water could coincide with increased leaching to ground water. Conversely, efforts to reduce soil erosion could also reduce nutrient losses. Simulation results suggest that environmental attributes tend to increase or decrease in tandem.
- Cost-effective environmental gains are contingent on the careful coordination of eligibility rules, payment incentives, and enrollment screening to attract only those producers who can deliver environmental gain at low cost.

It is difficult to find the appropriate incentive structure that results in the "right" amount of quality applications. Voluntary programs can achieve specific environmental benefits only if decisions concerning eligibility criteria, payment base, and payment limitations consider the type of benefits sought. For example, under EQIP's initial rule, confined animal feeding operations (CAFOs—the largest livestock operations) could not have waste management facilities funded under the program, even though half of EQIP funds were earmarked for livestock-related concerns. Congress eliminated that constraint in 2002, and a substantial share of EQIP funds now helps offset the costs to CAFOs of complying with EPA's new Clean Water Act regulations addressing animal waste management.

A broad base of applicants provides program decisionmakers leverage in pursuing environmental improvements. However, there can be too much of a good thing. The administrative burden of accurately evaluating a large number of applications can be high. Another side effect of too many applicants (relative to available funds) is that qualified producers may be discouraged from applying if the program is deemed to be too competitive. This may have been the case with EQIP initially. Great enthusiasm surrounded the program at its inception, with over 70,000 applications a year in 1997 and 1998. But applications dropped to below 40,000 in 2001 as the perception spread that acceptance was difficult.

Program design influence on transaction costs can be important. How does one create a competitive program without inducing producers to promise more than they can deliver? This is an important question because monitoring and enforcement of contractual agreements, besides being unpopular, are very costly. This is particularly true for working-land programs with many eligible practices. EQIP was structured to be as environmentally cost-effective as possible. Yet, 17 percent of contracts faced withdrawal of one or

more of the conservation practices agreed to in the conservation plan. Thus, some expected environmental benefits as approved in the conservation plan proved illusory (Cattaneo, 2003).

In a policy environment where it is costly to determine damages and enforce them, the government may prefer not to pursue action against producers who do not fully adhere to their conservation contracts. However, if increasing enforcement is not viable, the government may modify the incentives that lead to withdrawing practices prematurely. Many modifications to EQIP introduced by the 2002 FSRI Act may reduce the producer's incentive to withdraw practices. Shorter contracts, allowing more than one contract per tract of land, and elimination of the bidding procedure will likely contribute to follow-through, making the benefits from the program more certain.

Design decisions can lead to unintended consequences. When payments exceed participation costs for some producers, the potential exists for unintended consequences. Like most other agricultural and agri-environmental payments, WLPPs are tied to land management, so unintended consequences are likely to include changes in land use or land values.

Payments that exceed production costs can encourage producers to shift land use—changes that are typically an unintended consequence of policy. For example, if the program increases (decreases) the profitability of crop production relative to other land uses, producers may shift land from (to) forest or grazing use to (from) crop production. Land use conversion is a particular concern for CSP implementation, because tiered payments for cropland are larger than those available on other types land. Producers could gain by the conversion of some pastureland to crop production and, in the absence of provisions to limit land use change, could seriously undercut environmental gains. Even if the program results in environmental gains on land already in crop production, expanding the area in crop production could offset those gains to the extent that crop production is more damaging to the environment than forest or grazing use (see Claassen et al., 2001, for a broader discussion). These concerns are addressed in CSP by limiting eligibility to land that was cropped in at least 4 of the 6 years prior to enactment of the program.

Land values may also be artificially inflated due to capitalization of program benefits. This is the logical outcome of land-based farm support payments. For example, early (pre-1990) CRP payments were capitalized into the value of low-quality land that received payments higher than the market value of such land (Shoemaker, 1989). WLPPs could increase land values unintentionally through capitalization of payments if conservation payments exceed conservation costs, if payments are tied to agricultural land, or if payments are viewed as long-term in nature. Significant land value effects are unlikely to flow from cost-sharing in programs like EQIP. However, they could occur under CSP, where payments may exceed producer conservation costs.

Not all changes in land values are unintended, however. Conservation improvements can also increase the value of the land by maintaining soil

productivity, improving or eliminating gullies that can hinder farming operations, and slowing the outflow of other production inputs like nutrients. Structural practices like terracing, because they are long-term investments, may be most effective in enhancing land values. Management practices, such as conservation tillage or precision agriculture, may also maintain soil structure and increase organic matter, and thus increase the intrinsic value of the land.

The equity objective, revisited. Some WLPPs may not only aim to provide cost-effective environmental benefits, but to do so equitably, which complicates considerably the choice of policy instruments for WLPPs. Two examples of tradeoffs that emerge from the joint consideration of efficiency and equity are provided by (1) the bid-down provisions in EQIP and (2) the inclusion of stewardship payments in CSP.

By revealing producers' willingness-to-accept (WTA)—a combination of practices offered and payments accepted—the EQIP bidding process was cost-effective. From an equity point of view, however, bidding may also be viewed as discriminating against producers who cannot afford to bid down to get accepted into the program. Bidding on EQIP financial assistance was prohibited by the 2002 Farm Bill. To limit cost in the absence of bidding, USDA established a default cost-share rate of 50 percent for all practices, with case-by-case exceptions for high-priority practices. This shift from bid-based to fixed-rate cost-sharing may result in higher rates of cost-sharing for most practices, reducing program cost-effectiveness. In some cases, where higher rates of cost-sharing could be justified on the basis of potential environmental benefit, exceptions to the default cost-share could be used to target environmental priorities. Even so, such targeting is likely to be most effective at the evaluation phase, where a proposal can be assigned a score based on its environmental potential (especially true if site-specific factors are considered in assigning points).

Equity is often cited as a reason for including "good actors" in programs like CSP. Eligibility for stewardship payments is viewed by some as a reward for good stewardship. Maintenance payments also serve to prevent environmental damage when economic conditions change such that a producer might remove a beneficial conservation structure (e.g., by plowing under buffer strips) or discontinue a conservation practice (e.g., by overapplying nitrogen fertilizer). Producers who maintain these practices without compensation may be at a competitive disadvantage relative to producers who do not. Some argue that, in the long run, excluding good actors will discourage producers from undertaking future environmental improvements on their own, possibly resulting in perverse incentives against conservation. Critics of maintenance payments argue that these payments do little to improve the environmental performance of agriculture and divert limited funds from activities that could improve overall environmental performance.

How do different programs interact? Given the overlap between different agricultural programs in terms of eligibility, many agricultural producers could be directly affected by several programs and indirectly by others. These programs affect a wide range of agricultural production decisions, and many have environmental implications. While some programs directly

address agri-environmental problems, others may affect agri-environmental performance through agricultural input and land use (e.g., commodity program and tax policies). Coordination of all such programs pays obvious dividends in avoiding duplication of effort, eliminating conflicts among programs, and ensuring that where programs can work together or complement one another, these complementarities are fully realized. This is particularly true now that agri-environmental payment programs are growing in size relative to commodity programs. Of course, coordination would increase the administrative effort needed to implement programs. A complete analysis of cost-effectiveness would include both the benefits and the costs of program coordination.

Eligibility can eliminate duplication by preventing producers from receiving payments from two programs on the same land. For example, it makes little sense to continue commodity program payments on land enrolled in a land retirement program. Annual land retirement payments are based on cash rental rates, which incorporate the value of farm program payments. Receipt of land retirement and commodity payments would constitute "double dipping"—receiving overlapping benefits from more than one program. Likewise, land enrolled in the CRP or the Wetland Reserve Program (WRP) cannot also be enrolled in EQIP or the CSP.

On the other hand, some programs are complementary and producers may legitimately participate in two or more programs simultaneously. For example, a producer located in an urban fringe area may benefit from farmland protection payments, receive commodity payments, and improve environmental performance by receiving WLPP payments. Programs may also be complementary in the sense that each has a unique function or "niche" that is not filled by another program. In this case, coordination can improve overall environmental gain by ensuring that eligibility and other enrollment mechanisms direct producers toward the program that best advances the overall goals of agri-environmental policy. For example, it may be more cost-effective to retire land than attempt to address resource concerns with a working-land program. That's almost certainly true for many wetland services (wildlife habitat, filtering runoff, and floodwater retention). Other wildlife habitat may become viable only when the ecosystem is fully established, a process that may take years, and thus can best be provided with a long-term (10 years or more) dedication of that land to that purpose. A case can be made for coordination between programs that encourage new conservation effort (e.g., EQIP) and those that attempt to reward, and more importantly, preserve that conservation effort (e.g., CSP).

Eligibility criteria have also been used to reduce conflict among programs. Agri-environmental programs can interact with commodity programs because both can influence agricultural input use. A classic case of conflict and subsequent coordination is the compliance mechanisms adopted in the Food Security Act of 1985. There was evidence in the late 1970s and early 1980s to suggest that commodity programs were encouraging specific types of crop production with the highest potential for environmental damage (Watts et al., 1983; Reichelderfer, 1985). As such, commodity programs were working at cross-purposes with programs designed to conserve soil and preserve wetlands. Compliance mechanisms, adopted as part of the

1985 Food Security Act, made eligibility for commodity and many other Federal agricultural programs contingent on certain soil conservation and wetland preservation efforts (Claassen et al., 2004). Thus, consistency between commodity programs and other agri-environmental programs was increased.

Finally, payment limits or contract flexibility may become coordination issues if they affect producers' program choices. Small operations will generally not be affected by payment limits, but producers who are affected will base their participation on the effective "incentive rate" considering the payment ceiling. For example, EQIP at first provided up to 75 percent cost-share, but the $50,000 payment limitation made the effective rate progressively lower for farms undertaking conservation expenditures with total costs above $66,700.

What are the environmental benefits of working-land payment programs? If WLPPs grow in terms of budget and affected acres, the demand for estimating the benefits associated with these expenditures is sure to follow.[1] Because of the complexity of farm household decisionmaking, and the nonpoint source and site-specific nature of agri-environmental problems, measuring the benefits of agri-environmental conservation programs is data-demanding and technically challenging. Estimating the environmental benefits of a given program would require identifying those changes in farmer decisions directly attributable to the program, measuring the environmental change associated with those farmer decisions, and, ideally, assigning economic values to those environmental improvements. But valuing these "nonmarket" amenities is difficult. To date, good information on their values exists for only a subset of attributes, such as the offsite costs of soil erosion, or only at a local scale, like recreational values associated with pheasant viewing and hunting in the Prairie Pothole region. In the absence of economic values, changes in environmental metrics—like reduced nitrogen concentrations in water bodies and enhanced soil carbon levels—can provide a benchmark upon which to gauge program performance.

USDA has embarked upon an interagency effort designed to conduct a national assessment of environmental benefits and effects of 2002 Farm Bill programs (www.nrcs.usda.gov/technical/NRI/ceap/). Achieving that goal will depend on the ability to identify and measure those indicators that link to farmers' responses to conservation programs and to the environmental attributes those programs aim to influence (Smith and Weinberg, 2004).

Realizing the potential of WLPPs within the broader agri-environmental policy context. Calls for improved program coordination, balancing multiple objectives, and "global" assessments of program benefits could all be addressed by developing a comprehensive conservation benefits index, similar to our Aggregate Environmental Index (AEI), and using it to rank all proposed conservation and environmental projects. USDA's 2001 policy vision statement, *Food and Agricultural Policy: Taking Stock for the New Century*, describes the possible creation of an expanded index that would rate improvements in environmental, conservation, and rural community categories, with scores based on the expected benefits during the time of

[1]A benefit-cost analysis is, in fact, required for any U.S. government program with budgetary implications greater than $100 million. The exercise has been carried out twice for EQIP (USDA - NRCS, 1996 and 2003) and is currently ongoing for CSP (USDA - NRCS, 2004). What emerges from these studies is that information is scarce concerning the benefits on the ground of installed conservation practices. Typically, practices are bundled by natural resource concern addressed, and average estimates are taken from the available literature.

enrollment. Producers could propose the land management options and project durations that work best for them.

Cost-effectiveness of all programs would increase by allowing proposals for new activities on working lands to compete with proposals for retiring environmentally sensitive lands or maintaining existing practices. Similarly, single-year activities could compete with multiyear activities. Proposals for management activities on working lands, like switching from conventional to conservation tillage, would have lower opportunity costs than retiring the land, and so should generate a lower bid. At the same time, conservation tillage would likely receive a lower benefits score than land retirement. Contracts would be awarded to owner/operators with the greatest benefit index score relative to the bid. Moving to a single, comprehensive index would require considerable resources and a multiyear phase-in. For example, CRP and EQIP have very different approaches to constructing a benefit index (see box, "Defining Program Objectives," p. 10). Those approaches could form a starting point for thinking about a single comprehensive index.

The estimation of environmental gains from conservation expenditures could also benefit from the data gathering needed to build a comprehensive environmental index. Smith and Weinberg (2004) note that reconciling model predictions with actual observations is crucial for a successful conservation program that relies on voluntary participation. One possible approach would be to combine index data obtained as part of producers' agri-environmental program applications with current environmental data collection, as in the Natural Resources Inventory (NRI, USDA-NRCS, 1997). Even before the introduction of a comprehensive benefits index, such an approach could be tested with current CRP and EQIP indices used to rank applications. The information contained in these indices is not a physical measurement of impact, but rather an expected impact. Data collection at the plot level for a subsample of participants (where available) would assess the reliability and/or calibrate ex-ante benefit estimates. Combining producers' WTA, estimated from past participation or solicited through a bidding process, with calibrated environmental indices for multiple practices can reduce implementation costs and vastly improve cost-effectiveness.

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Appendix—Participation Incentives and Screening: A Graphical Analysis

The graphic analysis presented here is designed to help illustrate ideas presented in the text. We assume that program decisionmakers allocate a fixed budget among producers. Depending on the extent to which policymakers employ tools that enhance environmental cost-effectiveness (e.g., bidding, performance-based screening), the potential for environmental gain can vary widely.

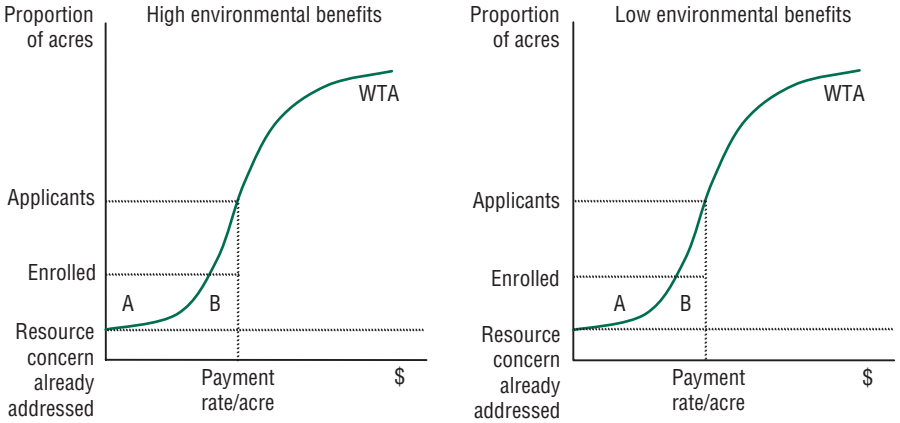
For the sake of clarity, we simplify the problem by assuming:

- Producers all address the same resource concern(s);
- Producers can be divided into "high-benefit" and "low-benefit" groups;
- Fixed payments are the same for all producers (as may be the case for management incentive payments within a single county);
- The distribution of WTA is the same for high- and low-benefit producers;
- The same proportion of high- and low-benefit producers have previously addressed the resource concern.

Here (fig. A), payments are fixed across producers without regard to costs or benefits. Payments are available for newly adopted practices only. For the payment rate shown, not all applicants can be enrolled. The screen reduces participation to match the budget (area A+B). Area A represents the cost of adopting new practices while area B represents surplus to the producer. In theory, a lower payment rate would reduce surplus to producers while enrolling the same producers in the program. However, program decisionmakers are unlikely to know the exact location of the WTA curve.

Because WTA is distributed in the same way across producers, an equal proportion of high-benefit and low-benefit producers accept the payment and address the resource concern. If producers in the high-benefit category were more likely to have low costs, environmental gain would increase. If they were more like to have high costs, environmental gain would decline.

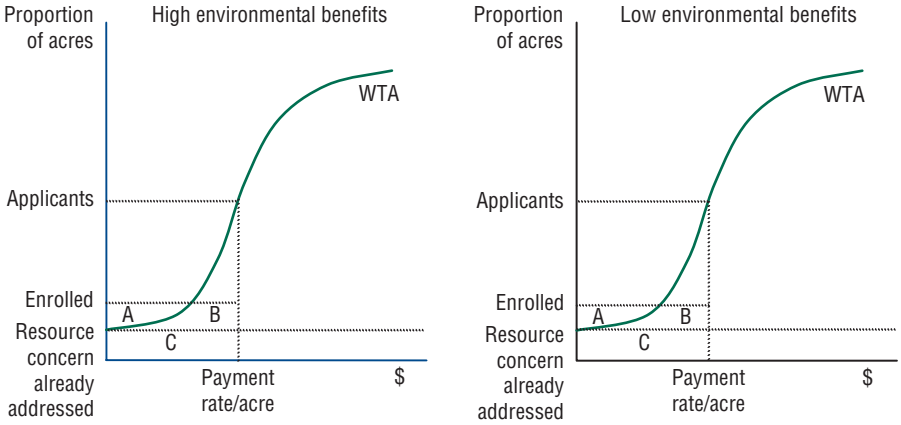
Appendix figure A
Fixed payments with allocative screening



In figure B, a stewardship payment component is added by extending payments to include previously adopted practices as well as new practices at the same payment rate. Given the fixed budget, the proportion of acres enrolled (and associated environmental gain) declines because budget resources are devoted to stewardship payments (area C). Other, somewhat less lucrative stewardship payments could be devised if it is possible to distinguish existing conservation practices from newly adopted practices. For structural practices, it is easy to detect existing practices. For some management practices, it could be quite difficult.

Appendix figure B

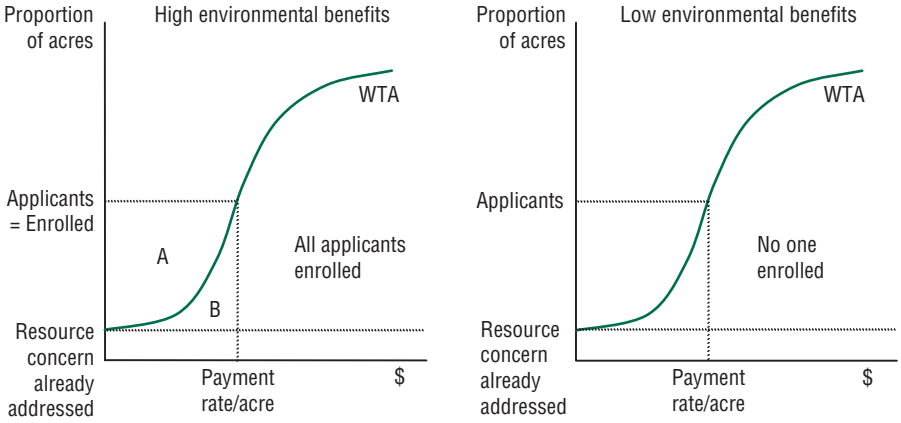
Fixed payments with allocative screening and stewardship payments



In figure C, performance-based screening shifts participation toward high-benefit producers. While the payment rate remains fixed, the screen gives preference to high-benefit producers. Because cost (in terms of program budget) is constant across producers while benefits are not, as much funding as possible is directed to high-benefit producers (as depicted above, all funding goes to high-benefit producers, areas A+B). In reality, there would be variation in contract cost—not all funding would go to producers yielding the highest benefit.

Appendix figure C

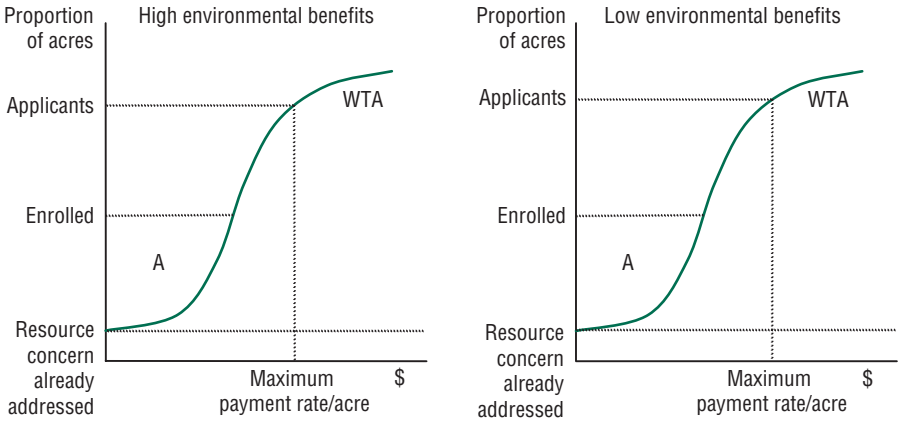
Fixed payments with a performance-based enrollment screen



If payments are based on bids and enrollment is truly competitive, producers will bid payments down to roughly the level of their WTA (payments = area A in figure D). Because producers no longer receive surplus as in the fixed-payment case, the enrollment screen can be relaxed, increasing program enrollment and environmental gain. Note that the number of applicants depends on the maximum payment rate. Everyone with WTA less than the maximum payment rate applies for the program.

Appendix figure D

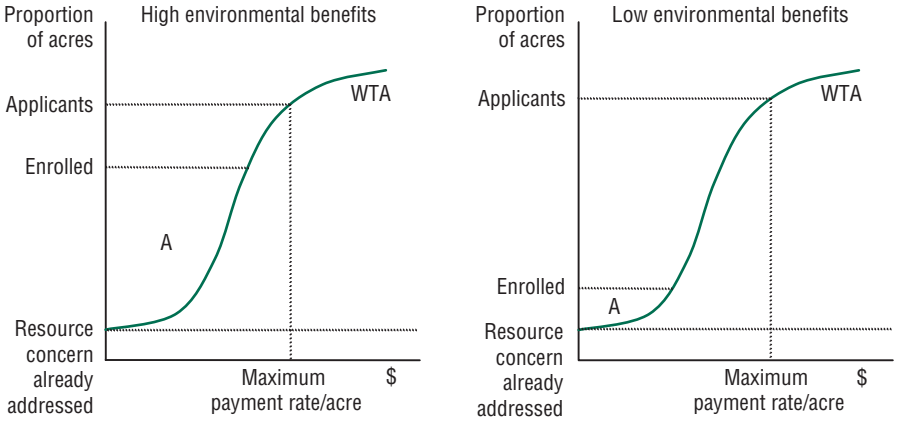
Bid-based payments



If the screen is based on environmental performance, program decision-makers can target participation toward high-benefit producers (fig. E). However, because the cost of contracts varies, cost-effectiveness may be obtained by seeking a balance between benefits and costs, retaining some low-benefit producers because they can realize these benefits at a low cost.

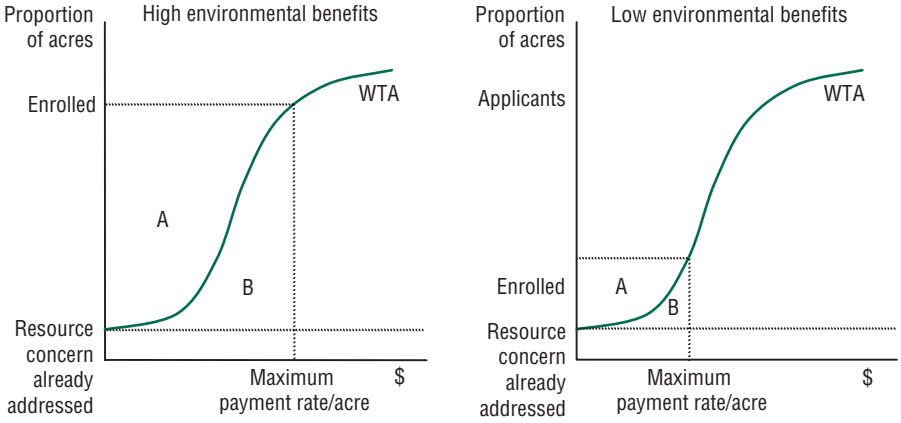
Appendix figure E

Bid-based payments with a performance-based enrollment screen



Finally, in figure F, performance-based payments direct higher levels of participation toward high-benefit producers through the use of higher payments (assuming the equal distribution of costs among high- and low-benefit producers). If payments (areas A + B) exceed the budget, a screening device will be needed to reduce expenditures.

Appendix figure F
Performance-based payments



Web Appendices A-C are available online only.

You can find them on the ERS website at www.ers.usda.gov/publications/err5/webappendix.

Web Appendix A
Simulating Working-Land Payment Programs

A.1 Regional Simulation Model

To evaluate the economic and environmental implications of alternative WLPPs, we employ a regional, agricultural-sector model for the United States. This is a comparative-static, spatial and market-equilibrium model, which incorporates agricultural commodity, supply, demand, environmental impacts, and policy measures (House et al., 1999). The model includes 45 geographic sub-regions, 23 production inputs, and the production and consumption of 44 agricultural commodities and processed products.[1] More than 5,000 crop production enterprises at the sub-region level are differentiated according to cropping rotations, tillage practices, and fertilizer rates; 90 livestock and poultry production enterprises are delineated at the region level by species. Production levels and enterprises are calibrated to regularly updated production practices surveys using a positive math programming approach (Howitt, 1990), the USDA multiyear baseline (USDA, 2001), and the National Resources Inventory (USDA, 1994).[2]

Changes in production are in turn linked to the potential environmental changes via the Environmental Policy Integrated Climate (EPIC) Model. The model simulates daily weather, hydrology, soil temperature, erosion-sedimentation, nutrient cycling, tillage, crop management and growth, and pesticide transport to the edge of the field (Mitchell et al., 1998). Crop yields and environmental externalities are estimated on a per-acre basis for short-run (mean over 7 years) and long-run production (mean over 67 years) given historical climate and soils data from across the United States. The yield data are combined and calibrated to current production patterns. For certain pollutants (e.g., nitrogen, phosphorus, soil sediment, and pesticides) a runoff transport component is calibrated to observed pollutant levels using estimates from the U.S. Geologic Survey (Smith et al., 1997) in order to estimate instream environmental effects of agricultural production.

A.1.1 Baseline Production

The simulation model is first calibrated to projected production patterns (USDA, WAOB, 2003), solving for optimal regional (subscript k) production levels for cropping enterprises (X_{ki}) and livestock activities (X_{kl}):

$$\text{(eq A.1)} \quad \max_{X_{ki}, X_{kl}} \sum_{ki} (P_i - VC_{ki}) X_{ki} + \sum_{kl} (P_l - VC_{kl}) X_{kl} .$$

Here P_i is the equilibrium price vector for cropping system i, and P_l are equilibrium prices for livestock; VC_{ki} and VC_{li} represent regional variable costs of production.

[1] The model accounts for production of the major crop (corn, soybeans, sorghum, oats, barley, wheat, cotton, rice, hay, silage) and livestock (beef, dairy, swine, and poultry) categories comprising approximately 75 percent of agronomic production and more than 90 percent of livestock production in the United States (USDA 1997). We do not consider potential applications of manure to rangeland, vegetable, horticulture, sugar, peanut, or silviculture operations.

[2] This model has been used to examine other agri-environmental policies (Johansson and Kaplan, 2004; Claassen et al., 2001), climate change mitigation (Lewandrowski et al., 2004), water quality policy (Ribaudo et al., 2001), wetlands policy (Heimlich et al., 1997), and sustainable agriculture policy (Faeth, 1995).

The acreage constraints imposed under the policy simulations are represented by:

(eq A.2) $\sum_i X_{ki}^0 = \sum_i X_{ki} \; \forall k$,

where $\sum_i X_{ki}^0$ is the amount of cropland acres in region *k* before implementing the WLPP and $\sum_i X_{ki}$ is the amount of cropland acres in region *k* after implementing the WLPP. In other words, producers cannot receive program payments for environmental benefits generated from retiring land from production or for land that had not previously been cropped prior to the WLPP implementation.

A.1.2 Practice-Based Agri-Environmental Payments

Those management practices that are targeted towards reducing soil erosion and generally improving water quality are modeled (table A.1).[3] These practices represent approximately 90 percent of the non-livestock, non-structural EQIP contracts between 1997 and 2000. Practice costs are calculated assuming a 3-year implementation period.[4] The 3-year total cost is then discounted at 7 percent over a 10-year contract period. In addition to management practices, "base payments" are included in the program payment, structured to resemble the tiered system of payments found in the Conservation Security Program. Base payments are pegged to regional crop rental rates and are calculated to represent a 10-year net present value of average rental rates for cropland (Farm Service Agency, 2003). [5]

[3] Note that the cost of these practices, the benefits provided, and the associated rental rates are often not correlated such that practice-based conservation payments solicit the most cost-effective environmental benefits (see Web Appendix C).

[4] This follows the benefit-cost methodology used by USDA (NRCS, 2003).

[5] Base payments in the Conservation Security Program increase with tiers. At the lowest tier, producers receive cost-share plus a base payment of 5 percent of the land rental rate. This rate increases to 15 percent at the highest tier of participation.

Table A.1. Practice-based conservation payments (per acre)

Eligible practices	Farm production region[a]									
	AP	CB	DL	LA	MN	NT	NP	PA	SE	SP
Base payment[b]	2.08	3.84	1.95	2.74	0.84	1.55	1.57	2.63	1.30	0.87
Conservation rotation[c]	2.81	1.41	1.40	1.40	1.83	1.87	1.40	1.88	2.81	1.87
Nutrient management[d]	2.81	2.25	1.40	1.68	2.81	2.25	1.24	2.81	2.81	4.49
Hay[e]	30.32	21.15	28.38	19.91	10.95	15.36	10.71	17.41	30.89	13.48
Mulch till[f]	2.81	2.25	2.81	3.37	2.81	3.37	1.63	1.68	8.42	2.62
No-till[g]	2.81	2.25	4.21	2.81	4.21	3.37	3.37	5.62	5.62	2.62

a/ Appalachia (AP) = KY, NC, TN, VA, WV; Corn Belt (CB) = IA, IL, IN, MO, OH; Delta States (DL) = AR, LA, MS; Lake States (LA) = MI, MN, WI; Mountain (MN) = AZ, CO, ID, MT, NM, NV, UT, WY; Northeast (NT) = CT, DE, MA, MD, ME, NH, NJ, NY, PN, RI, VT; Northern Plains (NP) = KS, ND, NE, SD; Pacific (PA) = CA, OR, WA; Southeast (SE) = AL, FL, GA, SC; Southern Plains (SP) = OK, TX.
b/ Base pay values derive from mean rental rates for non-irrigated cropland under the Conservation Reserve Program (FSA, 2003) multiplied by 5 percent to correspond to a tiered structure described in Chapter 4.
c, d, e, f, g/ The reported payments are the median contract values for EQIP calculated to reflect a 100 percent cost share (Cattaneo, 2003).

More formally, the working-land program payment (P_{ki}) for an eligible practice (k) in region (i) will be a function of the cost of implementing the eligible practice in that region (EP_{ki}), the percentage of that cost that is reimbursed under the program, and the base payment amount determined from regional crop rental rates. Cost-share percentages are chosen to be at the 50-percent level as found in the 2002 EQIP guidelines (USDA, NRCS, 2003). The program payment for any given eligible practice in our simulation model can be written:

(eq A.3) $P_{ki} = (0.5 \times EP_{ki}) + (Base\_Pay_i)$.

The total agri-environmental payment (AEP) available for a producer in region (i) for eligible practices (k) is then:

(eq A.4) $AEP_{ki} = \sum_k P_{ki}$.[6]

A producer can receive higher payments by combining several cropping production practices. For example, in our simulation, a producer in the Corn Belt could receive practice-based payments of $13.53 per acre for a no-till ($2.25 per acre) or mulch tillage cropping system that included nutrient management practices ($2.25 per acre) and hay rotation ($21.15), which is also a conservation rotation ($1.41 per acre) at a 50-percent cost-share rate. In addition, the producer would be eligible under this program for a base payment of $11.52 per acre (or 3 × $3.84) for a total of $25.05 per acre.[7]

A.2 Policy Simulations

A.2.1 Good-Act

Under this scenario, farmers already employing eligible practices (good actors) are eligible to receive WLPP payments along with an additional payment based on a regional land rental rate. Various levels of an exogenously determined budget (B) are simulated, restricting total payments so that the budget is not exceeded. Regional program payments are further restricted to be a percentage of the total budget ($distrib_k$), which is equal to the distribution percentage of regional EQIP payments:

(eq A.5) $B \times distrib_k \geq Perc_k \sum_i X_{ki} AEP_{ki} \; \forall k$,

where X_{ki} is the acreage level of the eligible practices after the WLPP is offered, and $Perc$ is the optimal percentage of acres that actually receive agri-environmental payments (AEP_{ki}) to meet the regional budget constraint. This distributional constraint is imposed to insure that program payments are spread across the entirety of U.S. cropland. The resulting optimization is:

(eq A.6) $\max_{X_{ki}, X_{kl}} \sum_i (P_i - VC_{ki} + AEP_{ki}) X_{ki} + \sum_l (P_l - VC_{kl}) X_{kl}$

subject to eq A.2 and eq A.5.

[6] Note that producers can receive two payments for incorporating hay into their rotation (*conservation rotation* and *hay*), but can only receive 1 × *base payment* for this combination.

[7] This is an upper bound on per acre payments for this combination of practices as the payment of $21.15 for planting hay will be multiplied by the share of hay in a particular rotation. For example, a continuous hay rotation would receive the full $21.15 payment (at a 50 percent cost-share rate), whereas a corn-soybean-hay rotation would receive $6.98, or 0.33 × $21.15 (also at a 50 percent cost-share rate).

A.2.2 Practice

Next, restrict eligibility for the practice-based payments (and base payments) to those farmers that adopt new practices:

(eq A.7)

$$\max_{X_{ki},X_{kl}} \sum_{ki} (P_i - VC_{ki})X_{ki} + \sum_{ki} (X_{ki} - X_{ki}^0)AEP_{ki} + \sum_{kl} (P_l - VC_{kl})X_{kl},$$

subject to eq A.2 and to

(eq A.8) $B \times distrib_k \geq Perc_k \sum_i (X_{ki} - X_{ki}^0)AEP_{ki} \ \forall k$.

A.2.3 Performance

Under this scenario, payments are simulated for reducing the number of Aggregate Environmental Index points, AEI_{ki} (see Web Appendix B), generated from crop production. No good-actor provisions or base payments are attached to these contracts. Furthermore, the distributional budget constraint from above is relaxed, as producers are able to garnish payments for environmental points broadly defined to include nine environmental criteria. The optimization model for this scenario is depicted by:

(eq A.9)

$$\max_{X_{ki},X_{kl}} \sum_{ki} (P_i - VC_{ki})X_{ki} + PPT \sum_{ki} (X_{ki}^0 - X_{ki})AEI_{ki} + \sum_{kl} (P_l - VC_{kl})X_{kl},$$

subject to

eq A.10) $B \geq PPT \sum_{ki} (X_{ki}^0 - X_{ki})AEI_{ki}$ and to eq A.2,

where *PPT* is the agri-environmental price per point offered under the program. A national price for environmental performance points is assumed, which could just as easily be specified on a regional basis.

A.2.4 Bid

To capture the fact that it is cheaper to achieve some benefits points than others, which would be reflected by bidding provisions, the area under the payment-marginal benefits curve distilled from the performance-based policy is integrated to determine aggregate program payments. Essentially, as the national price for environmental performance increases, an increasing number of farmers will be willing to accept performance-based contracts. Here WTA_{ki} replaces *PPT* as the per-point payment level each enterprise would accept to generate environmental benefits:

(eq A.11)

$$\max_{X_{ki},WTA_{ki},X_{kl}} \sum_{ki} (P_i - VC_{ki})X_{ki} + WTA_{ki} \sum_{ki} (X^0_{ki} - X_{ki})AEI_{ki} + \sum_{kl} (P_l - VC_{kl})X_{kl}$$

subject to (eq A.12) $B \quad WTA_{ki} \quad _{ki} \quad (X^0_{ki} \quad X_{ki})AEI_{ki}$ and eq A.2.

A.2.5 Hurdle

To model hurdle rates, payments are simulated for reducing the number of Aggregate Environmental Index points (see Web Appendix B) generated from crop production above and beyond a pre-determined reference level. The optimization model for this scenario is depicted:

(eq A.13)

$$\max_{X_{ki},X_{kl}} \quad _{ki} (P_i \quad VC_{ki})X_{ki} \quad PPT \quad _{ki} [\max(0,(\overline{AEI} \quad AEI_{ki})]X_{ki} \quad _{kl} (P_l \quad VC_{kl})X_{kl}$$

,

subject to eq A.2 and to

(eq A.14) $B \quad PPT \quad _{ki} [\max(0,(\overline{AEI} \quad AEI_{ki})]X_{ki}$,

where *PPT* is the agri-environmental price per point offered under the program for practices above a pre-determined reference level, $\overline{AEI}$ (recall that the lower the AEI_{ki} score, the better its environmental performance).

Web Appendix B
Aggregate Environmental Indices

B.1 Scoring Production Systems

An aggregate benefits score (AEI_{ki}) is generated for each cropland acre (i) and region (k). This aggregate benefits score is composed of the "relative damage estimate" (RDE_{kji}) for each of the environmental externalities (j) based on the mass of each pollutant that potentially arrives at the appropriate medium from cropping system (i) and region (k). The respective RDEs are the product of edge-of-field emissions and the corresponding transport factors:

(eq B.1) $RDE_{kji} = q_{kji} * t_{kj}$,

where q represents edge-of-field emissions and t represents the relevant transport factor. Transport factors are calculated using USGS-estimated agricultural discharge in the case of surface water pollutants,[8] and are assumed to be 100 percent for air emissions and leaching (i.e., there is no assumed loss in mass from the edge-of-field emissions to the relevant destination media).

Summing over current production levels provides an estimate of the potential discharge of these externalities, which vary considerably by region (table B.1). For example, the largest amount of sediment and nutrients are discharged from the Corn Belt, which has the most production acres of all regions. However, pesticide leaching to groundwater is highest in the Lake States region, where the underlying topography makes it relatively more susceptible to leaching. Nitrogen leaching is highest in Appalachia.

[8] Estimates of phosphorus and nitrogen discharge are found in Smith et al. (1997). Transport of nitrogen to estuaries is found in Alexander et al. (2000). Transport factors for surface water pesticides and sediment are assumed to be similar to phosphorus transport.

Table B.1. Baseline values for environmental indicators by region[a]

	Air		Soil	Groundwater		Surface water			
	Carbon[b]	Wind	Productivity[c]	Pesticides[d]	Nitrogen	Pesticides	Sediment	Nitrogen	Phosphorus
Region	(metric tons)	(Tons)	($)	(TPUs)	(Lbs.)	(TPUs)	(Tons)	(Lbs.)	(Lbs.)
NT	3	1	15	3,859	130	8,539	8	173	12
LA	12	113	11	11,942	357	27,217	20	358	15
CB	39	42	104	3,706	234	102,671	102	1,484	105
NP	24	120	102	1,272	112	21,583	15	407	24
AP	4	1	42	8,862	400	24,025	12	284	20
SE	2	0	1	4,526	182	17,847	12	116	12
DL	9	0	55	825	141	61,899	10	236	14
SP	13	185	3	916	63	103,250	17	234	15
MN	6	227	8	399	31	108,813	12	119	6
PA	2	29	30	13	55	54,173	5	89	2
US	114	718	372	36,322	1,706	530,017	213	3,499	225

a/ Environmental indicators are measured in millions of units discharged from cropland, not inclusive of animal production.
b/ Carbon emissions are calculated according to the Intergovernmental Panel on Climate Change estimates (IPCC, 1996). The values indicate the amount of carbon emitted when converting land from native pasture.
c/ Loss in soil productivity is measured in lost net present value of crop output per acre over a 60-year time horizon due to soil degradation.
d/ TPUs refer to "toxicity persistence units" (Barnard et al., 1997). These refer to the sum of reference doses (maximum daily human exposure resulting in no appreciable risk) of the pesticides used for a particular cropping enterprise multiplied by the number of days, each of those pesticides r emains active in the environment. As a point of reference the number of TPUs in a pound of DDT = 4,443 million and in a pound of Borax = 103,872.

Production systems with low relative damage estimates (RDEs) indicate cleaner practices; those with high RDEs contribute higher quantities of pollutants to the environment. To characterize each crop production system (*i*) and its potential to generate environmental benefits in each region (*k*), the relative damage estimates (RDE_{kji}) are converted to a 0-1 impact index (I_{kji}) for each pollutant (*j*):

(eq B.2) $$I_{kji} = \left(\frac{RDE_{kji} - \min(RDE_j)}{\max(RDE_j) - \min(RDE_j)} \right),$$

where min(RDE_j) and max(RDE_j) are the minimum and maximum damage estimates across all systems (*i*) and regions (*k*) for the *j*th environmental pollutant. For example, the potential to deliver nitrogen to groundwater is highest for conventionally tilled, soybean-wheat rotations on non-highly erodible land in the Lake States production region (65.83 lbs./acre/year). Its benefit index value for nitrogen loading to groundwater is therefore normalized to 1.0.

Normalizing potential discharge in this manner implies a point equivalency ratio between the nine pollutants:

(eq B.3)
$$\max(RDE_m) - \min(RDE_m) : \max(RDE_n) - \min(RDE_n) \ \forall \ m \neq n \in j .$$

The point equivalency values reflect equivalent amounts of each pollutant necessary to generate 1 unit of I_{ki}. For example, the point equivalency ratio between nitrogen and phosphorus discharge is approximately 10.93, which implies that the maximum potential reduction in nitrogen discharge given the range of practices in the simulation model divided by the maximum potential reduction in phosphorus discharge is 10.93.

The individual indicators are combined to generate an aggregate environmental index score (AEI_{ki}) specific to each production system and region that reflects the total management effects of that production system on the environment:

(eq B.4) $$AEI_{ki} = f(I_{kji}) .$$

Several functional forms have been promoted to construct aggregate measures of environmental quality from individual indices (Heimlich, 1994). This report uses a weighted sum of the individual environmental indicators as an aggregate environmental quality index:

(eq B.5) $$AEI_{ki} = \sum_j w_{kj} I_{kji} ,$$

where w_{kj} are weights on pollutant damages. This functional form implies that damages to the environment are continuous and linear in discharge. This is similar to other aggregate measures of environmental quality such as the Environmental Benefits Index, or EBI (USDA, Farm Service Agency, 2002)

and the Index of Watershed Indicators (U.S. EPA, 2002).[9] Ideally, the weights chosen would reflect socioeconomic preferences for mitigating the various pollutants. We develop several weighting schemes to illustrate how such preferences may result in different program outcomes.

B.2 Weights

Developing weights that reflect society's preference for different environmental benefits is difficult. One means to weight multiple criteria is to assign monetary values to changes in the amount of pollutants released into the environment -- increased levels of reduction are associated with higher environmental benefits and associated monetary value (see, for example, Hansen et al., 2002). Many studies have asked survey respondents how much they are willing to pay for a reduction in their exposure to certain chemicals. Examples include nitrates in drinking water supplies (Crutchfield et al., 1997); fertilizers, pesticides, and manure in surface water resources (Hite et al., 2002; Stumborg et al., 2001; Van Kooten et al., 1998). Others have used travel cost methods to determine how valuable variable recreation opportunities are to the public (e.g., sediment loads and fishing recreation in Feather et al., 1999) or hedonic analysis to reveal how preferences of consumers are affected by variable environmental quality (e.g., sulfur and nitrogen in the air and its affects on housing prices in Kim et al., 2003). Because these studies are often site specific, many researchers impute the estimated values to other regions or populations using a method termed "benefit transfer" (see also Web Appendix C). This saves on the cost of designing and implementing new surveys, but is less accurate than an original survey. Examples include nutrient loads in the Chesapeake Bay (Morgan and Owens, 2001), nitrate in drinking water (Crutchfield et al., 1997), and sediment loads in U.S. surface waters (Feather and Hellerstein, 1995).[10]

These studies raise several important questions. First, it is clear that there are many benefits to consider when examining the value of reducing pollutant levels, including human health benefits (e.g., reduced exposure to toxic chemicals), recreational benefits (e.g., the oft cited "swimmable, boatable, fishable" standard found in the Clean Water Act), and ecological benefits (e.g., reduced probability of fish kills). Second, these studies often examine the value of improving a particular metric by a percentage, making it difficult to decipher the value per physical unit of pollutant, suggesting that per-unit benefits will depend on the level from which the change is occurring.

In the absence of a national or local survey that explicitly asks such questions, this report adopts an approach using data about how program decisionmakers have valued past efforts at addressing multiple environmental criteria. How public preferences translate into program expenditures and mandates is well documented (Variyam and Jordan, 2001; Besley and Burgess, 2002; Dixit et al., 1997; Crémer and Palfrey, 2002). Looking explicitly at conservation programs Bastos and Lichtenberg (2001) noted that incentive payments are linked to public preferences for environmental quality. Moreover, while the link between policy expenditures for working-land payment programs, environmental standards, and public preferences may not be completely transparent,

[9] The assumptions of continuous and linear damages serve to illustrate the costs to producers in reducing the physical amounts of these pollutants from entering the environment. More complicated damage functions can be incorporated by changing the form of the aggregate environmental indicator.

[10] A summary of these methods can be found online at http://www.ecosystemvaluation.org/ (King and Mazzotta, 2003).

Reichelderfer and Boggess (1998) noted that program decisionmakers can learn and improve the cost-effectiveness of conservation program controls.

B.2.1 National-level weights

Environmental Benefits Index weights – The Conservation Reserve Program (CRP) was initially designed to reduce the quantity of soil erosion from cropland cultivation by encouraging U.S. farmers to "retire" lands with a high potential for soil erosion. Today, CRP contracts are evaluated at the national level using multiple environmental criteria found in the Environmental Benefits Index (EBI). The EBI in sign-up 26 (FSA, 2003), developed to score CRP contracts, includes weights for groundwater leaching, soil productivity loss, surface water discharge, wind erosion, and carbon sequestration. There are a total of 415 points available for any particular contract enrolled in the CRP (table B.2). However, this report does not consider wildlife benefits, water quality location, enduring benefits, or air quality zones in our analysis, which leaves a total of 230 points available for generating weights. [11]

Table B.2. Weights for an Aggregate Environmental Index (AEI) using the EBI

EBI Category	EBI	EBI	Weight
Wildlife			
N1a. Cover	50		
N1b. Enhancement	20		
N1c. Priority Area	30		
Total	100		
Water Quality			
N2a. Location	30		
N2b. Groundwater	25	25	0.11
N2c. Surface Water	45	45	0.20
Total	100		
Erosion (Soil Productivity)	100	100	0.43
Enduring Benefits	50		
Air Quality			
N5a&b. Wind Erosion	30	30	0.13
N5c. Air Quality Zones	5		
N5d. Carbon Sequestration	30	30	0.13
Total	415	230	1.00

Source: FSA(2004)

By mapping these weights to air, soil, groundwater, and surface water, a set of implicit weights is developed to broadly reflect the nine environmental criteria considered in this report. The EBI places a relatively large weight on maintaining long-term soil productivity (reducing soil erosion) and improving water quality (ground and surface), but values reductions in wind erosion and

[11] Because we do not have specific data about the effects of different cropping systems on these categories, it is unclear how they could map into the nine selected pollutants for this analysis. For example, points attributable to being located in a "water quality region" could map to either ground-water or surface water quality. The conservative mapping in table B-2 eliminates categories that do not directly correspond to the nine pollutants included in this report.

carbon sequestration to a lesser degree. However, these implicit weights leave the question of weights within media; e.g., nitrogen leaching versus pesticide leaching. For these within-group comparisons, data from EQIP contracts and from the U.S. Environmental Protection Agency (EPA) is used to distinguish constituents of groundwater quality (nitrogen and pesticide leaching) and of surface water quality (table B.3).

Table B.3. National-level weights from the EBI

Medium	Initial weights (%)	Resource concern	Weights (%)
Air	0.13	Carbon	0.13
		Wind	0.13
Soil	0.43	Productivity	0.43
Groundwater	0.11	Pesticides[a]	0.03
		Nitrogen[b]	0.07
Surface Water	0.20	Pesticides	0.01
		Sediment	0.10
		Nitrogen[c]	0.04
		Phosphorus[d]	0.04
	1.00	Total	1.00

a/ b/ The water quality weights are allocated to nitrogen and pesticide leaching calculated from EQIP data in table B.4.
c/ d/ The weights for nitrogen discharge and phosphorus discharge are calculated from EPA data in tables B.5, B.6, and B.7.

EQIP Payment Amount Weights – EQIP contracts account for a variety of "resource concerns," among them surface water (including pesticides, erosion, and nutrient discharge), groundwater quality (including pesticides and nutrient loading), air quality (including wind erosion), and soil quality (including maintenance of soil productivity). By examining EQIP contract amounts and the stated primary resource concern, different sets of weights can be derived for potential pollutants stemming from regional agricultural production. Therefore, a comparison can be made of the relative weights associated with how much a given management practice might be expected to address one externality or another (table B-4). These weights do not compare unit measures of pollutant abatement; e.g., 1 pound of nitrogen abated compared with 1 pound of sheet and rill erosion. Rather, they reflect the relative importance of the criteria based on the relative amounts of payments paid out to practices that addressed them. For example, because carbon sequestration is not a resource concern under EQIP, it receives a weight of 0.[12]

[12]Such weights may (partially) reflect the policymakers' preconception of the performance of the relevant conservation program. For example, EQIP does not specifically address carbon sequestration, but CRP does. That may not indicate that EQIP policymakers do not value carbon sequestration, but that they realize the EQIP does not have a comparative advantage in providing incentives for carbon sequestration; whereas land retirement under CRP might.

Table B-4. National-level weights using EQIP expenditures

Medium	Initial weights (%)	Resource concern	Weights (%)
Air	0.05	Carbon	0.00
		Wind	0.05
Soil	0.46	Productivity	0.46
Groundwater	0.16	Pesticides	0.05
		Nitrogen	0.11
Surface Water	0.33	Pesticides	0.02
		Sediment	0.17
		Nitrogen[a]	0.07
		Phosphorus[b]	0.06
	1.00	Total	1.00

Source: FSA (2002).
a/ b/ The weights for nitrogen discharge and phosphorus discharge are calculated from EPA data below (Tables B.5, B.6, and B.7).

Returning to nutrients (nitrogen and phosphorus), there is no distinction between the type of nutrient being addressed under the surface or groundwater quality resource concern in the EQIP database. It can be assumed that, for groundwater quality, the nutrient of concern is nitrogen, which can directly affect human health through impaired well-water quality. However, the discharge of nitrogen and phosphorus into surface waters both result in significant water impairments. Therefore, we look to EPA's published nutrient criteria for rivers, streams, lakes, and reservoirs (table B.5) to develop these weights. The nutrient criteria represent EPA recommendations to States and Tribes for use in establishing water quality standards consistent with section 303c of the Clean Water Act (CWA). Using these criteria we can also generate a recommended nitrogen to phosphorus ratio by region, an indicator often used to determine the eutrophic potential of a water body (e.g., Scasso et al., 2001).

Table B.5. EPA nutrient criteria

	Nitrogen criteria		Phosphorus Criteria	
	Lake	River	Lake	River
Eco-region	micrograms per liter		micrograms per liter	
1	660	310	55	47
2	100	120	9	10
3	400	380	17	22
4	440	560	20	23
5	560	880	33	67
6	780	2,180	38	76
7	660	540	15	33
8	240	380	8	10
9	360	690	20	37
10	570	760	60	128
11	460	310	8	10
12	520	900	10	40
13	1,270	1,140	18	15
14	320	710	8	31

Source: EPA (2003).

The criteria are mapped into the 10 Farm Production Regions used in this report using an area-weighted average. In addition, based on the percentage of lakes and rivers impaired in each region, the recommended nitrogen and phosphorus concentrations for lakes and rivers are weighted to derive a single value for nitrogen and phosphorus for each region. In all regions, there is an abundance of both nitrogen and phosphorus discharge. To attain the recommended criteria, the amount of nitrogen and phosphorus in the water would have to be reduced by more than 80 percent in all regions (table B.6). The ratio of nitrogen to phosphorus reduction gives an indication of the relative importance of reducing the two nutrients.

Table B.6. Regional nitrogen and phosphorus concentrations

	Nitrogen		Phosphorus	
	Recommended[a]	Estimated[b]	Recommended	Estimated
Region	micrograms per liter		micrograms per liter	
AP	458	2,766	18	286
CB	1,048	7,639	44	688
DL	583	8,940	63	488
LA	817	8,924	31	705
MN	417	44,301	22	6,131
NP	794	17,855	43	1,498
NT	393	2,950	14	302
PA	292	22,378	20	2,565
SP	577	12,597	36	1,514
ST	32	54	1	5
US	772	13,437	37	1,394

a/ Recommended represents a weighted average of river and lake criteria based on the percentage of assessed rivers and lakes in these regions that are listed as threatened or impaired under the Clean Water Act's 303d reporting protocol (EPA, 2003b)
b/ Current annual loadings are estimated by the USGS for nitrogen and phosphorus (Smith et al., 1997). Current water flow per region is estimated from EPA (1996) data.

For example, to reach recommended levels of nitrogen and phosphorus concentrations in Appalachia, reductions in nitrogen discharge should occur at a rate approximately 9 times that for phosphorus discharge (table B.7). Recall that the point equivalency ratio between nitrogen and phosphorus is 10.93 for the range of practices included in this report. That is to say, that by using points to measure the environmental performance of various practices, a ratio of N:P weights of 10.93 is implicitly assumed. Therefore, the recommended N:P ratios in table B.7 are normalized by 10.93 to develop regional and national weights for nitrogen and phosphorus abatement. These weights are then multiplied by the weight given to the resource concern "nutrients discharged to surface water" to generate the relative national-level weights for reductions of nitrogen and phosphorus runoff (tables B.3 and B.4).

Table B.7. Recommended reductions for N and P runoff

Region	Recommended reductions		N:P ratio	Weights	
	N	P		N	P
	micrograms per liter			%	
AP	2,308	268	8.61	0.56	0.44
CB	6,591	644	10.24	0.52	0.48
DL	8,357	425	19.67	0.36	0.64
LA	8,107	674	12.02	0.48	0.52
MN	43,884	6,109	7.18	0.60	0.40
NP	17,061	1,455	11.73	0.48	0.52
NT	2,557	288	8.88	0.55	0.45
PA	22,086	2,545	8.68	0.56	0.44
SP	12,020	1,478	8.13	0.57	0.43
ST	22	4	4.95	0.69	0.31
US	12,666	1,357	9.33	0.54	0.46

B.2.2 Regional Weights

Incorporating Benefits – To enhance the national-level weighting scheme derived from the EBI, benefits data are used to develop regional weights that reflect the value of environmental benefits generated under these programs. Earlier benefits studies (Feather and Hellerstein, 1997; Feather et al., 1999) examined the value of reducing soil erosion through the CRP across the United States. These studies accounted for the variable effect of water quality (soil erosion) on recreational expenditures from the National Survey of Recreation and the Environment and estimated the marginal benefit of reducing soil erosion by 1 ton for recreational uses at each of the NRI survey points. Individual estimates were imputed to the national population using a calibrated benefits transfer approach (Feather and Hellerstein, 1997).

Following the benefits transfer, the marginal benefit of reducing a ton of erosion in any particular region can be generated for each Farm Production Region. Based on simulation estimates of actual soil erosion occurring in these regions, a weighted average for valuing soil erosion at the Farm Production Region level is determined (table B.8). Implicit in these regional weights will be the population size and characteristics embodied in the benefits transfer exercise conducted by Feather et al. (1999). Values show that the average marginal benefit of reducing soil erosion is closely linked to population density per square mile.

Table B.8. Marginal benefits of reducing soil erosion

Region	Mean marginal benefits $ per ton	Weight %	Population density per sq. mile
AP	1.81	0.09	137.92
CB	1.91	0.09	149.21
DL	1.32	0.07	70.06
LA	2.13	0.11	106.02
MN	1.57	0.08	21.23
NP	0.50	0.02	19.09
NT	4.64	0.23	346.12
PA	2.61	0.13	135.57
SP	2.21	0.11	73.51
ST	1.47	0.07	169.25

Source: Feather et al. (1999).

This regional measure of the value of environmental benefits (i.e., marginal benefits of reducing soil erosion) is multiplied by the national-level weights developed using the EBI (table B.2) to determine one set of regional weights for weighting multiple environmental criteria (table B.9).

Table B.9. Benefit-adjusted regional weights using the EBI

	Regional weights									
Resource concerns	AP	CB	DL	LA	MN	NP	NT	PA	SP	ST
Carbon emissions	0.12	0.12	0.09	0.14	0.10	0.03	0.30	0.17	0.14	0.09
Wind erosion	0.12	0.12	0.09	0.14	0.10	0.03	0.30	0.17	0.14	0.09
Productivity loss	0.39	0.41	0.28	0.46	0.34	0.11	1.00	0.56	0.48	0.32
Pesticide leaching	0.03	0.03	0.02	0.04	0.03	0.01	0.08	0.05	0.04	0.03
Nitrogen leaching	0.06	0.06	0.04	0.07	0.05	0.02	0.16	0.09	0.07	0.05
Pesticide runoff	0.01	0.01	0.01	0.01	0.01	0.00	0.03	0.02	0.02	0.01
Sediment runoff	0.09	0.10	0.07	0.11	0.08	0.02	0.23	0.13	0.11	0.07
Nitrogen runoff	0.04	0.04	0.03	0.05	0.03	0.01	0.10	0.06	0.05	0.03
Phosphorus runoff	0.04	0.04	0.03	0.05	0.03	0.01	0.10	0.06	0.05	0.03

This assumes that the region with the highest average marginal benefit for reducing soil erosion (as measured by recreational benefits) is also the region with the highest value of overall environmental quality.

A similar set of regional weights can be developed from the EQIP contract data (table B.4) following the same procedure as for the national-level weights (table B.10).

Table B.10. Regional weights using EQIP contract data

	Regional weights									
Resource concerns	AP	CB	DL	LA	MN	NP	NT	PA	SP	ST
Carbon emissions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wind erosion	0.01	0.00	0.00	0.02	0.10	0.18	0.03	0.08	0.02	0.00
Productivity loss	0.43	0.48	0.62	0.52	0.61	0.51	0.22	0.35	0.46	0.41
Pesticide leaching	0.07	0.05	0.07	0.06	0.01	0.01	0.06	0.08	0.00	0.02
Nitrogen leaching	0.13	0.10	0.05	0.13	0.13	0.07	0.20	0.07	0.03	0.16
Pesticide runoff	0.00	0.02	0.00	0.02	0.00	0.03	0.06	0.11	0.04	0.02
Sediment runoff	0.31	0.16	0.22	0.10	0.14	0.10	0.13	0.10	0.27	0.05
Nitrogen runoff	0.03	0.10	0.01	0.08	0.00	0.04	0.17	0.11	0.10	0.23
Phosphorus runoff	0.02	0.09	0.02	0.08	0.00	0.05	0.14	0.09	0.07	0.10

After an initial comparison of the weights in tables B.9 and B.10, one might expect a working-land program using regional weights derived from the EBI to result in greater levels of carbon sequestration than one using weights derived from past EQIP expenditures. Similarly, a program using the regional weights from the EBI might be expected to enhance environmental performance of working lands to a greater degree in the Northeast than a program using regional weights derived from EQIP expenditures. However, these weights do not reflect the extent to which practices that address one resource concern are complements or substitutes for other resource concerns. For example, various tillage practices that reduce sediment runoff may enhance soil productivity, but might result in increased pesticide and nitrogen leaching. Hence, we cannot say, prior to empirically simulating these weighting schemes within the framework of alternative working-land programs, what the potential results may be.

Additional Weighting Schemes – In addition to the two regional-level weighting schemes described above, two other weighting schemes were considered at the regional level. The first of these are regional weights derived from the EBI, similar to table B.9, but with zero weights for changes in soil productivity (table B.11).

Table B. 11. Regional weights derived from the EBI without valuing soil productivity

	Regional weights									
Resource concerns	AP	CB	DL	LA	MN	NP	NT	PA	SP	ST
Carbon emissions	0.21	0.22	0.15	0.24	0.18	0.06	0.53	0.30	0.25	0.17
Wind erosion	0.21	0.22	0.15	0.24	0.18	0.06	0.53	0.30	0.25	0.17
Productivity loss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pesticide leaching	0.03	0.03	0.02	0.04	0.03	0.01	0.08	0.05	0.04	0.03
Nitrogen leaching	0.14	0.15	0.10	0.17	0.12	0.04	0.36	0.20	0.17	0.11
Pesticide runoff	0.02	0.02	0.02	0.03	0.02	0.01	0.06	0.03	0.03	0.02
Sediment runoff	0.16	0.17	0.12	0.19	0.14	0.04	0.41	0.23	0.19	0.13
Nitrogen runoff	0.07	0.07	0.05	0.08	0.06	0.02	0.18	0.10	0.09	0.06
Phosphorus runoff	0.06	0.06	0.04	0.07	0.05	0.02	0.15	0.09	0.07	0.05

A common feature of both the EBI- and EQIP-derived weights is the relatively large weight that CRP and EQIP place on maintaining soil productivity. Such large weights may be unnecessary, as producers likely prefer practices that maintain or improve soil productivity, which has inherent value. Producers would be expected to directly benefit from enhancing soil productivity, and therefore, additional payments are not necessary to encourage such behavior. Consequently, the weights on the other indicators are augmented relative to their initial importance in the weighting scheme.

Given the amount of information necessary to generate weights for multiple environmental criteria, program decisionmakers may prefer to simplify this procedure and weight practices that address alternative resource concerns equally across all the nine environmental indicators and 10 regions (i.e., a weight of 0.11 for each resource concern in each region). As mentioned earlier, a uniform weighting scheme implicitly adopts the point equivalency ratios (eq B.3) belying the 0-1 benefit index (I_{kji}) for each pollutant (*j*). That is to say, the practice that potentially discharges the largest amount of phosphorus to surface waters is weighted equivalently to the practice that potentially sequesters the least amount of carbon, etc.

Web Appendix C
Conservation Benefits, Installation Costs, and Land Rental Rates

The data used to analyze correlation among conservation benefits, conservation costs, and agricultural land rental rates come from a number of sources including:

The Natural Resource Conservation Service (NRCS) Work Load Assessment (WLA);
Environmental Quality Incentives Program (EQIP) contract data;
National Resource Inventory (NRI) point data files;
1997 Census of Agriculture;
An ERS database of estimates – drawn from previous studies – of a wide range of benefits that are likely to flow from soil erosion reduction and the wildlife benefits of establishing conservation cover from partial field practices such as grassed waterways and filter strips;
Rental rate data developed for the Conservation Reserve Program (CRP) and Grassland Reserve Program (GRP).

C.1 Resource Concerns

Data on acres that require the application of one or more conservation practices to address a resource concern is from the WLA. For each county, the WLA provides the acreage of various land types (e.g., cropland, pasture) that require the application of practices for various resource concerns. A total of 573 million acres of cropland and grazing land have some treatable resource concern (Table C.1).

Table C.1. Summary of WLA data on resource concerns by land type and resource concern

	Resource concerns					
Land type	Soil erosion	Nutrient & pest mgmt	Irrigation water	Grazing	Wildlife	Totals
			million acres			
Cropland	162	35.8	42.6	1.4	6	247.8
Grazing land	55.8	12.9	2.1	235.6	18.8	325.2
Totals	217.8	48.7	44.7	237	24.8	573

To adapt WLA data for use in comparing benefits and costs, several adjustments were necessary. First, separate estimates of wind and water erosion concerns were needed. This report assumes that the proportion of acres needing treatment for wind erosion is roughly equal to the proportion of acres with wind erosion in excess of the soil loss tolerance, or "T" level. A similar procedure is used to determine the number of acres that were assigned a water erosion concern. Data on wind and water erosion is from the 1997 NRI. To allocate other resource concerns among non-irrigated and irrigated cropland, it

is assumed that resource concerns are distributed proportionately among irrigated and non-irrigated cropland, by county. Data on irrigated and nonirrigated cropland is obtained from the 1997 Census of Agriculture.

C.2 Conservation Practice Installation Costs

Conservation practice installation costs are estimated from EQIP data for 1996-2001. The cost of addressing a given resource concern is the average cost of installing or adopting practices that are typically used to address it. Practices are grouped according to the physical processes they affect, i.e., practices that reduce water erosion are grouped together, etc. Groupings are similar to those used in *Environmental Quality Incentives Program: Benefit-Cost Analysis* (USDA, NRCS, 2003). To address a resource concern, producers would be required to address one or more of these physical processes. The average per-acre cost of practices used to address various physical effects is calculated from a subset of 33 of the practices most frequently used in EQIP contracts.

To estimate the average cost of installing or adopting conservation practices used to address specific resource concerns, total practice cost is used. For structural practices, total cost is the cost-share paid divided by the cost-share rate. For management practices, total cost is estimated as the maximum allowed incentive payments, obtained by dividing payment amount by the proportion of the maximum that is actually paid to the producer. While the maximum payment rates are designed by NRCS to approximate local costs, there remains considerable uncertainty about the actual costs of applying management practices. Nonetheless, these rates are the best available proxy for the cost of applying management practices.

For some practices, the extent of application is described in units other than acres. For example, the extent of terraces cost-shared is described in terms of linear feet. For these practices, conversion factors developed for the EQIP benefit-cost analysis are used to convert units into acres treated.

Although the data are identified to counties, NASS Agricultural Statistics Districts (ASDs) were used as the basic unit for averaging costs. Historically, EQIP has not been a large program and many counties include only a small number of EQIP contracts. Thus, a larger, multicounty area is likely to provide more reliable estimates of practice installation cost while also capturing spatial variation in conservation costs. ASDs were selected for this purpose because they are sub-State areas defined along county lines. Within each ASD, the average cost of practices addressing specific resource concerns is the acre-weighted sum of practices generally used to address the resource concern.

C.3 Benefits of Conservation

The benefits generated by the application of conservation practices are estimated using benefits transfer techniques. Benefit estimates were drawn from the literature and applied using additional data and physical process models. For example, water quality benefits are typically expressed in terms of damage reduction per ton of soil erosion reduction. These benefits can be applied on a per-acre basis using estimates of potential erosion reduction derived from the NRI.

C.3.1 Water Quality

Control of water erosion can improve water quality. Benefits generally grouped under the rubric "water quality" actually represent a wide range of distinct benefits, including water-based recreation, loss of reservoir storage capacity due to silt buildup, dredging costs for navigation, and additional water treatment costs for both drinking and industrial use. Increased benefits to water-based recreation from reduced soil erosion are based on estimates by Feather and Hellerstein (1997). Hansen et al. (2002) estimate the cost of soil erosion based on the cost of downstream dredging to maintain navigation channels. Other benefits are based on Ribaudo (1990).

Benefit estimates from these studies are in dollars per ton of soil conserved. To convert these figures to dollars per acre, likely water erosion reductions were estimated using historical data from NRI. Within a watershed (8-digit hydrologic cataloguing unit), expected erosion reduction due to practice application is estimated as the acre-weighted average erosion reduction on NRI points where: (1) erosion was above the soil loss tolerance (T) level in 1992; (2) erosion was reduced by 25 percent or more between 1992 and 1997; and (3) the erosion rate was below 1.25*T in 1997.[13] The same procedure is used to estimate erosion reductions for both cropland and grazing land.

[13]The factor of 1.25 accounts for the soil-erosion tolerance allowed producers.

C.3.2 Air Quality

Control of wind erosion can improve air quality. Benefits generally grouped under the rubric "air quality" include, among other things, decreased cleaning costs due to dust accumulation and health effects. Like water benefits, data is provided on the basis of benefits per ton of soil conserved. These benefit estimates are converted to a per-acre basis using a procedure analogous to that outlined above for water erosion. Ribaudo et al. (1990) developed regional measures of the cost of particulate pollution caused by wind erosion. The cost model is estimated using contingent valuation techniques and data from a survey of households in New Mexico (Huszar and Piper, 1986). Benefit estimates are provided per ton of soil conserved. Per-ton estimates are converted to a per-acre basis using procedures analogous to those used for water erosion.

C.3.3 Soil Productivity

Conservation of soil depth preserves soil productivity. Soils can also lose productivity, in the short run, when nutrient or other costly production inputs are lost with the soil. Reductions in soil erosion will increase the future productivity of farmland and reduce the loss of soil nutrients that can be washed away with the soil. For this study, average losses in soil productivity and nutrients per ton of soil erosion are derived from Ribaudo et al. (1990).

C.3.4 Wildlife Habitat

Benefits used for the calculations in this report are based on an ERS study described in Feather et al. (1999). Benefits are based on *use values*, or the value derived from directly using the resource – specifically for wildlife viewing and

pheasant hunting. Although improvements in wildlife habitat benefit a number of avian species, the demand for pheasant hunting was easier to quantify based on existing recreational data. The ERS model evaluates the quantity and quality of the cover available for specific avian species, then estimates the surplus resulting from enrolling land in CRP. Since establishing grassland or forest cover creates suitable habitat for birds, small game, and large game, hunters and wildlife viewers then benefit from these increased populations. The model also incorporates travel costs, landscape diversity, and population density. There are limitations associated with using benefits estimated for the CRP in the context of a working-land program. However, most of the practices that generate wildlife benefits in the working-land context produce wildlife cover similar to that found on CRP land. Grassed waterways, windbreaks, and similar practices generate wildlife benefits in much the same way CRP would. Nonetheless, this report addresses any difference by reducing the wildlife benefits estimated to be generated through CRP by 50 percent.