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Balancing the Multiple Objectives of Conservation Programs

Andrea Cattaneo, Daniel Hellerstein, Cynthia Nickerson, and Christina Myers

Abstract

Many of the Nation's conservation programs seek to achieve multiple environmental objectives. Implementing a multi-objective program efficiently requires program managers to balance different environmental and cost objectives. A number of conservation programs use an index approach to prioritize objectives and rank program applications. This approach keeps program objectives distinct and enables program managers to use weights to determine the relative importance of each objective. This report provides empirical evidence on the environmental and cost tradeoffs of different index weighting schemes in USDA's Conservation Reserve Program (CRP). The analyses take into account both land characteristics and how changes to an index affect producer decisions to voluntarily apply. While small changes in index weights do not markedly affect the outcomes of the CRP, larger changes can have a moderate effect. Opportunities for obtaining multiple environmental benefits simultaneously by increasing the index weight on one objective appear limited, and increasing an objective's index weight by at least 20 percent can trigger losses of benefits related to other objectives. Weight changes in smaller incremental program enrollments also result in more tradeoffs than in very large program enrollments.

Keywords: Conservation Reserve Program, Environmental Benefits Index, environmental benefits, conservation program participation.

Acknowledgments

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Summary

To help minimize the negative and maximize the positive environmental impacts of agricultural production, the Federal Government supports a variety of conservation programs. These include land retirement, working lands, and easement programs. Land retirement programs, such as the Conservation Reserve Program (CRP) and the Wetlands Reserve Program, pay landowners to implement environmentally enhancing practices on land they voluntarily take out of production. Working lands and easement programs, such as the Environmental Quality Incentive Program, Conservation Security Program, and the Farm and Ranch Lands Protection Program, pay participants to maintain or enhance conservation efforts on farmland kept in production. In 2005, expenditures for these programs exceeded $2.8 billion. Each of these programs seeks to achieve multiple environmental objectives, including reducing soil erosion, increasing water and air quality, and protecting wildlife habitat cost effectively.

What Is the Issue?

Implementing multi-objective programs efficiently requires balancing different environmental and economic objectives. A number of the largest U.S. conservation programs use an "index," in which measures of multiple environmental and cost objectives are weighted by program manager perceptions of relative importance. The index calculates a score for, and is used to rank, applications for enrollment submitted by potential program participants. This approach gives program managers the option, in each enrollment period, to change the relative weights assigned to each objective in the index. For example, new information about heightened public interest in protecting wildlife habitat may induce program managers to increase the weight on a wildlife habitat objective. Applications meeting the favored objective would then be prioritized, resulting in a different mix of applications selected from the pool of applicants. Getting new information about societal preferences for environmental outcomes can be expected, given that at present, little is known about how society values one environmental improvement over another. Also, little is known about the effect of index weight changes on environmental outcomes. That is, do small changes in weights significantly affect the mix of applications selected for enrollment, leading to very different program outcomes? Or do large changes in weights only minimally affect the selected set of applicants and thus have a limited impact on program outcomes?

What Did the Study Find?

Small changes to index weights made relatively little difference in environmental outcomes, but larger changes generated larger impacts in the CRP. Environmental outcomes in the CRP were not very sensitive to *small* changes in the program's index weights, even when the size of the enrollment was allowed to vary from 2 million to 33 million acres. For example, environmental objectives sought in the CRP included soil erosion reduction, water quality improvements, and increased wildlife benefits, and these three objectives have received equal weight in recent years. A 10-percent change in the weight on the soil erosion weight objective increased erosion reduc-

tion benefits by 5 percent at most. Weight changes of more than 20 percent generated larger impacts on environmental outcomes. For example, an approximately 50-percent increase in the wildlife objective weight increased wildlife benefits up to 15 percent. The largest weight changes generated the largest changes in outcomes: tripling the erosion reduction weight increased erosion reduction benefits by 50 percent.

These findings may seem intuitive. Yet, they highlight that as long as CRP outcomes approximately reflect public preferences, then few opportunities exist for improving environmental outcomes by fine-tuning the index weights. But if new information suggests that an alternative mix of environmental improvements is preferred, program outcomes can be affected by larger changes in weights.

In terms of tradeoffs, only a large increase in the weight of a particular environmental objective caused losses of benefits related to other objectives. Throughout our analyses, tradeoffs occurred between achieving additional wildlife benefits and erosion reduction benefits, but the effects were relatively weak. Erosion reduction benefits declined 15 percent when the wildlife habitat weight doubled, and wildlife benefits declined about 5 percent when the erosion weight was doubled. Other tradeoffs appeared to have more modest responses, although this effect varied by region.

Changes in the CRP objectives' weights affected program costs more than environmental outcomes. In particular, improvements in water quality were more costly to obtain than other objectives. A 10-percent increase in water quality benefits generated by the CRP would increase costs up to 20 percent, while increasing wildlife benefits by 10 percent entailed less than a 14-percent cost increase. Also, benefits could be achieved more cost effectively when we simulated enrollment in a newly formed program. This effect suggests that achieving environmental improvements may become more expensive as ongoing enrollments reduce the pool of available lands.

When program objectives, overall program sizes, or other features are mandated by law, changing index weights can serve as a lever for moderately affecting CRP outcomes. In addition to changing index weights, program decisionmakers may find that adjusting other program design features, such as eligibility criteria or the mix of allowable land management practices, or allowing weights to vary by region help bring about changes in program outcomes.

How Was the Study Conducted?

The CRP has used an environmental benefits index (EBI) since the early 1990s to rank applications for land enrollment. In the CRP's 26th signup in 2003, the EBI considered several different types of objectives: wildlife habitat quality, water quality, erosion reduction potential, enduring benefits, air quality, and cost. We used CRP application and enrollment data from this signup to simulate how small and large changes in the EBI objectives' weights would affect the economic and environmental outcomes of the program. The simulations considered the types of land available for enrollment and the degree to which changes in index weights induce landowners

to enroll different types of land. We examined the impacts of changing the weights for a single enrollment period (i.e., when 2 million acres are added to an ongoing program). We also simulated the effects of weight changes when no land was previously enrolled (that is, when 33 million acres are enrolled—simulating a full-program enrollment).

The analyses assumed applications scoring the highest among each of several objectives would have the largest actual environmental impacts in the CRP. As different simulations generated new scores for applications, different sets of farmland were selected for enrollment. Because each set contributed different environmental impacts and entailed different costs, different environmental and cost outcomes were possible.

Balancing the Multiple Objectives of Conservation Programs

Andrea Cattaneo, Daniel Hellerstein,
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Introduction

Historically, the primary function of agriculture has been the production of food and fiber. Over the last several decades, however, the multidimensional aspects of agriculture have taken on a progressively more important role. Structural changes in the economy, technological improvements in agriculture, and urbanization have expanded society's perception of agriculture as a provider of a variety of outputs, especially in industrialized countries. In particular, public awareness of the positive and negative byproducts of agricultural production is increasing.

In unregulated markets, agricultural producers often bear few or none of the costs associated with negative byproducts, and they reap few benefits of the positive byproducts, of agricultural production—rather, these costs and benefits accrue to society as a whole. Due to these "externalities," governments may seek to influence agricultural producers' incentives and choices in ways that limit the negative, and increase the positive, impacts. These efforts can be narrowly focused on a single objective, or they can be simultaneously concerned with multiple objectives.

Addressing Multiple Objectives: Multiple Programs or One Multi-Objective Program?

Government intervention in agriculture can take numerous forms, including regulatory measures (such as standards, bans, and restrictions on input use) and incentive-based measures (such as voluntary conservation programs and subsidies). In situations where producers create private goods in combination with externalities, economists' standard policy recommendation is to let market forces freely determine the level of production, consumption, and trade of the private goods, while at the same time address any positive or negative externalities through targeted policy measures.

Standard economic policy theory implies an optimal strategy would address each externality through a separate policy instrument (Tinbergen, 1952). However, addressing each externality through a separate policy instrument is optimal only under certain conditions: program implementation/administrative costs must be negligible, and policy objectives must be independent of each other. But, in fact:

- Program implementation costs are high. By some estimates, administrative costs for conservation programs in the United States and Europe range from about 5 to nearly 50 percent of total program costs—about 20 times higher than administrative costs for traditional price and income support programs (Falconer et al., 2001; Falconer and Whitby, 1999; McCann and Easter, 2000; Vatn, 2002; Leathers, 1991).

- Linkages can exist among the externalities targeted by a policy. For example, phosphorus travels off-farm through binding with eroded soil particles, contributing to a "complementary" relationship between soil erosion and phosphorus runoff (USDA-NRCS, 1997). Alternatively, the water and air quality externalities associated with animal waste problems may be considered "substitutes," when reducing runoff to improve water quality leads to increased emissions that worsen air quality. In such cases, achieving a single policy objective independently may be difficult or impossible (see box, "Linkages Between Agri-Environmental Externalities").

- Externalities that do not initially appear to be strongly linked (as complements or substitutes) may become so, once a program's eligibility criteria constrain the universe of land that qualifies for program participation. For example, a program might target highly erodible lands, and phosphorus runoff and soil erosion externalities may be more closely associated on these lands than on other land types.

For these reasons, separate programs aimed at altering producer choices to reduce each of the negative externalities associated with agricultural production may not be optimal (see box, "Potential Inefficiencies From a Multiple Program Approach: An Illustrative Example"). Indeed, many conservation programs today are designed to achieve multiple objectives.

Prioritizing Objectives in a Multi-Objective, Voluntary Program

The need for prioritizing program objectives often arises in the context of voluntary conservation programs. Rarely are budgets (or acreage targets, if a fixed amount of land is sought for enrollment) large enough to enroll all producers who offer to apply in any particular year. Prioritizing can encourage efficiency, because doing so allows program managers to first enroll those potential program participants offering to provide the most value to society.

In theory, program managers can design an efficient multi-objective program when they have and use information on society's values for the positive and negative externalities the program seeks to address. In practice, estimating and comparing the relative value of offers, where each offer addresses a diverse mixture of environmental concerns, is no easy task. Perhaps the most difficult aspect of this is that information on the relative importance society places on different environmental concerns is often not available. This hampers a program manager's ability to determine the priority to place on each concern.

Linkages Between Agri-Environmental Externalities

Many factors can affect the outcomes of conservation policies, including relationships that exist among the environmental resources of concern. Analogous to how economists describe commodities or factors of production as "complements" when they tend to be used together, or "substitutes" when they tend to be used in place of the other, resources can be thought of as "complements" or "substitutes." Resources can be thought of as complements when an improvement (decline) in one environmental resource results in an improvement (decline) in the other. A resource that acts as substitute has the opposite or no effect on other resources when improvements (declines) occur to it.

These linkages between environmental resources can arise from the following:

- *Intrinsic relationships between the externalities.* For example, phosphorus runoff and soil erosion are intrinsically related, because by its nature phosphorus attaches to eroded soil particles to travel off-farm.

- *Land use allocations.* How producers allocate a fixed amount of land can give rise to complementary and substitutability relationships (Boisvert, 2001). For example, some crop rotations generate complementary reductions in erosion and pesticide runoff but the substitution effect is more nitrogen leaching (Mitchell et al., 1998; USDA-NRCS, 1997).

- *Choices made in the production process.* Complementary relationships can arise when producers choose inputs that jointly produce a bundle of outputs. For example, the labor required to implement a no-till practice that produces both erosion reduction and wildlife benefits is a nonallocable input.

When these linkages exist, the methods used to address one environmental concern can influence other environmental concerns. Accounting for these linked externalities is possible in a multi-objective, but not in a single objective, program approach.

In some cases, program managers can prioritize different environmental concerns based on monetary values that are derived from measures of the net benefits reaped by society when each of the different environmental concerns is alleviated. Alternatively, program managers can use stakeholder input to establish the relative importance of different environmental concerns. However, net benefits are often not available, and obtaining stakeholder input and engaging in negotiations can be very costly and time consuming. This means policymakers or program managers are often faced with prioritizing based on their perceptions of stakeholder preferences and societal goals. Nevertheless, the prioritization can be guided by monetary estimates for benefits when they exist, even if incomplete.

Potential Inefficiencies From a Multiple Program Approach: An Illustrative Example

To illustrate how high program implementation/administrative costs (economists refer to these as "transaction costs") and interrelationships between policy objectives can affect the efficiency of implementing multiple programs, consider a case where program managers have the option to either set up separate conservation programs aimed at reducing soil erosion, reducing nitrogen runoff, and increasing wildlife habitat, or introduce one comprehensive program considering all three of these environmental concerns at the same time.

Some features would be common to both approaches: producers voluntarily submit offers to provide environmental services on agricultural land, they agree to implement certain practices or retire certain land from production, and those accepted into the program are paid their offer amount.

The multiple program approach would likely have greater transaction costs than a single multi-objective program, given the larger number of separate contracts to be stipulated. It could also create inefficiencies due to the interrelationships between environmental concerns. For example, a producer may offer to install vegetation cover on a parcel close to a stream, which would provide multiple benefits (such as erosion control, wildlife habitat benefits, and aesthetic benefits). This offer may be rejected by each of the separate programs because vegetation cover does not provide enough benefits in any single category—even though it would be economically efficient to implement because it provides more aggregate benefits than any other offer/practice combination.

Policymakers or program managers then use these priorities to establish a set of "weights" that is combined with physical measures of each environmental concern to construct an index. This index can be used to assign a single summary score to each program applicant, which summarizes how well each application meets the full set of objectives. The resulting scores are used to rank applications, with higher values indicating which applicants to enroll first.

The weights program managers ultimately use in conservation program indices can act as levers to induce changes in program outcomes. As weights change, index scores on existing offers will change, leading to a change in the ranking and mix of applicants that are enrolled. Furthermore, the incentive effects of weight changes can change the set of lands offered for enrollment: producers who previously offered to enroll land in a program might not do so when faced with a new set of weights, if they perceive the change lowers the likelihood their enrollment offer will be accepted (or that the change lowers the net returns from participating). Similarly, new producers may opt to participate if weight changes induce more favorable perceptions of their enrollment offer being accepted.

Program managers cannot control some factors that affect program outcomes—such as the extent to which environmental concerns are easy for producers to address simultaneously, or the extent to which farm household

characteristics (such as a producer's age) might affect a producer's decision to offer land for program enrollment. Questions arise, then, regarding the sensitivity of a program's outcomes to a program manager's choice of weights. Understanding the sensitivity of program outcomes to weights may be particularly important given that the "correct" weights are rarely determined precisely in the first place. For example, new information may suggest that existing program outcomes do not reflect the relative values society places on the various objectives (or that relative values have changed). Program managers and policymakers could benefit from understanding how outcomes might vary if the weights are changed. To date, few studies have addressed this issue.

Prior research has focused on clarifying what *types* of conservation programs are used, given agriculture's multiple outputs, and recognizing the risk of conflict between such programs and further agricultural trade liberalization (OECD, 2003; Bohman et al., 1999). This report focuses on how the *design* of conservation programs affects economic and environmental outcomes.

With these considerations in mind, this report asks the following questions:

- How do existing conservation programs trade off environmental concerns?

- How sensitive are environmental outcomes and program costs to the choice of weights in a conservation program index? Does the sensitivity vary depending on the number of acres enrolled or on the size of changes in the weights?

- For which environmental concerns would program managers benefit the most from having better information on nonmarket values?

Indices in a Multi-Objective Program: Experience and Design in U.S. Conservation Programs

Over the last 20 years, the Federal Government has established a number of agricultural land conservation programs. While these programs do not seek the exact same types of environmental improvements, the goal of achieving multiple objectives within the confines of a single program is widespread. Multi-objective programs include the Conservation Reserve Program (CRP) and the Wetlands Reserve Program (WRP), which seek environmental improvements by retiring farmland; the Environmental Quality Incentives Program (EQIP) and the Conservation Security Program (CSP), which are designed to improve environmental outcomes on "working" agricultural lands; and the Farm and Ranch Lands Protection Program (FRPP), which seeks to prevent the loss of environmental resources to nonagricultural uses.

Experience in U.S. Conservation Programs

Conservation programs continue to rely on voluntary participation, and producer interest in participating continues to outpace budgetary outlays or acreage constraints. The need for methods to select among applicants in multi-objective programs likewise continues.

Many Federal conservation programs seek to achieve multiple objectives, but not all use the same mechanism for choosing between competing offers (table 2.1). For example, in most multi-objective programs, program managers use a "parcel selection index" to target enrollments on the basis of environmental benefits and costs. In the CSP, however, the concept of an index is embodied in the use of benefits-based payments (higher payment rates for producers providing greater levels of environmental benefits).

Even when programs use a parcel-selection index in some fashion, the elements of the indices can vary. For example, as a component of the CRP's environmental benefits index (EBI), cost directly affects the selection of land for enrollment. Conversely, cost is not an explicit factor in selecting lands into the CSP, though it does serve to limit overall program size. Also, while several programs focus on the same type of environmental resource (improving water and soil quality, for example), some have standards for reducing environmental degradation while others (i.e., the CSP) seek improvements beyond those standards. These uses of indices have been supplemented through geographic targeting and other mechanisms to enhance the ability of the programs to achieve multiple objectives (app. A).

Differences in program structure can give rise to the use of multiple indices within a single program. For example, decentralized programs such as EQIP and FRPP use indices in a two-step process. First, Federal program managers use a "budget allocation" index to allocate the Federal budget to various States. This index can incorporate a number of factors, such as

Table 2.1

Using Indices To Balance Objectives in Major U.S. Conservation Programs

Program	Program objectives	How objectives are balanced
Conservation Reserve Program	1985-89: Reducing soil erosion 1990-present: Providing wildlife benefits, improving water quality, reducing soil erosion, providing enduring benefits, improving air quality, clustering in priority areas, and providing cost savings.	1985-1989: Applications were approved on the basis of ability to reduce soil erosion. 1990-present: Environmental benefits index (EBI) used to target enrollments on the basis of multiple environmental objectives and cost.
Environmental Quality Incentives Program	Reducing soil erosion, improving water quality, providing wildlife benefits, and improving air quality on working agricultural lands.	One index is used to allocate program funds to States; State (and county, in some cases) indices are used to target enrollments on the basis of multiple environmental benefits. Some States also consider cost.
Conservation Security Program	Improving soil quality, water quality, air quality, wildlife habitat, and energy on working agricultural lands.	Enrollment categories are used to rank applicants, where soil quality and conservation *effort* determines category assignment. Also, benefits-based payments embody the index concept by paying higher payments to producers who adopt more conservation practices.
Wetlands Reserve Program	Increasing wetland functions and values, including wildlife habitat.	One index is used to allocate program funds to States, on the basis of ecological concerns, State performance, producer interest, and cost. State indices are used to target enrollments on the basis of wetland benefits and program costs.
Farm and Ranch Lands Protection Program	Preventing the loss of prime agricultural land and important topsoil to nonagricultural uses (primarily urban uses).	One index is used to allocate program funds to States, partly on the basis of recent rates of farmland loss, program costs, and States' performance. State and local entities use indices to target enrollments based on environmental measures, farmland management efforts, development pressure, and location.

State-level measures of environmental resources and data on past performance of State-level programs. Second, State and local program managers typically use a multi-objective parcel selection index to prioritize and select offers. These parcel selection indices can prioritize offers on the basis of parcel-level environmental characteristics (e.g., percent of prime or erosive soils), implementation costs, and other factors.

Designing an Index

Program managers use indices in multi-objective conservation programs to weigh the different environmental concerns of interest. Each index computes, for each producer's offer to enroll land in the program, a score that can be used to rank the offers. However, from a program-design perspective, weighing the environmental concerns and computing an offer's score are simply the final steps of the process. Developing an index that

allows multidimensional information to be aggregated into a single summary number requires the following steps:

1) *Choice of objectives*—Clearly defined program objectives form the basis of the index. These objectives can include environmental objectives, such as reducing soil erosion, and economic objectives, such as minimizing program costs.

2) *Choice of indicators*—For each program objective, quantifiable variables must be defined to measure the likely environmental or cost impact of an offer. For example, for wildlife benefits, indicators may include the diversity of species planted for wildlife habitat or the number of endangered species that are expected to benefit from a given combination of lands and practices that producers offer for enrollment. Cost impacts are measured based on monetary measures of different land/practice combinations.

3) *Assignment of unit values for each of the indicator variables*—These values could be represented in physical units (tons, acres, etc.) or through a relative scale for the indicator (a 0 to 100 percent range). For example, the wildlife habitat benefits from planting cover crop X might achieve 75 percent of the wildlife benefits provided by the best possible cover crop.

4) *Choice of weights*—Weights signal tradeoffs. A decision must be reached in terms of the relative importance of different program objectives.

5) *Choice of functional form used for index*—The functional form is used to aggregate the indicator variables for an offer into a single value. Any given functional form represents how different objectives combine to yield an overall value. Different functional forms can yield different orderings from the same underlying set of environmental concerns and weights. To be useful, the ordering represented by the index needs to be unambiguous.[1]

Using these steps, the score for an offer using an additive functional form can be calculated as:

$$Score\ (for\ offer\ i)\ =\ (w_1 * x_1) + (w_2 * x_2) + (w_3 * x_3) + (w_4 * x_4) \ldots$$

The *x*'s represent the indicator variables expressed in unit values, and the *w*'s are the weights assigned to the associated environmental concern.

Illustrative example: The effect of index weights on program outcomes depends on linkages between environmental resources

In Chapter 1, we described how environmental resources can be linked – either as "complements," so that improvements to one resource lead to improvements in the other, or as "substitutes," for which improvements to one resource have no impact or a negative impact on the other. Understanding what type of linkages exist between resources is an important part of designing an index because they affect what type of response

[1] Avoiding ambiguity requires the ordering to be invariant to the choice of units. Ebert and Welsch (2004) identify the conditions under which an environmental index provides an unambiguous ordering. One of their major findings is that indices in the form of a weighted geometric mean (Cobb - Douglas type – e.g., Total Score = $x_1^{w_1} \cdot x_2^{w_2} \cdot x_3^{w_3} \cdot x_4^{w_4} \ldots$ where x_{1-4} are indicator variables and w_{1-4} are the weights assigned to the environmental concern) are generally preferable to those obtained using a weighted arithmetic mean.

occurs when program managers set up or change index weights—and, importantly, whether complementary relationships may be strong enough to contribute to unintentional weighting of a resource objective in excess of the weight that is directly assigned to that objective. As the next several figures demonstrate, outcomes may be more predictable in response to a weight change if resources are complements, but may be less so if resources are substitutes.

Figure 2.1 illustrates how the choice of weights in an index affects which offers, or producer applications, a program manager accepts for enrollment in a multi-objective program. The hypothetical program aims to reduce both soil erosion and excess nitrogen from agricultural production. Producers make decisions about what land to enroll and what practices to offer to implement. Each dot in the figure represents a producer's offer to participate in the program, with its horizontal position in the graph determined by the per acre nitrogen and its vertical position determined by the erosion reduction of the proposed land/practice combination (we assume all offers have the same cost). With an additive functional form, the score for application i is: $Score_i = (w_N * x_{N_i}) + (w_E * x_{E_i})$. The weights assigned to the two environmental concerns determine the slope of the "cutoff line" ($slope = w_E / w_N$) separating accepted offers (white dots) from those that are rejected. The position of the line will depend on the available budget: with a limited budget, only those offers providing the most erosion reduction and the most nitrogen reduction will be accepted (the dots farthest from the origin). Increasing the budget (shifting the line down) allows more offers to be accepted (grey dots).

How the offers (the sets of dots) are distributed in the graph will depend on whether the two objectives are complements or substitutes. The greater the amount of complementarity, the more the offers will be clustered about a

Figure 2.1

Tradeoffs between environmental outcomes and weights
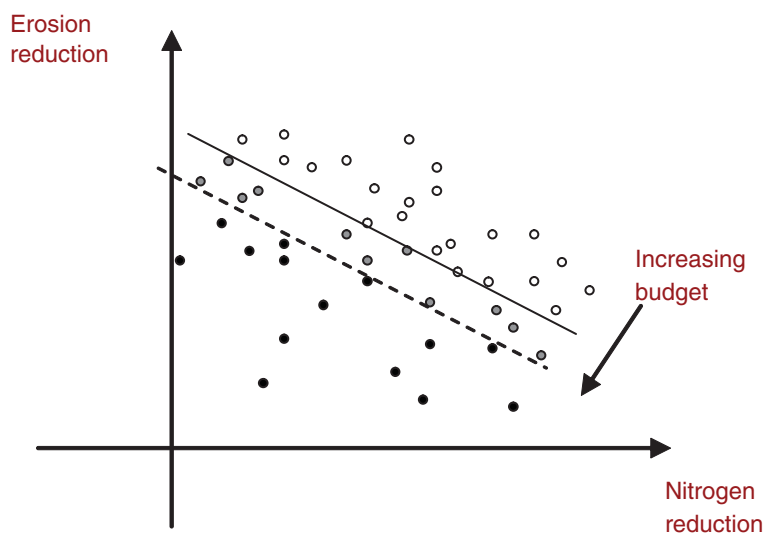
Notes: Each offer (point) is assigned a score for nitrogen reduction and erosion reduction. White dots represent accepted offers.

Source: USDA, Economic Research Service.

ray extending from the origin. The left graph in figure 2.2 illustrates complementarity: for example, a proposed nutrient management plan may simultaneously reduce excess nitrogen and phosphorus.

The right graph illustrates the substitution that occurs when a proposed plan to reduce runoff from animal waste problems improves water quality but worsens air quality (from increased emissions). In such cases, the offers will tend to be spread out perpendicular to a ray from the origin.

These figures emphasize the importance of interdependency relationships in understanding the tradeoffs that may occur when index weights are changed (i.e., as the "cutoff line" is rotated). When resource objectives are complements, even though some offers may be dropped and others accepted as a result of a change in weights, the environmental characteristics of the offers that are dropped and accepted are roughly similar. However, if the two objectives are substitutes, the offers that are dropped and those that are accepted can have quite different environmental characteristics, even for small changes in weights. That is, a small weight increase on the water quality objective could significantly increase the amount of water quality benefits obtained, but only at the expense of air quality benefits.

In a voluntary program, the willingness of eligible producers to participate will be a determinant of program outcomes. The prior discussion assumed a fixed set of producer offers and examined how the weights assigned to each objective affect which offers are accepted. However, and possibly of greater importance, the weights may affect producers' incentives to submit offers. A producer's willingness to submit an offer in a program will depend, among other things, on the likelihood of being accepted—which depends on the weights assigned to the environmental concerns. For example, producers who are better positioned (due to location, land characteristics, management skills, etc.) to provide one benefit

Figure 2.2

Effect of weight change determined by the degree of complementarity between objectives
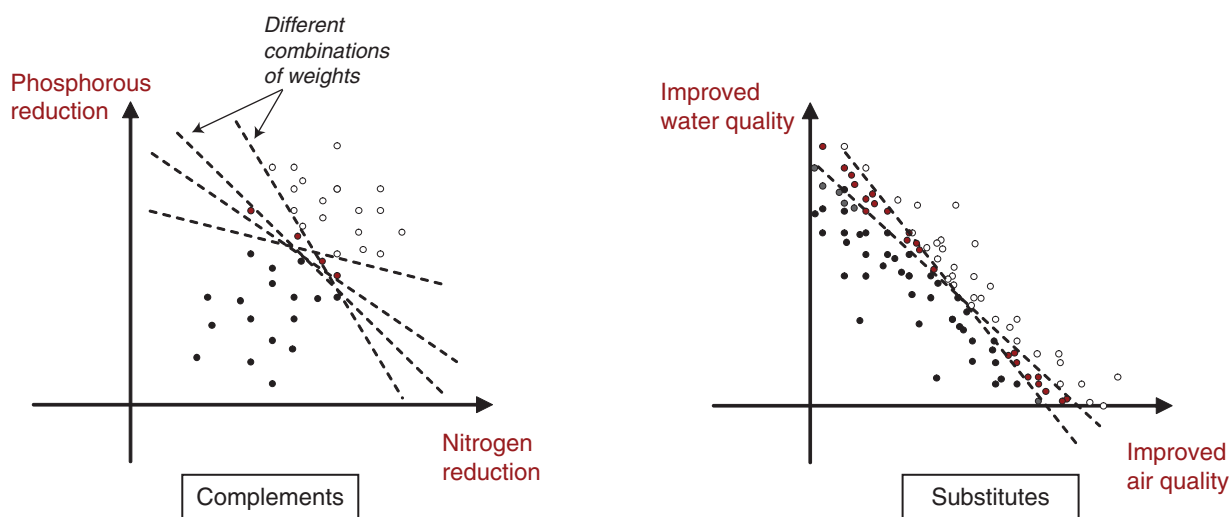
Source: USDA, Economic Research Service.

versus another may be more likely to offer land for enrollment if the weight assigned to that particular benefit is higher.

If these incentive effects matter[2] (meaning the weights affect the type of offers made), then analyzing the tradeoffs that occur when index weights are altered requires simulating the outcomes using models that predict what offers producers will submit as the vector of weights change.

[2]Incentive effects are greatest when producers face large transaction costs of making an offer. Basically, producers with low index scores may conclude that their offer is unlikely to be accepted, and will probably not take the time and expense to make an offer. They will only make an offer when a weight change increases their index score sufficiently. However, if the time and expense of making offers is minimal, producers who consider enrolling will always make an offer, regardless of their index score—and in this case, incentive effects will not be present even with large changes in weights.

The CRP Balancing Act:
The Sensitivity of CRP Outcomes
to Changes in EBI Weights

In a voluntary conservation program, weights assigned to different environmental concerns in a selection index affect the mix of land ultimately enrolled through two distinct channels. First, they provide a guide for potential program participants in deciding which, if any, land to offer for enrollment and conservation practices to offer to adopt. The weights affect producer incentives by providing information on the likelihood that an offer will be accepted into the program and, thus, the expected returns from participation. Changes in these incentive effects may induce some current program applicants to not apply, while some who have not yet applied may make new offers to enroll land or adopt practices. The environmental and economic characteristics of this new group of offers can differ from previous groups—due to different land/practice combinations, and due to the complementarity or substitutability relationships among environmental concerns. Second, the weights provide program managers with a basis for choosing the parcels (from among those offered) to enroll. Intuition suggests that a program's environmental benefits and cost outcomes will be affected by changes in the weights through both of these channels. The question is, by how much?

Data on enrollments in the CRP help illustrate the tradeoffs between different environmental and economic concerns when different weights are assigned to those concerns. The CRP has retired nearly 34 million acres of cropland under 10-15 year contracts, making it USDA's largest conservation program. Approximately 95 percent of CRP acres are enrolled through "general" signups.[1] In general signups, offers from across the country are pooled. Program managers use an Environmental Benefits Index, or EBI, a national index that has one uniform set of objectives and weights, to rank all of the offers (app. A). The objectives in the EBI include soil erosion impacts, wildlife impacts, air and water quality impacts, and the requested payment. Program managers determine the relative importance of addressing these environmental and cost concerns (i.e., the implied weights) by establishing maximum attainable scores for each concern.

Land is enrolled in the CRP in varying quantities and at different points in time, allowing for an analysis of the tradeoffs among environmental and economic concerns as index weights are altered. This analysis sheds light on the interdependency between environmental and cost concerns and the possible tradeoffs if changes in program priorities dictate a change in EBI weights. As outlined in table 3.1, this study included several analyses on how environmental and economic outcomes change under the following conditions:

- The weights assigned to different environmental concerns were altered in marginal (small) and nonmarginal ways.

[1]The other 5 percent of acres are enrolled through noncompetitive "continuous" signups in which an index is not used.

Table 3.1
The analyses examining the sensitivity of CRP outcomes to changes in EBI weights

	Small signup	Large signup
Small change in weights	Scenario 1	Scenario 2
Large change in weights	Scenario 3	Scenario 4

Source: USDA's Economic Research Service.

- Weights were altered in different-sized enrollments; that is, when the number of acres enrolled was small (2 million acres, the size of the recent 26th signup) and large (33 million acres, about the total number of acres enrolled in CRP general signups).

- "Incentive effects" were considered; that is, producer choices about parcels to offer in the CRP were allowed to change in response to weight changes.

We analyzed the impacts of weight changes both with and without considering these incentive effects. Our analyses revealed that ignoring the incentive effects of weight changes could lead to small understatements of the environmental and cost impacts in the CRP. Results from the "with incentive effects" models follow.[2]

The Action at the Margin: Small Changes in EBI Weights Have Relatively Small Effects

How might even small changes in the weights assigned to environmental and cost concerns affect conservation program outcomes? From the program manager's perspective, the decision process that determines the land to enroll involves selecting, from producers' voluntarily submitted offers, the parcels with the highest "scores" until a program enrollment constraint has been reached. In each signup period, program managers typically have the opportunity to alter the weights that are assigned to different concerns. The weights that program managers assign to different program objectives may have considerable impact in terms of the acceptance or rejection of "marginal" parcels (see fig. 2.2). For example, if a large number of offered parcels could provide wildlife benefits, a program manager's decision to assign a slightly larger weight to wildlife concerns could result in the selection of more parcels with wildlife benefits that would have been rejected under alternative weight schemes. The responsiveness of program outcomes to changes in weights has broad implications for other index-based USDA programs.

Scenario 1 uses data from CRP's 26th signup, for which offers were submitted in May-June 2003.[3] The database of 71,000 observations contains the EBI score for all parcels on which offers were submitted. Figure 3.1 identifies the set of national objectives and the maximum EBI scores used for the 26th signup. In scenario 1, we test the sensitivity of environmental benefits and costs by randomly altering the implied maximum weights in a narrow range (+/- 10 percent) relative to the values used in the CRP signups. This process is equivalent to altering the maximum EBI score attainable for each concern. We hold the total score (545 points) constant, so that a

[2]Results of the analysis that examines how outcomes change when incentive effects are ignored are available from the authors.

[3]A parallel analysis using data from the 20th signup yielded similar results (see box, "Do Marginal Impacts Depend on the Signup?").

Do Marginal Benefits Depend on the Signup?

Data from the 26th signup data suggest that potential benefits are not very sensitive to marginal changes in the weights. Other signups may have different sized pools of applicants, differences in the environmental objectives and weights in the EBI, or other circumstances that may contribute to different levels of benefits when weights are altered within a narrow range. We investigated the sensitivity of our results by simulating a single signup using data from signup 20 and recalculating the elasticities. The EBI in signup 20 contained an additional objective of prioritizing offers located in "priority areas," but otherwise the objectives and weights assigned were similar to those in signup 26.

We found the responsiveness of the potential benefits to weights exhibits some sensitivity depending on the signup data used. This suggests that overall conditions prevailing at the time of a signup may have an effect. Some patterns are evident across the two single signups, however: (1) benefit and cost outcomes for the 26th signup appear to be more responsive to shifts in weights, (2) the effects on environmental benefits from changing weights are consistently quite weak, and (3) objectives are confirmed to be substitutes or complements based on the sign of the elasticity (with a few exceptions, where the magnitude of the elasticity, although statistically significant, was approximately zero).

Figure 3.1

EBI objectives and weights in CRP's 26th signup
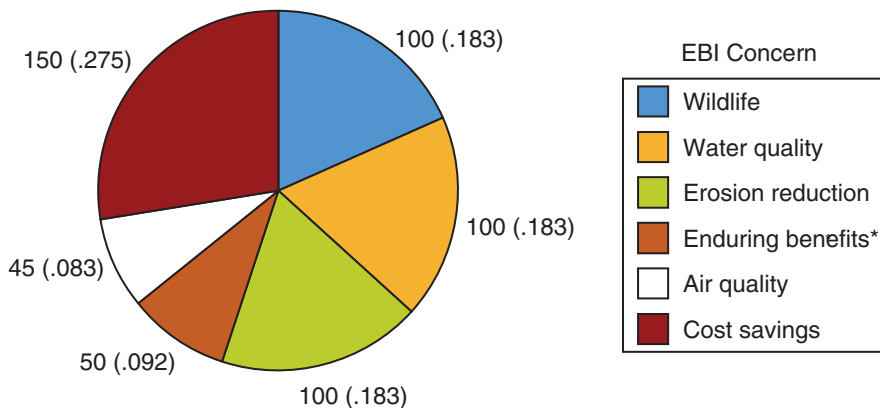
Note: Implicit weights are in parentheses.

*Points awarded for "enduring benefits" are based on the likelihood that certain practices (such as tree planting) will remain in place beyond the CRP contract period.

Source: Compiled by USDA's Economic Research Service from CRP data provided by USDA's Farm Service Agency.

marginal increase in one concern's weight is matched by decreases among some or all of the other weights. These decreases could be distributed among the other weights in numerous combinations; to determine how environmental benefits and costs would change *on average*, we constructed a

thousand scenarios, each with a different set of weights. We then re-computed the EBI score of each offer according to the new weight assigned to each concern, and re-ranked the parcels based on these new scores. Offers are assumed to be accepted into the program until the acreage threshold is reached. In scenario 1, this threshold is defined as 2 million acres, the amount that was enrolled in the 26th signup.

The primary interest in these simulations is understanding the effects of altering weights on the CRP's ability to provide environmental benefits and the effects of such changes on program costs. We analyze this by defining the *potential benefits* of an offer—which measures the approximate contribution of each offer to meeting the environmental concerns contained in the index (for a full description of *potential benefits*, see box, "Potential Benefits of an Offer – Defined").[4] To investigate the outcomes that may result, given a vector of EBI weights, we used the following steps to compute the *average* potential benefits for concern i, APB_i:

- For a candidate vector of EBI weights, we determined the lands that will be offered and accepted in the simulated 26th signup. To accommodate changes in producers' decisions about land to offer when the EBI weights are altered, we used an expansion factor. This offer-specific expansion factor summarizes the extent to which offers submitted in the actual 26th signup are representative of a larger set of acres. As discussed in appendix B, this expansion factor is modeled as a function of a variety of offer-specific attributes, including the offer's EBI score and county-level regional socio-economic variables.

- For each accepted offer in the simulation, we computed the *potential benefits* for each of the "i" concerns.

- The APB_i is the weighted average, across all accepted offers, of the *potential benefits for concern i*. For each concern, we computed a separate weighted average. The acreage of the offer, and the expansion factor, is used as the weight.

How does the APB_i change as different weight vectors lead to a new pool of accepted offers, when each pool possesses a different set of environmental characteristics? Table 3.2 reports the actual APB_i's for the environmental concerns that were attained in signup 26. For an APB_i equal to 0.68, the set of offers actually accepted was expected to contribute an average of 68 percent of the maximum possible benefits for that environmental concern, based on the parcel attributes and the practices that would be implemented.

Table 3.2
Actual average potential benefits attained in signup 26

Environmental concern	Average potential benefits (APB_i)
Wildlife	0.68
Water quality	0.57
Erosion reduction	0.60
Enduring benefits	0.18
Air quality	0.37

Source: Compiled by USDA's Economic Research Service from CRP data provided by USDA's Farm Service Agency.

[4]The drawback of our definition of environmental benefits is that we relied on indirect data, whose primary purpose is to provide a rough measure of value for use in USDA's Farm Service Agency internal ranking mechanisms. An alternative would be to use biophysical data, such as data in the National Resources Inventory (NRI). The problem with using NRI data, for our application, is that although it samples extensively throughout the United States, there is no way to know how representative the sample points are of the parcels being offered for enrollment (the NRI does note whether a point is in the CRP but not if it was offered and not accepted). The definition adopted here may be subject to biases but had the advantage that the data were available for the land parcels in question.

Potential Benefits of an Offer – Defined

The key to having the weight alterations result in new EBI scores for each offer, and a reordering of the offers accepted during a signup, is that the actual attributes of each offer are assumed not to change – that is, producers do not change the set of proposed practices for the land they offer to enroll in the CRP as the weights are narrowly changed. The recomputation of each offer's EBI score, under each scenario, is based solely on the new weight vector. To understand this, we define the *potential benefits* of offer *b* as the ratio of the offer's score earned for that objective to the maximum score that could be earned. Letting $EBI_{i,b}$ represent the EBI score for concern *i* and offer *b* and EBI_i^{max} represent the maximum EBI points that can be obtained for concern *i*, the potential benefits in terms of the *i*th concern ($PB_{i,b}$) can be defined as:

$$PB_{i,b} = \frac{EBI_{i,b}}{EBI_i^{max}}$$

The value of $PB_{i,b}$ will fall between 0 and 1 depending on how well offer *b* originally performed in terms of the *i*th environmental concern. For example, if an offer obtained a score of 75 for *wildlife benefits* out of the 100 available points for the category in signup 26, that offer's *wildlife benefits PB* will be 0.75. Each offer's potential benefits remains fixed, but as new weights are assigned (leading to a new maximum score for each concern) the offer's total EBI score can change.** This leads to a reordering of all the offers in each simulation (based on their total EBI scores), and, hence, a different set of lands that are enrolled.

The average potential benefits (APB_i), which is the acre-weighted average of $PB_{i,b}$ across all accepted offers, is recomputed based on the land to be enrolled and provides an indication of overall expected performance relative to the *i*th concern.

** One way to interpret this definition is that it assumes program managers will "scale up" or "scale down" the score an offer receives for each concern ($EBI_{i,b}$) proportionally to the change in the concern's weight.

A useful framework for discussing how the assigned weights affect the APB_i is to consider the elasticities of the concerns relative to the weights assigned. In essence, an elasticity indicates the effect of a one-unit change in a weight on the APB_i. For example, an elasticity of 1.0 means that a 10-percent change in weight *i* leads to a 10-percent change in APB_i, whereas an elasticity of 0.5 means that a 10-percent change in weight *i* leads to only a 5-percent change in APB_i. The relevance of the results lies both in illustrating exactly which parcels are enrolled and in determining whether benefit and cost outcomes are sensitive to minor shifts in the weighting mechanism (see box, "Computing Elasticities"). Table 3.3 reports the environmental concerns' estimated elasticities for signup 26. The bold underlined elasticities are "own-elasticities," since they represent the effect of a change in each concern's weight on its own potential benefits. The other elements in the table capture the effects of weight changes on other environ-

Computing Elasticities

A useful framework for analyzing the results is in terms of the elasticities of the environmental concerns relative to the weights assigned. This will provide a first glimpse as to the nature of the tradeoffs involved both among the environmental benefits and for program cost relative to environmental weights. The elasticity of an environmental concern relative to one of the EBI weights represents the relative change in the concern's potential benefits divided by the corresponding relative change in the weight. First, we define the *environmental benefits susceptibility elasticity*:

$$\eta_{i,j} = \frac{\partial APB_i}{\partial w_j} \cdot \frac{w_j}{APB_i}$$

In a similar spirit, a related quantity that will be of interest when considering the tradeoffs between environmental benefits and program cost will be the elasticity of program cost relative to environmental *benefits*:

$$\sigma_i = \frac{\partial COST}{\partial APB_i} \cdot \frac{APB_i}{COST}$$

The regressions performed rely on the definitions of elasticities provided above. Since we are interested in the elasticities for environmental benefits susceptibility, both the independent and dependent variables were converted to a percent change relative to the values for CRP signup 26, which functions as our baseline. In this way, the coefficients obtained from the estimation are the elasticities of interest. The system of equations estimated can be represented as:

$$dAPB_i = \sum_{j=1}^{6} \eta_{i,j} \cdot dw_j + e'$$
$$dCOST = \sum_{j=1}^{6} \sigma_i \cdot dAPB_i + e'$$

The constant in the regression is constrained to equal zero so that if the weights coincide with those of the EBI used for the signup, the simulated enrollment will exactly replicate the actual enrollment and there will be no deviation in the environmental benefits. The system was estimated within Stata using Iterated Seemingly Unrelated Regression (ITSUR).[a] Although the equations are simultaneous, there is no estimation bias given that there is unidirectional dependency among the endogenous variables (in the first set of equations, the endogenous variables are determined only by exogenous variables).[b]

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[a]A Breush-Pagan test for independent equations led us to reject the null hypothesis that the disturbance covariance matrix is diagonal and conclude that contemporaneous correlation between equation errors does exist.

[b]Since the EBI weights always sum to 1, the cost weight was dropped to avoid multicollinearity, and the total cost was estimated relative to the average attained benefits.

mental concerns. These "cross-elasticities" indicate of the extent to which environmental concerns are complements or substitutes in the enrollment process. The closer a value is to zero, the less sensitive an expected change in the concern's potential benefits are to a marginal change in a weight.[5]

Scenario 1
CRP's average potential benefits do not appear to be very sensitive to small weight changes in single signups

Overall, the results reported in table 3.3 imply that at a national level, the potential to achieve different environmental benefits does not appear to be very sensitive to marginal changes in the weights assigned to CRP objectives.[6] That is, no major shifts in the types of benefits that could be earned tend to occur when the weights are altered within a narrow range. The highest elasticity among the environmental concerns is 0.362 for erosion reduction benefits relative to its own weight in the EBI, but most elasticities are quite close to zero. This finding implies that as long as CRP outcomes approximately reflect relative social preferences, then few opportunities exist for obtaining improvements in environmental benefits by fine-tuning the index weights.

The values of the own-weight elasticities of environmental benefits are useful in indicating the objectives that could be improved by increasing their weight in the EBI. For example, increasing the weight of *erosion reduction or enduring benefits* by 10 percent (which is equivalent to increasing the scores for these concerns from 100 and 45 to 110 and 50, respectively) would result in approximately a 3.5-percent improvement in the average potential benefits for that environmental concern. Conversely, increasing the weights for the wildlife or the air quality objectives by 10 percent would generate 1 percent or less of an increase in those benefits.

The signs of the cross-elasticities indicate whether the selected offers tend to address multiple environmental concerns in a complementary way. These coefficients indicate that (1) complementarity exists, albeit small, between the enduring benefits and the wildlife concerns (cross-elasticity = 0.049), and (2) substitutability exists between the enduring

[5]All elasticities are significantly different from zero at the 1-percent significance level, except for those of water quality benefits relative to the weights assigned to wildlife and to air quality. Hence, this section will not discuss significance levels.

[6]These results do not exclude the possibility of larger regional or local shifts in the level of benefits. We explore regional effects in a later simulation.

Table 3.3
26th Signup estimation results: Elasticities of average potential benefits given small changes in EBI weights

Dependent variable	Independent variables				
	Wildlife weight	Water quality weight	Erosion reduction weight	Enduring benefits weight	Air quality weight
	Elasticities				
Wildlife *APB*	**0.133**	-0.015	-0.126	0.002	0.003
Water quality *APB*	0.034	**0.240**	-0.022	-0.010	0.002
Erosion reduction *APB*	-0.104	-0.039	**0.362**	-0.045	-0.025
Enduring benefits *APB*	0.049	-0.118	-0.262	**0.324**	-0.017
Air quality *APB*	-0.010	-0.068	-0.124	-0.016	**0.040**

Number of observations: 1,000. *APB* = average potential benefits.

Source: USDA's Economic Research Service.

benefits and the erosion reduction concerns (cross-elasticities = -0.262). The complementary relationship between wildlife and enduring benefits is intuitive to the extent that enduring benefits points are assigned in the EBI for tree plantings, wetland restoration, and plantings of multiple types of native grasses, which are all conducive to improving wildlife habitat. The substitutability between erosion reduction and enduring benefits could stem from (1) points awarded for erosion reduction being highest in areas such as the Northern Plains or the Midwest, where there are traditionally few tree plantings; or (2) the possibility that producers with parcels that score highly on the erosion reduction component of the EBI do not view the provision of enduring benefits as strategically necessary for the parcel to be accepted in the program.[7]

Small weight changes have greater impacts on program costs

Because the CRP is not budget constrained (rather, a cap on the total acreage that can be enrolled exists), total payments for the signups are not decided by policy. However, understanding how program costs change as environmental priorities change helps in understanding the tradeoffs that can occur in multi-objective programs, particularly in an era of tightening Federal budget constraints.

Table 3.4 shows the percent change in total cost of a signup that is needed to obtain a 1-percent change in the average potential benefits of a specific environmental objective (elasticity of total cost relative to the average potential benefits attained). Findings reveal the additional cost of obtaining marginal improvements (relative to the actual levels of expected benefits attained in the 26th signup) for a specific objective depends on initial conditions: (1) the EBI weight for that objective as adopted in the signup, and (2) the potential benefits that were actually achieved in signup 26. For example, marginal improvements in enduring benefits, which has a low weight (0.092, see fig. 3.1) and which actually provided only low potential benefits (0.18, see table 3.2), can be obtained with relatively small increases in total costs. As noted in table 3.4, a 10-percent improvement in enduring benefits would entail an approximately 5-percent increase in total costs. At the other extreme, a 10-percent increase in water quality benefits would require a 20-percent cost increase for the signup. Unlike enduring benefits, the water quality concern had a high implicit weight (.183) and provided relatively high potential benefits (0.57, see table 3.2) in signup 26.

[7]Even accounting for the weights, the cross-effects may be nonsymmetrical. For example, increasing the enduring benefits weight will lead to a decrease in *air quality* benefits, but the symmetrical effect will be minimal. This may be due to land brought into the program by increasing the *enduring benefits* weight providing less of the other benefit than the land it excludes. Instead, if the *air quality* weight is increased, the land that is brought in is very similar in terms of enduring benefits being offered to the land that becomes excluded.

Table 3.4
Elasticities of total cost relative to average potential benefits

Dependent variable	Independent variables—average potential benefits				
	Wildlife	Water quality	Erosion reduction	Enduring benefits	Air quality
Total cost – signup 26	1.378	1.995	1.905	0.487	1.530

Number of observations: 1,000.

Note: The elasticity indicates the percent change in total signup cost needed to obtain a 1-percent change in average potential benefits.

Source: USDA's Economic Research Service.

An intuitive interpretation of the results is that it can be costly to improve performance for an environmental concern that already is weighted relatively high. On one hand, little room for improvement may exist in the higher weighted environmental concerns because most of the benefits in that dimension have already been extracted from the pool of proposed offers (elasticity of average potential benefits with respect to its own-weight is low, such as is the case for water quality and wildlife). Even a large increase in the concern's weight may not obtain a significant benefit increase. Alternatively, given the pool of offers, room for improvement may exist (elasticity of average potential benefits with respect to its own-weight is higher as for erosion reduction), but the improvement is conditional on bringing more profitable (and hence more costly) land into retirement.

Note that our simulations were conducted when a significant amount of land that might be profitably enrolled was already in the program. As of the 26th signup, about 30 million acres, over 35 percent of the 80 million acres that FSA estimated could be profitably enrolled in CRP, had been previously enrolled.[8] Thus each additional signup may achieve environmental benefits that are increasingly less sensitive to weight changes since the "best" eligible acres may have already been enrolled. Our findings only apply to a relatively small proportion (about 6 or 7 percent) of the land enrolled in CRP.

Scenario 2
Impacts of small changes in weights are greater under the full-enrollment scenario

Another element in understanding the sensitivity of environmental benefits to changes in EBI weights considers the responses to changes when the best acres were available for enrollment, or when more significant amounts of land could be enrolled (relative to program constraints). These best acres would be available at program inception, and also when significant amounts of enrolled land are up for re-enrollment. We explore the effects of weight changes assuming the CRP could enroll all 33 million acres (close to the total program enrollment as of signup 26) and that no eligible land was already enrolled. The analysis was similar to the previous model using the 26th signup data, in which the initial set of weights were altered in a narrow range (see appendix B for technical details).

For a number of reasons, the findings from this analysis can only be considered suggestive. Most importantly, the analysis maintains the assumption that producers will not alter the set of practices they propose to implement, and hence the potential environmental benefits of any given offer will remain constant as the weights are altered. That is, the analysis assumes the marginal weight changes lead only to changes in an offer's EBI score, and not to a producer's choice of practices. Hence, the impacts due to changes in EBI weights, on the CRP as a whole, are driven by enrollment of a different set of parcels, rather than by modifications to currently enrolled parcels. This assumption may be most reasonable when producers face similar weights and environmental concerns across multiple signups. With the exception of the "priority area" objective being dropped, signup 26 was similar to previous signups in terms of weights assigned to environmental concerns. Even though weight changes were not large, the potential benefits

[8]The national acreage that could be "profitably enrolled" is derived from FSA's "likely to bid model," a model based on both biophysical measures of the landscape (derived from the NRCS's Natural Resource Inventory data), and information on average farm production and agricultural prices.

of previously enrolled producers' offers may not have remained constant when faced with signup 26 weights.

The APB_i's in this "full-program enrollment" scenario (table 3.5) reflect more sensitivity to changes in weights relative to the analysis where only 2 million acres were enrolled (see table 3.3). Even so, large changes in weights would still be necessary to achieve rather modest gains in environmental benefits. For example, the most significant change is the effect of an own-weight change for enduring benefits. In this scenario, a 10-percent increase in the weight on the enduring benefits concern generates an approximately 4.9-percent increase in that concern's average potential benefits, up from 3.2 percent. Perturbations to the wildlife weight generate fewer wildlife environmental improvements than in the 2-million-acre analysis, suggesting wildlife benefits may be rather uniformly distributed across all eligible CRP acres so that weight changes have little effect on outcomes.

The most noticeable change between simulating enrollment of a "full program" versus enrollment in a 2-million-acre single signup is that most of the cross-effects are complements, rather than the substitutes that were prevalent in the latter simulations (the signs on cross-elasticities changed from negative to positive). However, the effects of weight changes are still quite weak, with increases in erosion reduction being most sensitive to changes in the weight on enduring benefits (a 10-percent change generates a 1.35-percent change in the erosion concern's average potential benefits).

What are the policy implications of these changing relationships? Taken together with the single signup analysis, these results suggest that it may be easier to address environmental concerns simultaneously in the early phases of the CRP, but that achieving improvements in each concern in subsequent signups happens increasingly at the expense of the other concerns as enrollments continue to limit the pool of acres available.

Changes in total program costs exhibit larger differences in response to increases in the expected performance for particular environmental concerns (table 3.6). In these full-program simulations, total program costs ranged from $2.0 billion to $2.36 billion ($2.22 billion on average). Relative to

Table 3.5

Full-program estimation results: Elasticities of average potential benefits relative to the EBI weights, considering "full-program" signup

Dependent variable	Independent variables				
	Wildlife weight	Water quality weight	Erosion reduction weight	Enduring benefits weight	Air quality weight
	Elasticities				
Wildlife *APB*	**0.115**	0.009	-0.079	0.021	0.015
Water quality *APB*	0.028	**0.270**	0.074	0.099	0.055
Erosion reduction *APB*	-0.107	0.051	**0.467**	0.135	0.068
Enduring benefits *APB*	0.012	0.049	0.038	**0.492**	0.108
Air quality *APB*	-0.014	-0.062	-0.097	-0.005	**0.036**

Number of observations: 1,000. *APB* = average potential benefits.

Source: USDA's Economic Research Service.

Table 3.6
Elasticities of total signup cost relative to average potential benefits, considering "full-program" signup

Dependent variable	Independent variables—average potential benefits				
	Wildlife	Water quality	Erosion reduction	Enduring benefits	Air quality
	Elasticities				
Total cost (33-million-acre enrollment)	0.528	0.173	-0.216	-0.233	-1.314

Number of observations: 1,000.
Source: USDA's Economic Research Service.

single-signup simulations (scenario 1), the change in costs is significantly smaller with respect to each objective. In fact, cost elasticities are negative for erosion, enduring benefits and air quality, suggesting that additional environmental benefits could be achieved without increases in total program costs. This effect is intuitively appealing because offers providing higher levels of benefits, and which cost relatively less, were more likely to have been previously accepted into the CRP—hence, such lands were only considered eligible for enrollment in the 33-million-acre simulation. Combined with the total cost impacts for a single signup reported in table 3.4, it appears that, overall, it is less expensive to achieve environmental benefits when pre-existing enrollments are limited. As signups continue to enroll eligible land, program costs per unit of expected benefit rise as the pool of available acres becomes more constrained. Findings also suggest that program managers are enrolling better and cheaper lands first, and that producers are more likely to first offer lower productivity lands.

When Changes Are Nonmarginal: Larger Changes in EBI Weights Have Larger Impacts

Small changes in the weights associated with the environmental concerns in the EBI have small effects on CRP outcomes, at least the way we have measured environmental benefits. The implication of this limited effect is that little would be gained from more precisely determining the numerical value of the weights – as long as they approximate society's preferences. If new information reveals that program outcomes do not reflect relative societal values, or that values change, the question then is how sensitive environmental benefits are to bigger relative changes in the weights. Put another way, is the CRP always enrolling more or less the same type of acres regardless of the weights on different objectives?

Using elasticities to measure the impacts of weight changes is accurate only for marginal changes. However, we can estimate the impacts of larger weight changes through their effects on average potential benefits. From the patterns evident in the calculations, we can infer the effect of weight changes, including complementarity and substitutability of the environmental concerns (whether more or less average potential benefits would be achieved, respectively, when other weights are increased). As with the marginal analyses, we examine the responses in benefits and costs for both single signup and full-program enrollments.

Scenario 3
Large weight changes and single signups : erosion
reduction most affected by weight changes

Figures 3.2a – 3.2e depict the impacts for a single signup of 2 million acres when one weight at a time is increased up to 80 percent.[9] The first data points in each graph are the same and represent the baseline average potential benefits achieved in signup 26 (i.e., the points correspond to the average potential benefits in table 3.2). In these simulations, we again account for incentive effects by allowing the pool of land offered for enrollment to change as the weights are changed.

The figures reveal similarities between, and some differences from, the results in scenario 1's single signup analysis when weights changed by only small amounts (see table 3.3). In both cases, the own effects of the weight changes are consistently positive: increases in a weight lead to more benefits of the associated environmental concern. Also, most of the environmental concerns still appear to be substitutes with each other—the slopes of the lines of other environmental concerns (those whose weights are not the focus of interest) are mostly decreasing, comparable to the negative signs on the cross-elasticities in table 3.3. However, one difference from the earlier results is that erosion benefits are now the most sensitive to changes in other weights (as evidenced by the steeper decline in the erosion line in the figures of the other environmental concerns).

This analysis reveals further insights into the "locality" of the findings of the marginal analysis. Specifically, it appears that the few complementary relationships previously noted—such as the positive relationship between the wildlife weight and both water quality and enduring benefits, as well as between air quality and wildlife benefits—may exist only for weights that are similar to the actual weights used in the 26th signup. This is revealed by noting the initial slight upward slopes of, for example, the water quality and enduring benefits lines in figure 3.2a where the wildlife weight is significantly altered.

Perhaps the most significant policy implication of these results is the relationship between erosion reduction benefits and the other environmental concerns. On one hand, the loss in erosion reduction benefits is consistently most pronounced when the weights on other environmental concerns are increased. This effect is most evident when the wildlife weight is increased. The average potential benefits for erosion reduction drops from about .62 to about .40 as the wildlife weight increases up to 57 percent of total EBI points. Increasing the weight for water quality instead of wildlife also results in a notable loss of erosion benefits, from an average of .65 to .48. On the other hand, comparing data in figure 3.2c with that in figures 3.2a, 3.2b, 3.2d, and 3.2e reveals that increases in the erosion reduction weight lead to the broadest collective negative impacts on the remaining environmental concerns. Potential wildlife benefits decline the most in this case.

In terms of the impacts of changing the cost weight, figure 3.2f reveals that average per acre cost (relative to the baseline cost from signup 26) decreases as the cost weight increases. Not surprisingly, most of the average potential benefits decrease as the cost weight increases: the more a land retirement

[9]As before, the total EBI score is held constant. As the weight on one environmental concern is increased, the weights on all the others decrease proportionally—the weights of these "other" factors all move together. For example, as the wildlife weight increases, the (water quality weight)/(erosion weight) ratio will always equal 1.0, and the (water quality)/(enduring benefits) ratio will always equal 2.0.

Figure 3.2

Changes in average potential benefits (*APB*) as particular EBI weights are increased — large changes and small program enrollments
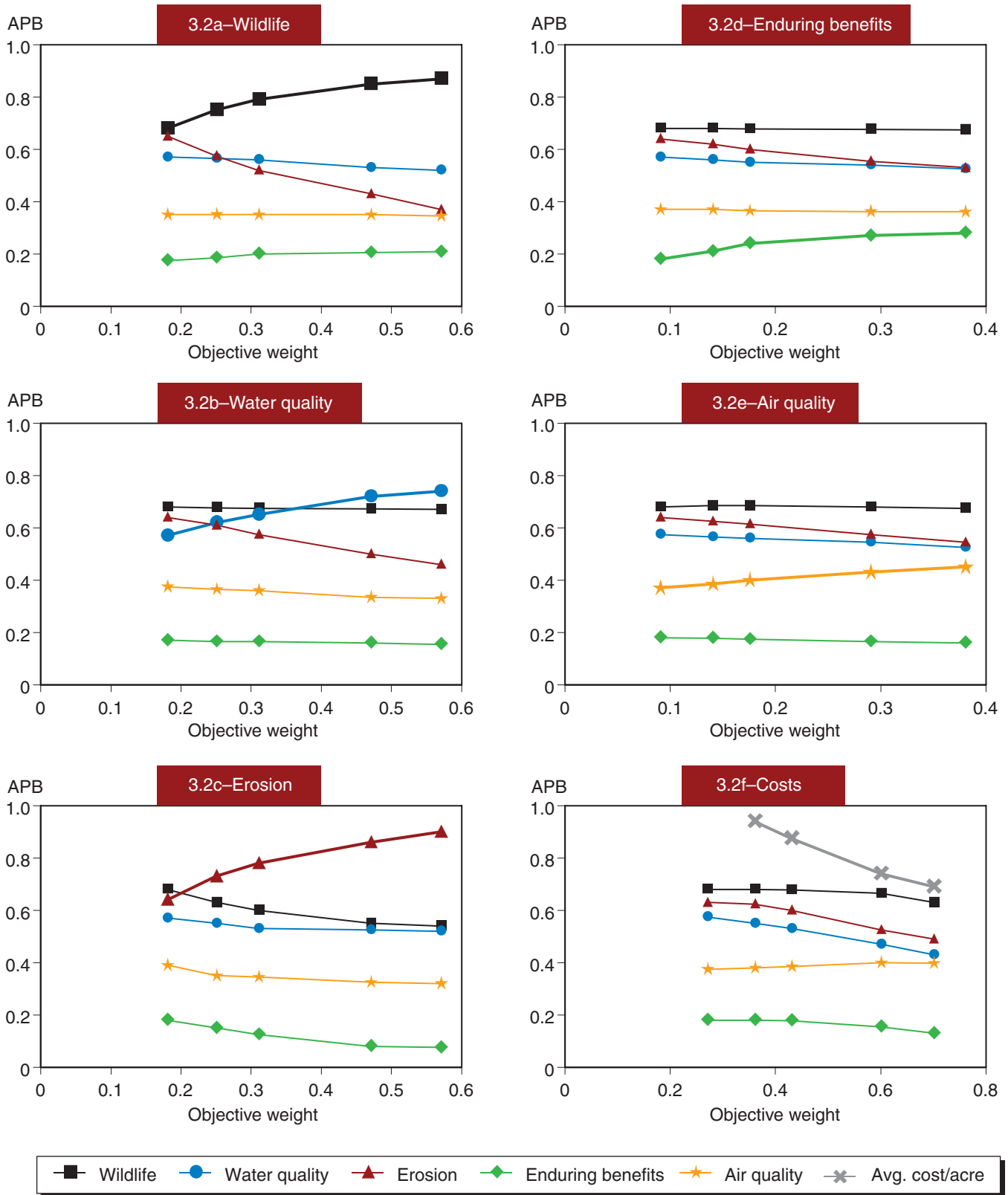
program focuses on enrolling the least expensive cropland first, the greater the likelihood environmental benefits will decline. The exception is air quality, which shows a slight increase in benefits. This effect may be explained by the relatively low cost of enrolling land that is most subject to wind erosion (such as land in the Northern Plains). While it is difficult to compare these findings with the small change-single signup findings (scenario 1) because the analyses are constructed differently, it is worth noting that both analyses suggest the greatest tradeoffs exist between water quality benefits and cost, and between erosion benefits and cost: additional benefits for these two environmental concerns are the most costly to attain (they have the largest elasticities with respect to total program cost in table 3.4), and benefits fall at a greater rate with large increases in the cost weight (they have the steepest slopes in the nonmarginal analysis in figure 3.2f).

Scenario 4
Large weight changes affect erosion reduction benefits
similarly in the full program and the single signup enrollments

In this last set of analyses we simulated how large weight changes would affect outcomes when significantly more land is enrolled—33 million acres. Our findings, depicted in figures 3.3a – 3.3f, are fairly consistent with previous analyses. Large changes in weights affect the ability to achieve erosion reduction benefits the most, regardless of program enrollment size, with increases in wildlife and water quality weights generating the greatest losses in erosion reduction benefits.

As noted in the marginal analyses (comparing tables 3.3 and 3.5), having the flexibility to enroll the full 33 million acres softens substitution effects, so that fewer tradeoffs amongst potential benefits occur as weights are changed. However, far fewer complementary relationships remain when viewed from a national perspective (see box, "Strong and Weak Complementarity"). The most complementary effects – providing more of one benefit without sacrificing others – are achieved by increasing the weight on enduring benefits. In fact, only large changes in the enduring benefits weight generate additional benefits for every other environmental concern in this analysis.[10] Overall, a comparison of the "full-program enrollment" scenarios 2 and 4 with the "single signup" scenarios 1 and 3 supports a key finding from the marginal analysis: improvements in each environmental concern are increasingly achieved at the expense of improvements in other concerns as existing enrollments limit the pool of available acres.

Comparisons of the cost impacts of a single signup and a full-program enrollment, using figures 3.2f and 3.3f, do not reveal any major differences. In both, as the cost factor increases, the per acre cost decreases, and the average potential benefits for most environmental concerns decrease (air quality again is slightly increasing).[11] Though not major, some differences are evident, however. In the single signup, it appears that as the cost factor weight increases, the losses of environmental benefits accelerate—the lines' slopes become steeper. In a full-program enrollment, the converse is true— the lines' slopes become less steep. That is, the tradeoffs between cheaper program costs and environmental benefits are greater in a single signup when large portions of eligible land are not available because they are already enrolled. This finding is consistent with our findings in the marginal

[10]Regional variation exists in response to changing the enduring benefits weight, with the Eastern Uplands, Northern Great Plains, and Southern Seaboard regions experiencing the largest losses in other benefits (12-, 9-, and 3-percent declines in soil erosion benefits, respectively) when the enduring benefits weight is doubled. For a description of ERS Farm Resource Regions, see www.ers.usda.gov/publications/aib760/.

[11]Caution should be used when comparing results across figures 3.3a to 3.3e. In particular, to ensure simulation of a full 33-million-acre program, different "EBI cutoffs" were used in several of the sets of simulations. In particular, enduring benefits required use of a low cutoff (since most CRP offers have no enduring benefits points).

Figure 3.3

Changes in average potential benefits (APB) as particular EBI weights are increased — large changes and full-program enrollments
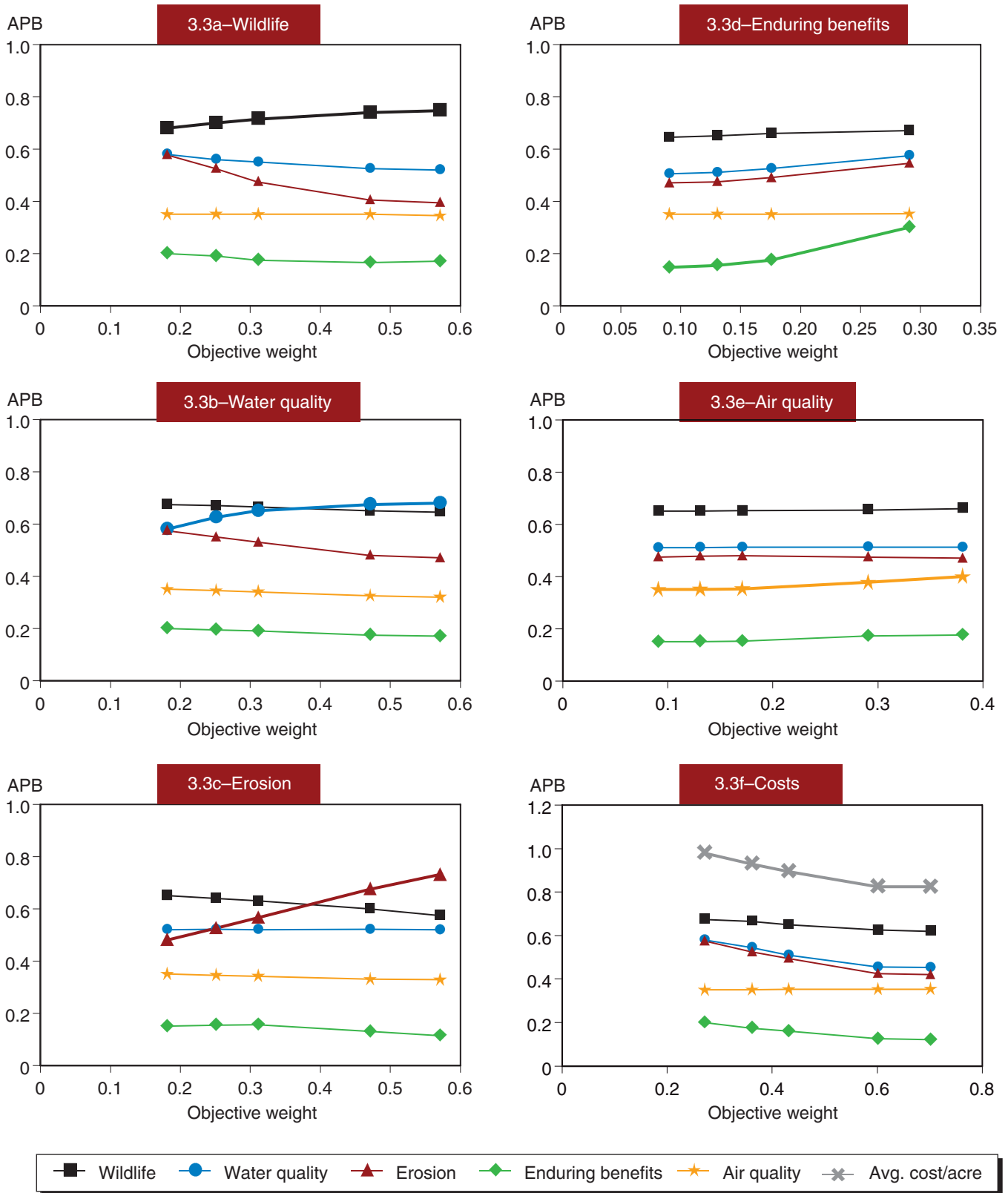
Source: USDA's Economic Research Service.

Strong and Weak Complementarity

Complementarity between two environmental concerns is defined as a positive correlation between two APB_i's. Our marginal analyses (small change in weights) indicates that a number of complements exist, such as the 0.051 elasticity of the erosion reduction APB_i and the water quality weight. However, the nonmarginal analyses (scenarios 3 and 4) suggest little complementarity when weights are changed by large amounts (though water quality and erosion reduction do seem to be complements of enduring benefits).

It is useful to distinguish between two types of complementarity: strong and weak. These are defined in terms of how APB_i's change as EBI weights change.

- Strong complementarity: when the weight on factor A increases, the APB_i of factor B will increase even though the weight on factor B decreases proportionally.

- Weak complementarity: when the weight on factor A increases, the APB_i of factor B will increase so long as the weight on factor B stays constant.

To look for weak complementarity, we examined the set of 1,000 simulations using regression analysis and comparisons across quintiles. Both methods allow for all the EBI weights to vary, rather than the simple rule that the increase in one weight is offset by decreases in some or all other weights.

Using these tools, we find evidence of weak complementarity that closely reflects the findings from the marginal analysis. For example, the figure below shows a regression fit of the water quality APB_i as the erosion reduction weight changes – revealing that as the erosion reduction weight increases, the water quality APB_i also tends to increase.

Water quality avg. potential benefits   R-sq=0.0469

Erosion weight
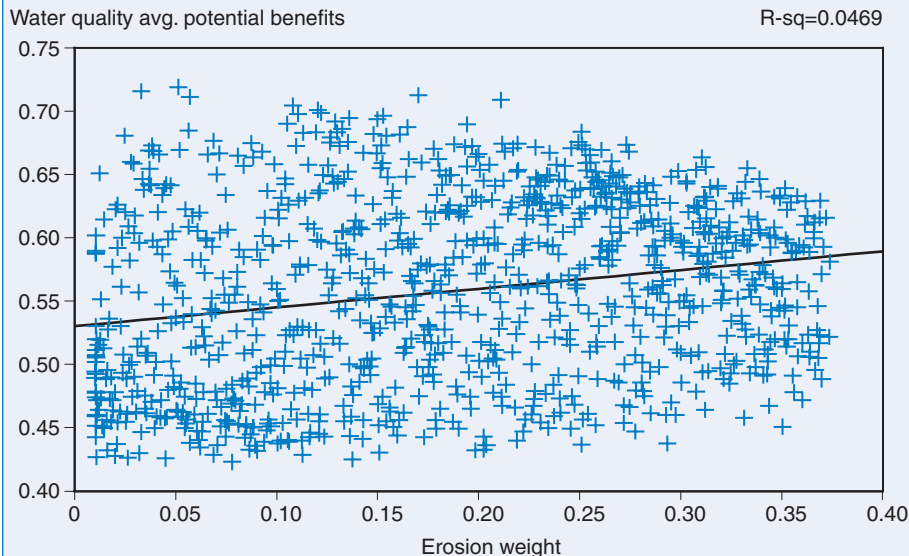
Source: USDA's Economic Research Service.

analyses—by assuming no acres were previously enrolled and simulating a full-program enrollment, additional environmental benefits are achieved at lesser costs.

From a national perspective, these analyses of large weight changes (scenarios 3 and 4) uncover no stark results. However, they do show that the choice of weights assigned to environmental concerns can matter—with a sufficiently high weight, improvement is obtainable in a targeted environmental concern. These improvements come at a cost: in general, benefits from all the other environmental concerns decrease (sometimes noticeably). In fact, strong complements do not appear to exist—assigning a large weight to one environmental concern does not generally result in substantial additional benefits from other environmental concerns. However, this conclusion is tempered by a few other findings:

- The impacts on environmental benefits from large changes in the EBI weights can be even larger when viewed from a regional perspective than they appear when examining impacts from a national perspective (see box, "Regional Impacts of Large Changes in EBI Weights").

- Evidence of weak complements exists – increasing the weight on one concern can increase the APB_i of another concern, as long as this other concern's weight does not decline (see box, "Strong and Weak Complementarity").

Weight changes can affect the geographic distribution of enrolled acres

Large weight changes may also affect the distribution of enrolled acres across the United States. Some large weight changes may enable counties to gain CRP acres, while others cause counties to lose CRP acres. To explore these impacts, we generated six different simulations. In each simulation, one objective weight was doubled for a full-program enrollment. Figure 3.4 shows the biggest absolute change in CRP acres that each county would experience across these simulations. Counties colored dark red in the figure have CRP enrollment levels that are the most sensitive; these counties lose or gain at least 100 percent of their enrolled acres in at least one weight change scenario. Note, though, that in these counties other scenarios may have generated lesser impacts on enrollment.

Every county with land eligible for CRP enrollment experiences a change in enrolled acreage in at least one weight change scenario. Enrollment patterns were most sensitive to doubling the weight on the wildlife factor, the water quality factor, and the cost factor (i.e., doubling each of these weights, one at a time, generates the most dark-red counties). Most of these impacts tend to be concentrated in the Northern Great Plains. For example, doubling the wildlife weight or the cost weight tends to generate large percentage *increases* in enrolled acres in this region. Yet, doubling the water quality weight generates large percentage *losses*. In general, CRP enrollment levels in the Southern Seaboard region tend to be the least impacted when an objective weight is doubled.

Regional Impacts of Large Changes in EBI Weights

An analysis of average potential benefits across regions in the full-program simulations revealed the following:

- Some results do hold across regions. For example, the greatest losses of erosion reduction benefits occur when wildlife and water quality weights are doubled. These losses range from 7 to 25 percent when the wildlife weight is doubled and from 11 to 23 percent when the water quality weight is doubled.

- In other cases, results vary significantly by region. For example, doubling the weight of enduring benefits generates average gains in benefits for other environmental concerns, but the average gain in erosion reduction benefits—due largely to the 29-percent gain in the Northern Crescent—masks 9-percent and 13-percent losses in erosion reduction benefits in the Southern Seaboard and Eastern Uplands regions, respectively.

- Similarly, on a national scale, doubling the weight for wildlife benefits appears to generate only a modest decline in enduring benefits but the following map reveals larger regional differences.

Change in enduring benefits APB when wildlife weight is doubled
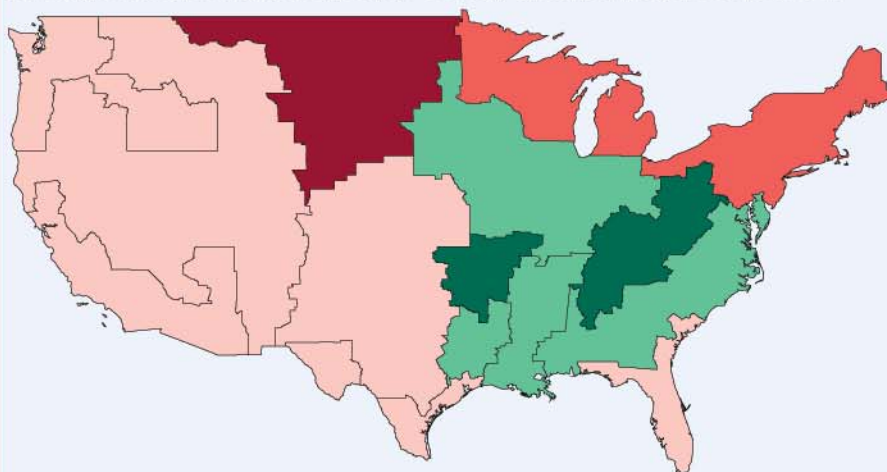
Change in enduring benefits APB

- 30.1 - 45% loss – Northern Great Plains
- 15.1 - 30% loss – Northern Crescent
- 0 - 15% loss – Prairie Gateway, Fruitful Rim, Basin
- .01 - 15% – Heartland, Mississippi Portal, Southern Seaboard
- 15.1 - 30% – Eastern Uplands

For a description of ERS's Farm Resource Regions, see http://www.ers.usda.gov/publications/aib760/.

Source: USDA's Economic Research Service.

Figure 3.4

Impact of doubling weights on CRP acreage, by county
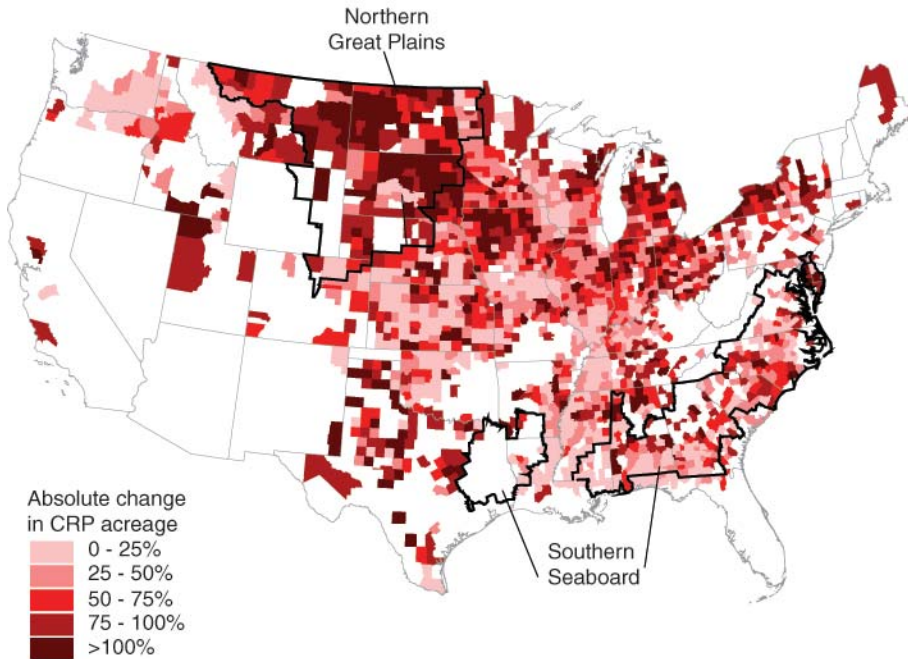
Note: CRP enrollments in each county are sensitive to change in EBI weights. This map shows the largest percentage change in acres (in absolute terms) a county would experience, if any objective weight in signup 26 was doubled.

Source: USDA's Economic Research Service.

In some cases, doubling a weight induced new enrollments in some counties that previously had no CRP participation. In other cases, doubling completely eliminated enrollments in a county. Doubling the cost weight induced new enrollments in the greatest number of counties (66 counties), while doubling the wildlife weight eliminated enrollments in the greatest number of counties (111 counties).

Conclusions

The byproducts of agricultural production, which include environmental "goods" as well as environmental "bads," are increasingly the target of government conservation programs. When these byproducts are jointly produced, such as soil erosion and water quality problems that might be generated through producers' use of conventional tillage practices on highly erosive land, economic theory suggests it will be more efficient to address these multiple concerns within a single program, rather than through many single-objective programs. This theoretical insight is reflected in real practice. Over the last 20 years, a number of Federal conservation programs have been designed to achieve multiple objectives. For example, the goals of the Conservation Reserve Program include improving soil quality, water quality, air quality, and wildlife habitat through land retirement. The Environmental Quality Improvement Program seeks many of the same environmental benefits on land that remains in production. The Conservation Security Program provides incentives for producers to enhance quality beyond the standards sought in CRP and EQIP for many of the same resources as well.[1]

While multi-objective programs may be more efficient than single-objective programs, they are more complicated to administer. With single-objective programs, simple rules (such as cost minimization) can guide program decisions. With multiple objectives, such simplifications are not possible because objectives are not typically perfect complements and they cannot all be maximized at once.

Managers of multi-objective programs are increasingly using an "index" as a means of aggregating a variety of indicators into a single summary measure. The index is typically constructed by multiplying indicator variables, which are correlated with environmental improvements (i.e., program objectives), by a vector of weights—where the weights reflect program manager perceptions of relative importance. The single summary score that is calculated allows program managers to rank and select producer applications based on the applications' potential contributions toward achieving the program objectives.

The use of an index to select program applicants raises a plethora of questions. For example:

- Do the chosen indicator variables accurately measure the biophysical conditions that the program seeks to improve?

- How well do the chosen weights result in outcomes that reflect environmental improvements valued by society?

- If new information suggests society values somewhat different environmental improvements than those delivered by a conservation program, can changes to an index's weights result in desired outcomes?

[1]Even though several U.S. conservation programs share some common environmental goals, it may still be optimal to have several multi-objective programs—versus a single program encompassing all the individual program objectives—when subsets of program objectives are sufficiently different. For example, EQIP and CSP share some environmental objectives but have different strategies: EQIP helps producers meet environmental regulations on land in production while CSP provides payments to a different set of producers who already demonstrate minimum levels of environmental stewardship. Whether having many multi-objective conservation programs in the United States is optimal is beyond the scope of this report.

Underlying these questions is an essential problem: *constructing an index that measures the actual environmental improvements that can be attributed directly to a particular conservation program is inherently difficult.* A host of physical and environmental factors, as well as other agricultural and environmental policies, affect the environment and "teasing out" the impacts of one particular source of change is challenging (Smith and Weinberg, 2004). Even assuming the impact of a specific program can be separately identified at the plot-level, measuring biophysical relationships requires the use of indicator variables that may be a simplistic approximation of the underlying processes and impacts. Determining whether weights result in outcomes that reflect relative social values is even more difficult because data on prices for environmental improvements associated with the indicator variables are rarely available—they typically are not traded in markets, so measuring their value to society is not easy.

Our study examines whether changing weights within an index is an effective way to alter program outcomes. In this study, we provide insights into the sensitivity of program benefits (i.e., environmental improvements) and costs to changes in the weights associated with different program objectives. Our analyses use data on the CRP, which has used an environmental benefits index (EBI) since the early 1990s to balance multiple environmental objectives and cost, and to rank applications of potential program enrollees. In these analyses, we analyzed how changes in the weights associated with the objectives could affect environmental benefits and costs through the re-ranking and re-selection of applications on eligible lands. Our analyses considered the types of land available for enrollment and the degree to which changes in index weights induce producers to enroll different types of land. They took a simplified approach that assumed variations (across different parcels) in scores for each objective included in the index reflected the differences in value of enrolling these parcels. Different outcomes, for the CRP as a whole, were thus possible as different sets of weights resulted in different sets of farmland being enrolled—with each set containing unique combinations of environmental benefits and costs.

Small changes to CRP weights tended to generate small impacts on environmental outcomes, though larger weight changes have more noticeable impacts. We found that our measures of environmental benefits were mildly sensitive to *small* changes in the weights assigned to different environmental objectives in the CRP. These findings held regardless of whether we simulated the effect for a *single* signup of 2 million acres as part of an ongoing program (using offer and enrollment data from the 26th signup) or for a "large program enrollment" in which we simulated the enrollment of 33 million acres into a new program. Environmental improvements increased the most in the "large program enrollment" scenario, in response to changes in own weights—(e.g., reductions in soil erosion increased by about 5 percent in response to a 10-percent change in the soil erosion reduction weight (which is equivalent to increasing the soil erosion score from 100 to 110 and reducing other weights proportionally, holding total EBI points constant). The limited sensitivity suggests that if the index initially results in levels of benefits that generally reflect the relative propor-

tions most favored by society, then fine-tuning the index may not help much in achieving more precise outcomes.

While small changes in weights did not yield large changes in outcomes, larger changes to weights did provide a mechanism to steer the level and composition of environmental benefits. For example, in our simulations an approximately 50-percent increase in the wildlife score from 100 to 150 points increased expected wildlife benefits by about 15 percent. Larger changes in weights generated larger changes: in a large program enrollment, increasing the erosion reduction score from 100 to over 300 would generate a 50-percent increase in erosion reduction benefits (from an average of 48 to 72 percent of the maximum attainable benefits). These findings suggest that if it becomes apparent that program outcomes do not generally reflect social environmental priorities, changing the index weights may be useful in affecting larger changes—even though it may take large weight increases for any one objective to achieve moderate improvement in the corresponding environmental benefits.[2] We also found that large weight changes can also have different effects on regional enrollment levels, with some counties gaining acreage while others lose acreage as particular weights are doubled.

Program costs were sensitive to changes in environmental benefits, with small additional increases in environmental benefits requiring a greater than proportional cost increase. That these cost sensitivities were greater for small program enrollments than for larger enrollments suggests that achieving improvements in environmental benefits may be less costly in the early phases of the CRP and could become more expensive as ongoing enrollments reduced the pool of available lands.

For the CRP, the tradeoffs from changing index weights tend to be small. When two or more environmental objectives can be achieved simultaneously (as complements), the impacts of changes in weights are less of a concern – because when producers provide more of one environmental benefit (as its weight is increased), more of the other environmental benefits will be provided as well. Conversely, when environmental concerns are substitutes, weight changes can induce greater tradeoffs because the kinds of lands accepted under alternative weighting schemes can be substantively different in terms of the types of benefits they provide.

Our simulations reveal that overall complementary and substitution effects are rather weak. However, we did note the following:

- Whether environmental resources act as complements or substitutes depends in part on the *size* of the program enrollment. *Smaller* incremental program enrollments involved more tradeoffs—perhaps because farmland that offered multiple benefits might already be enrolled in the program, and the remaining pool of eligible farmland offered fewer benefits simultaneously.

- A consistent tradeoff occurred between wildlife benefits and erosion benefits: increasing the wildlife weight provides more wildlife benefits at the expense of erosion reduction benefits—but again the effects are quite weak (10-percent increase in wildlife weight results in a 1-percent decline in erosion benefits). However, this effect translates

[2]Some evidence suggests that public values associated with CRP's impacts on wildlife may not be reflected in a correspondingly high value for the wildlife factor of the EBI (Feather et al., 1999); further research would be necessary to determine whether substantial changes in the EBI are warranted.

into about an 18-percent reduction in erosion reduction benefits when the wildlife habitat weight is doubled.

- Because the EBI is defined nationally, our analyses largely maintained a national perspective; yet, regional analyses reveal that regional responses can vary more dramatically. Complementarity and substitution relationships between objectives are likely to be more evident at the local level, and the nature of the relationship may differ from one region to another.

When program objectives, overall program sizes, or other features are mandated by law, changing index weights can serve as a lever for moderately affecting CRP outcomes. With the widespread use of environmental indices as a method for targeting program payments, either directly to agricultural producers or to State and local jurisdictions, this report provides new insight on the sensitivity of program outcomes to some of the choices made in such an approach. Our findings suggest that in the CRP, large changes in the EBI weights could affect program outcomes, while small changes in weights have lesser impacts.

These findings imply that an index may be most useful for guiding program benefits toward those that basically reflect societal values, but that fine-tuning the index weights may not be as helpful in achieving precise outcomes. Program decisionmakers may find that adjusting other program design features—such as eligibility criteria, or the set of allowable conservation practices—helps effect subtle changes in program outcomes.

Lessons learned for other conservation programs. What lessons can be drawn for other conservation programs? At least three issues are worth considering when assessing how this study's findings relating to the CRP can provide insights on the effects of weight changes in other conservation programs. First, the sensitivity of environmental benefits to changes in index weights may differ in programs that seek more varied types of objectives than the CRP. For example, objectives of the FRPP include maintaining production and social amenity benefits, such as keeping prime farmland in agriculture and maintaining historical resources. Whether greater dissimilarities in objectives within a program result in more pronounced tradeoffs when weights are altered may ultimately depend on whether landowners are more or less likely to offer to provide multiple dissimilar benefits when applying to a program.

Second, the different sensitivities in expected environmental outcomes at the national level versus the regional levels revealed by the CRP simulations suggest that the degree of centralization or decentralization of a program's enrollment decisions may determine the broad applicability of these findings. The CRP is centralized, and all applications nationwide are prioritized and chosen on the basis of a single index. Several other programs, such as EQIP, WRP, and FRPP, are decentralized. In these programs, once Federal funds are disbursed to the States (typically using an index type of mechanism), State or local governments make decisions about applications to accept using State or locally developed indices. This approach accommodates heterogeneity in local objectives as well as in the relative importance of the objectives. Also, changes in indices could generate different impacts

on program outcomes across States or regions. The extent of the variation in impacts may ultimately depend on the distribution of environmental concerns, as well as indicator variables used to measure performance for environmental concerns, across the landscape (Babcock et al., 1996).

Finally, the presence of ecological "threshold effects" may determine outcome sensitivity but not necessarily in a predictable way. The sensitivity of outcomes may be due in part to the extent that a program's basic eligibility criteria achieve desired environmental benefits. If a conservation program obtains most of its benefits by meeting program eligibility standards, then even large perturbations in the index weights (or payment rates in programs like CSP) may have little impact on program outcomes.[3] On the other hand, if a certain threshold of environmental quality must exist before significant environmental benefits can be reaped, and a program's eligibility criteria are set near this threshold, then small changes in index weights could result in quite large impacts on environmental benefits (Wu and Skelton-Groth, 2002). Knowledge of such threshold effects helps in measuring the performance of an index in a conservation program (Ferraro, 2003).

[3]Large changes in weights might also have little impact if the eligibility criteria act to exclude the best opportunities to make improvements in multiple environmental concerns.

References

Babcock, B.A., P.G. Lakshminarayan, J. Wu, and D. Zilberman (1996). "The Economics of a Public Fund for Environmental Amenities: A Study of CRP Contracts." *American Journal of Agricultural Economics* 78 (November): 961-971.

Barbarika, A. (2004). *CRP: Planting for the Future.* U.S. Department of Agriculture, Farm Service Agency. June. Available at www.fsa.usda.gov/pas/crpconf04/crp_overview_june2004.pdf

Bohman, M., J. Cooper, D. Mullarkey, M.A. Normile, D. Skully, S. Vogel, and E. Young (1999). "The Use and Abuse of Multifunctionality." U.S. Department of Agriculture, Economic Research Service. Available at www.ers.usda.gov/briefing/WTO/PDF/multifunc1119.pdf

Boisvert, R. (2001). A note on the concept of jointness in production. Annex 1, in *Multifunctionality:Toward an Analytical Framework*. Organisation for Economic Co-operation and Development.

Cattaneo, A. (2003). "The Pursuit of Efficiency and Its Unintended Consequences: Contract Withdrawals in the Environmental Quality Incentives Program." *Review of Agricultural Economics* v25, n2 (Fall-Winter): 449-69.

Ebert, U., and H. Welsch (2004). "Meaningful Environmental Indices: A Social Choice Approach." *Journal of Environmental Economics and Management* v47, n2 (March): 270-83.

Esseks, J.D., and S.E. Kraft. (2002). "Are Owners of Urban-Edge Agricultural Land Willing to Provide Environmental Benefits that Urban and Suburban Residents Value?" *Report for American Farmland Trust*. Available at www.aftresearch.org/farmbill/docs/ FINLEnvirBenefitsFiveStates.doc/.

Falconer, K., and M. Whitby (1999). "The Invisible Costs of Scheme Implementation and Administration." In G. Van Huylenbroeck and M. Whitby (eds.). *Countryside Stewardship: Farmers, Policies and Markets.* Elsevier Science, (pp. 67-88).

Falconer, K., P. Dupraz, and M. Whitby (2001). "An Investigation of Policy Administrative Costs Using Panel Data for the English Environmentally Sensitive Areas." *Journal of Agricultural Economics* 52(1), 83-103.

Feather, P., D. Hellerstein, and L. Hansen (1999). *Economic Valuation of Environmental Benefits and the Targeting of Conservation Programs: The Case of the CRP.* Agricultural Economic Report No. 778. U.S. Department of Agriculture, Economic Research Service. April. Available at www.ers.usda.gov/publications/aer778/

Ferraro, Paul J. (2003). "Conservation Contracting in Heterogeneous Landscapes: An Application to Watershed Protection with Threshold Constraints." *Agricultural and Resource Economics Review* (32:1), 53-64.

Ferraro, Paul J. (2004). "Targeting Conservation Investments in Heterogeneous Landscapes: A Distance-Function Approach and

Application to Watershed Management." *American Journal of Agricultural Economics* 86(4). 905-18.

Hellerstein, D., C. Nickerson, P. Feather, D. Mullarkey, A. Tegene, J. Cooper, Dwight Gadsby, and C. Barnard (2002). "Farmland Protection: the Role of Public Preferences for Rural Amenities." Agricultural Economic Report No. 815. U.S. Department of Agriculture, Economic Research Service. November. Available at www.ers.usda.gov/publications/aer815/

Larson, J. M., J. L. Findeis, and S.M. Smith (2001). "Agricultural Adaptation to Urbanization in Southeastern Pennsylvania." *Agricultural and Resource Economics Review* 30(1), 32-43.

Leathers, H.D. (1991). "Allocable Fixed Inputs as a Cause of Joint Production: A Cost Function Approach." *American Journal of Agricultural Economics*, 1083-1090.

Mitchell, G., R. H. Griggs, V. Benson, and J. Williams (1998). Environmental Policy Integrated Climate Model. Available at www.brc.tamus.edu/epic/introduction/aboutmanual.html

McBride, W.D., and N. Key (2003). *Economic and Structural Relationships in U.S. Hog Production.* Agricultural Economic Report No. 818. U.S. Department of Agriculture, Economic Research Service. November. Available at www.ers.usda.gov/publications/aer818/.

McCann, L., and K.W. Easter (2000). "Estimates of Public Sector Transaction Costs in NRCS Programs." *Journal of Agricultural and Applied Economics* 32(3), 555-563.

Organisation for Economic Co-operation and Development (OECD) (2003). *Multifunctionality: The Policy Implications.*

Osborn, Tim, and Heimlich, Ralph (1994). "Changes Ahead For Conservation Reserve Program." *Agricultural Outlook*, AO- 209. July, pp. 26-30.

Osborn, Tim (1997). "New CRP Criteria Enhance Environmental Gains." *Agricultural Outlook.,* AO-245, October, pp. 15-18. Available at www.ers.usda.gov/publications/agoutlook/oct1997/ao245e.pdf

Ribaudo, M.O., D.L. Hoag, M.E. Smith, and R. Heimlich (2001). "Environmental Indices and the Politics of the Conservation Reserve Program." *Ecological Indicators* 1: 11-20.

Ribaudo, Marc, Noel Gollehon, Marcel Aillery, Jonathan Kaplan, Robert Johansson, Jean Agapoff, Lee Christensen, Vince Breneman, and Mark Peters (2003). *Manure Management for Water Quality: Costs to Animal Feeding Operations of Applying Manure Nutrients to Land.* Agricultural Economic Report No. 824, U.S. Department of Agriculture, Economic Research Service. June. Available at www.ers.usda.gov/publications/aer824/.

Shumway, R.C., R.D. Pope, and E.K. Nash (1984). "Allocatable Fixed Inputs and Jointness in Agricultural Production: Implication for Economic Modeling." *American Journal of Agricultural Economics* 66(14):72-78.

Smith, Mark E. (2000). "Conservation Reserve Enhancement Program: Early Results from a Federal-State Partnership," *Agricultural Outlook.* AO- 277. December, pp. 16-20. Available at www.ers.usda.gov/publications/agoutlook/dec2000/ao277f.pdf

Smith, Katherine, and Marca Weinberg (2004). "Measuring the Success of Conservation Programs." *Amber Waves*, Vol. 2, Issue 5. November, pp. 14-21. Available at www.ers.usda.gov/amberwaves/september04/features/measuringsuccess.htm

Tinbergen, J. (1952). *On the Theory of Economic Policy*. Amsterdam: North-Holland.

U.S. Department of Agriculture, Commodity Credit Corporation (USDA-CCC) (2003). Farm and Ranch Lands Protection Program Final Rule. Federal Register, 7 CFR Part 1491, Volume 68, Number 95, May 16. Available at edocket.access.gpo.gov/2003/03-12064.htm

U.S. Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS) (1997). *Water Quality and Agriculture: Status, Conditions and Trends.* Working Paper No. 16. July. Available at www.nrcs.usda.gov/technical/land/pubs/WP16.pdf

U.S. Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS) (2004a). "2004 County EQIP Sign-up Information: Montana NRCS." Available at www.mt.nrcs.usda.gov/programs/eqip/eqip2004counties.html

U.S. Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS) (2004b). "Program Status: Wetlands Reserve Program." Available at www.nrcs.usda.gov/programs/wrp/State_Maps_Stats/progstat.html.

Vatn, A. (2002). "Multifunctional Agriculture: Some Consequences for International Trade Regimes." *European Review of Agricultural Economics* 29(3), 309-327.

Wu, JunJie, and Katharine Skelton-Groth (2002). "Targeting Conservation Efforts in the Presence of Threshold Effects and Ecosystem Linkages." *Ecological Economics* 42: 313-331.

If an index were the only design feature that affected which applications were accepted into an agri-environmental program, that index would be a significant determinant as to how well that program met its environmental goals. However, different agri-environmental programs typically contain different combinations of features, which collectively act to make landowners more likely to offer to enroll certain parcels of land over others. This means that even if two programs seek the same environmental goals, an index—or changes to that index—may have different impacts on program benefits and costs depending on which other features define the program.

The Effects of Changing Weights in an Index Can Be Influenced by Other Program Features

One example of a program feature that can easily affect outcomes in voluntary agri-environmental programs is eligibility criteria. Eligibility requirements may constrain the universe of eligible lands such that lands enrolled are very similar in the types of environmental benefits that could be achieved. If most benefits in an agri-environmental program are obtained just by meeting eligibility requirements, even large perturbations in index weights or payment rates (as in the Conservation Security Program) may have little impact on environmental quality.

The type, and length, of contracts used in a program may also affect outcomes and the impact of changes in index weights. The Conservation Reserve Program (CRP), Environmental Quality Incentives Program (EQIP), and Conservation Security Program (CSP) offer contracts up to 15 years in length, while the Wetlands Reserve Program (WRP) and Farm and Ranch Lands Protection Program (FRPP) use permanent or very-long-term (30-year) easements. In the former case, the potential turnover in enrolled lands provides program administrators with more opportunities to influence environmental outcomes through modifications to an index. Permanent easements remain continuously enrolled in the program so changing an index would only influence outcomes for easements that are enrolled subsequent to the change.

How programs target enrollments based on location relative to other land uses can also help determine whether index weight changes affect program outcomes. In particular, over the long term, the environmental benefits provided by enrolled land can be affected by practices taking place on *adjacent* lands. These effects can be significant, such as when the conversion of adjacent farmland into residential housing units hampers the ability of a farm enrolled in a conservation program to deliver wildlife or other benefits. Conversely, close proximity to permanently preserved natural lands may help maintain benefits. The effects of making changes in a program's index may have more predictable impacts when programs account for adjacent land uses.

By design, some programs trade off cost or environmental performance against reducing the risk of contract nonperformance. For example, in the FRPP, easements are co-held with local entities, and the local entities are responsible for managing the easement in perpetuity. The weights given to factors measuring program performance have been as large as those assigned to cost factors in allocating national FRPP program budgets to States (see table A1.7).

Multi-Objective Programs and Indices in Action: Examples From U.S. Conservation Programs

Five of the Nation's largest agri-environmental programs seek multiple objectives and demonstrate different combinations of program features that affect how objectives are traded off (see box, "Multi-Objective Programs in Action: The Case of U.S. Conservation Programs"). Two of the programs retire land (CRP and WRP), while the other three are working lands programs (EQIP, FRPP, and CSP).

Conservation Reserve Program

The CRP is a land retirement program and is the Nation's largest conservation incentive program in terms of acres enrolled. In the early years of the CRP, landowner applications satisfying a single environmental objective—reducing soil erosion—were accepted until the program acreage constraint was met. In the early 1990s, increasing concerns about offsite problems arising from farming operations motivated the adoption of a selection mechanism that could address additional resource concerns. The environmental benefits index (EBI) was adopted in 1990 to help measure the multiple environmental benefits and the costs of implementing conservation practices on parcels offered for the program and to target enrollments to parcels on this basis (Osborn, 1993; 1997). In essence, the EBI balances the benefits of reducing negative environmental impacts of agricultural production against the costs of retiring the land and installing conservation practices.

Before adoption of the EBI, between 1986 and 1989 the CRP enrolled over 33 million acres based on the land's potential to provide benefits from reduced soil erosion. After adoption of the EBI in the early 1990s, which considered multiple objectives, the program enrolled about 37 million acres through multiple general signups (Barbarika et al., 2004).[1] The bulk of the acres enrolled in both the pre- and post-EBI periods are in the Northern Great Plains, Prairie Gateway, the Heartland, and along the Mississippi Basin (fig. A1.1). At a national level, only minor geographic shifts in pre- and post-EBI enrollment patterns are evident.

At the local level, larger shifts are obvious. As shown in figure A1.2, counties coded green experienced at least a 20-percent increase in enrolled CRP acreage during the time period following adoption of the EBI (1995-2003). These counties are clustered in the Northwest (Washington State, north central Montana), the Mississippi Basin, and several New England States. Regional differences in the ability of the land to provide multiple environ-

[1]The 33 million and 37 million acres represent all land accepted for enrollment into the CRP during the respective time spans and include lands enrolled as old contracts expired. The totals do not represent the enrollment at any given time (which has never exceeded 35 million acres).
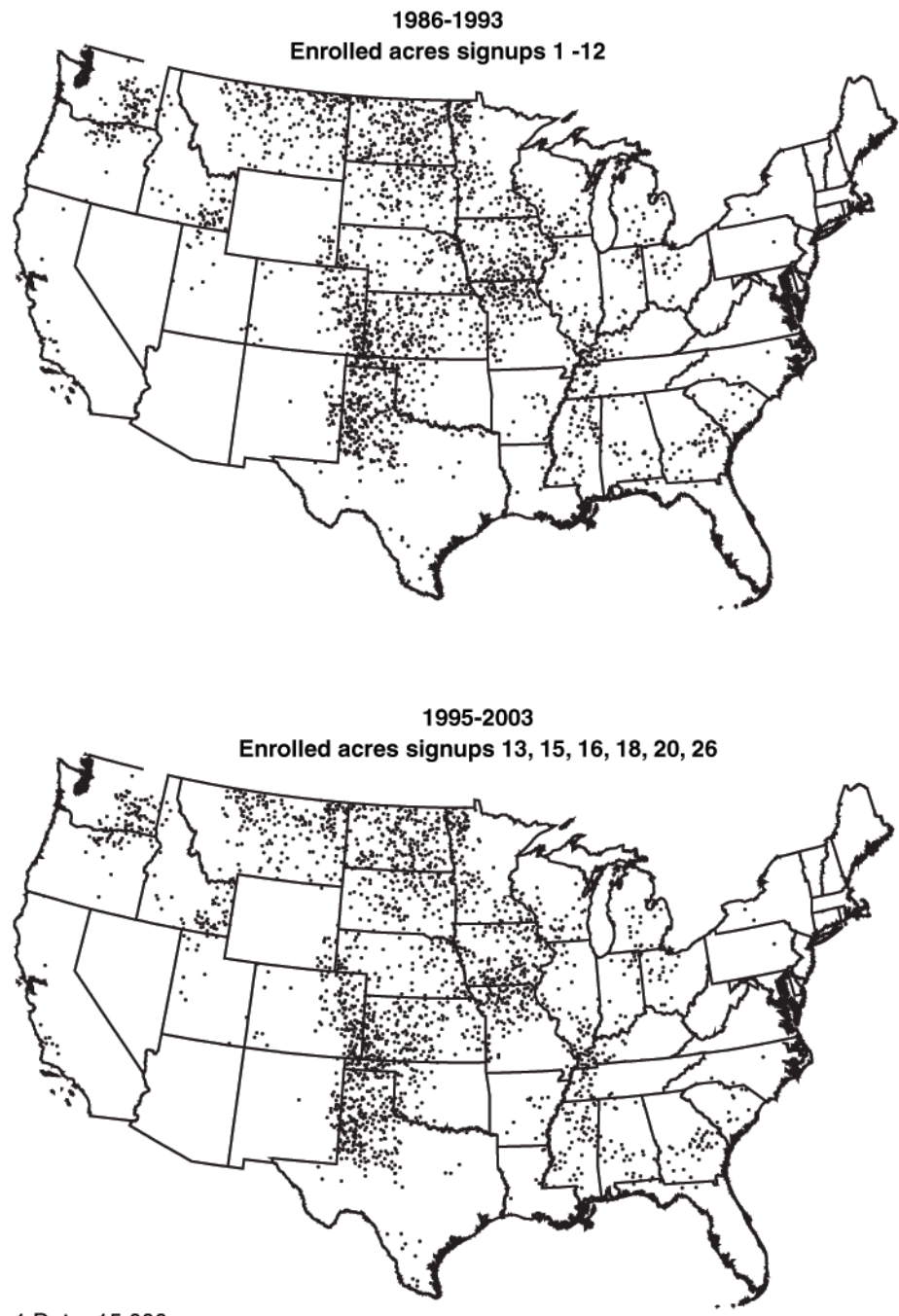
Multi-Objective Programs in Action: The Case of U.S. Conservation Programs

Many of the Nation's largest conservation programs have adopted a multi-objective approach to achieving program goals. The programs reviewed in this appendix include:

- *Conservation Reserve Program (CRP).* The CRP is the largest conservation program ever to be adopted at the Federal level. The CRP offers landowners incentive payments (and cost sharing for installation costs, in some cases) to implement environmentally enhancing practices on agricultural land that they take out of production for 10- to 15-year terms. Congress mandated an acreage enrollment cap, which the Farm Security and Rural Investment Act of 2002 (2002 Farm Act) expanded to 39.2 million acres from 36.4 million acres. Program expenditures have averaged over $1.3 billion annually. The CRP was initiated in 1985 and is administered through the USDA's Farm Service Agency. For further information, see http://www.ers.usda.gov/Briefing/Conservation AndEnvironment/qa.htm#consreserve. Or see http://www.fsa.usda.gov/dafp/cepd/crp_statistics.htm for current CRP statistics.

- *Environmental Quality Incentives Program (EQIP).* Implemented in 1996, EQIP provides farmers and ranchers with financial and technical assistance to install or implement structural and management conservation practices on "working" agricultural lands. The 2002 Farm Act significantly increased funding for this program, with an authorized $6.16 billion for the 6-year period 2002-07. USDA's Natural Resources Conservation Service (NRCS) administers EQIP. For further information, see http://www.ers.usda.gov/data/eqip/.

- *Conservation Security Program (CSP).* The CSP provides payments to farmers and ranchers for maintaining and enhancing conservation efforts on "working" agricultural lands. It is a new program authorized by the 2002 Farm Act and has a congressionally mandated payment cap of $3.8 billion over 10 years. Although originally deemed an entitlement program in which all eligible producers are enrolled, budget constraints have resulted in use of a selection mechanism based on soil quality and the level of environmental effort to be undertaken. CSP is administered by NRCS. For further information, see http://www.nrcs.usda.gov/programs/csp/.

- *Wetlands Reserve Program (WRP).* The WRP was mandated in 1985 to provide assistance to farmers to protect, restore, or enhance wetlands in exchange for retiring land from agricultural production. The program currently has an acreage enrollment cap of 2,275,000 acres, with annual enrollment limited to 250,000 acres. As of fiscal 2003, 1.47 million acres were enrolled. In fiscal 2004, almost $275 million was spent on WRP contracts. This program is administered by the NRCS. For further information, see http://www.nrcs.usda.gov/programs/wrp/.

- *Farm and Ranch Lands Protection Program (FRPP).* Unlike the above programs that primarily seek changes in land use or land-use practices, the primary purpose of FRPP is to prevent a change in agricultural land use. Specifically, FRPP provides matching funds to State and local governments, tribal governments, and nonprofit organizations and acquires an interest in easements that prevents conversion of the land to urban uses. Landowners retain the rights to farm the land. The 2002 Farm Act gave FRPP a significant funding boost, authorizing a more than tenfold increase from about $53 million during 1996-2001 to $597 million for 2002-07. Since program inception through 2003, easement interests have been secured on nearly 295,000 acres across 41 States. This program is administered by NRCS. For further information, see http://www.nrcs.usda.gov/programs/frpp/.

Figure A1.1
Location of CRP enrolled acres: Pre- and post-EBI

1986-1993
Enrolled acres signups 1 -12

1995-2003
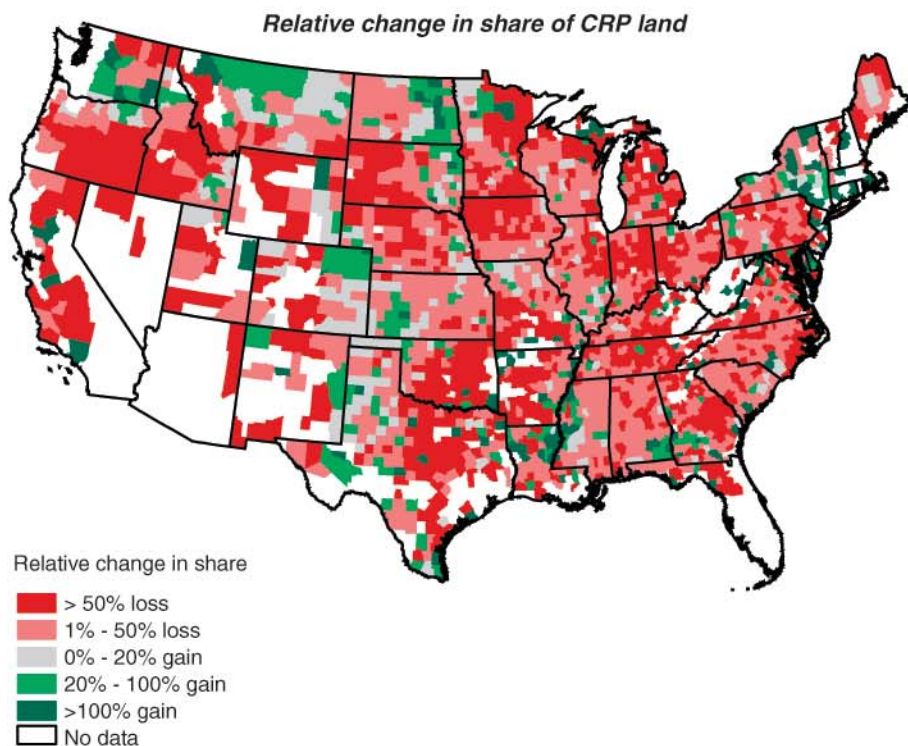### Enrolled acres signups 13, 15, 16, 18, 20, 26

1 Dot = 15,000 acres

Source: Compiled by USDA's Economic Research Service
using data from USDA's Farm Service Agency.

Figure A1.2

Change in acreage enrolled in CRP between 189 (pre-EBI and 2002 (post-EBI)

Relative change in share of CRP land

Relative change in share

- ▇ > 50% loss
- ▇ 1% - 50% loss
- ▇ 0% - 20% gain
- ▇ 20% - 100% gain
- ▇ >100% gain
- ☐ No data

Source: Compiled by USDA's Economic Research Service
using data on CRP contracts from USDA's Farm Service Agency.

Change in CRP-share: By relative category

Category	Number of counties	Total change in share	Average change (per county)
20 to 100 percent loss	1,464	-15.3	-0.0110
0 to 20 percent loss	348	-1.5	-0.0043
0 to 20 percent gain	285	2.5	0.0088
20 to 100 percent gain	297	10.9	0.0370
> 100 percent gain	165	3.3	0.0190

Notes: The map shows what counties lost and gained "share" between 1993
(acres enrolled in pre-EBI signups) and 2005 (acres enrolled in post-EBI signups).
Since total CRP acreage changes over time, the share of total CRP
acreage in a given county is used.

Share is defined as: county_crp_acres / national_crp_acres.

The categories are based on the proportional change in share, defined as
(share_2005 – share_1993) / share_1993.

Total change in share is defined as: change in percent of total CRP acres
(summed across all counties in a category). The average change is defined as
(total change in share)/(# of counties).

Note that 1,812 counties had their "proportional change in share" decrease,
while 747 had an increase. Consequently, the change in share in "loss" counties
is (on average) about 40 percent of the change in "gain" counties.

Numerous factors can contribute to these changes, such as changes in commodity prices.

mental benefits, as opposed to only soil erosion benefits, may have contributed to these shifts.[2]

Relative to the program targeting primarily on the basis of achieving the single objective of reducing soil erosion, adoption of the EBI is expected to enhance the CRP's provision of environmental benefits (Ribaudo et al., 2001). For example, using economic models of recreational trip taking, Feather et al. (1999) show that adoption of the EBI increases public enjoyment of wildlife viewing and water-based recreation.

The CRP is a centralized program, and (at least since 1990) all offers for a given signup are evaluated on the basis of the same EBI. The types of environmental concerns considered in the EBI have changed over time, however. Initially covering about 2.5 million acres enrolled between 1990 and 1992, the EBI considered reduced soil erosion benefits, water quality benefits, and enduring benefits (which measures the length of time benefits are expected to endure). From the 17-million-acre 15th signup of 1997 until the present, the EBI has also considered wildlife habitat and air quality, as well as reducing program costs. Overall, the points awarded to the various concerns have remained relatively similar since they were introduced, with equal priority given to wildlife habitat, water quality, and soil erosion benefits, and the greatest allocation of points to the cost factor (see table A1.1a for an outline of the EBI points used since 1997, and table A1.1b for details on the practices that contribute to the EBI points used in the 26th (2003) signup).

Environmental Quality Incentives Program

EQIP seeks three of the four environmental objectives sought by CRP:

- Reduction in soil erosion
- Reduction in water pollution from agricultural nonpoint sources
- Habitat conservation

EQIP also seeks the reduction of a fourth type of pollutant: emissions to the atmosphere, including particulate matter, nitrogen oxides, volatile organic

[2]The EBI may not have been the only reason for these shifts in enrollment patterns. Other influences could include changes in commodity prices or commodity program payments that affect the returns a landowner could earn by keeping the land in production.

Table A1.1a
EBI weights used in signups 15 to 29

Objective	15th signup (1997)		16th - 20th signups (1998-2001)		26th and 29th signup (2003-04)	
	Maximum EBI score attainable	Implicit maximum weight	Maximum EBI score attainable	Implicit maximum weight	Maximum EBI score attainable	Implicit maximum weight
Wildlife	100	0.167	100	0.179	100	0.183
Water quality	100	0.167	100	0.179	100	0.183
Erosion reduction	100	0.167	100	0.179	100	0.183
Enduring benefits	50	0.083	50	0.089	50	0.092
Air quality	25	0.041	35	0.063	45	0.083
Priority area benefits	25	0.041	25	0.045	0	0
Cost savings	200	0.333	150	0.268	150	0.275
Total	600	1.000	560	1.000	545	1.000

Note: Until the 26th signup in 2003, the EBI included an objective that assigned additional points to lands located within designated State or national conservation priority areas (CPAs). In all signups, location within these CPAs was one of several possible eligibility criteria.

Source: Compiled by USDA's Economic Research Service using data from USDA's Farm Service Agency.

Table A1.1b
Details of the 26th signup EBI: Points awarded to subfactors

EBI concerns					
Wildlife (100 points)	Water quality (100 points)	Erosion reduction (100 points)	Enduring benefits (50 points)	Air quality (45 points)	Costs (150 points)
Cover: Introduced grass, native grass, trees (50 points	Within designated State Water Quality Zone (30 points)	All points awarded based on erodibility index (100 points)	All points awarded based on enduring benefits (tree plantings, wetland restoration,existing tree, grass seeding) (50 points)	Air quality benefits (35 points)	Per acre rent (125 points maximum) 125 * (185- bid amount) / 185 (185 is CRP's maximum allowed bid)
Priority zones (30 points)	Groundwater vulnerability (25 points)			Wind erosion soils (5 points)	No cost share (10 points)
Wildlife enhancement (20 points)	Surface water vulnerability (45 points)			In air quality zones (5 points)	Bid below maximum rate (15 points)

Source: Compiled by USDA's Economic Research Service using data from USDA's Farm Service Agency.

compounds, and ozone precursors and depleters. EQIP is also meant to help producers comply with regulations. Although this is not an environmental objective, it does play a role in terms of the resource concerns addressed. For example, 60 percent of the program's funds are targeted to livestock-related resource concerns, with the expectation that they can offset some of the costs of recently introduced environmental regulations for confined animal feeding operations (Ribaudo et al., 2003).

EQIP is operated in a decentralized manner, with two separate indices used to implement the program. Environmental outcomes can be affected through changes in either mechanism. The first index is a single index used to allocate the national program budget to States, where the allocation is made on the basis of these four environmental objectives (see table A1.2 for an outline of this index). This index largely determines the overall spatial distribution of total environmental benefits that can be achieved—for example, States receiving higher funding amounts may be able to provide more environmental benefits. The second index consists of a set of indices developed by State and local Natural Resources Conservation Service (NRCS) conservationists, which are used to prioritize and select applications for acceptance into the EQIP program. States and localities have considerable flexibility in designing their indices, with some States even allowing for county-level variation within the State-level index. For example, the index used in Montana includes a statewide ranking for animal feeding operations but accommodates locally developed rankings for other provisions of EQIP (such as for counties affected by the spring rise of the Missouri River) (NRCS, 2004a). These indices distribute potential environmental benefits across the landscape at a finer spatial scale and also determine the types of benefits that will be achieved in any particular location. For example, water conservation is given priority in Utah, while Minnesota

Table A1.2
Summary of EQIP formula to allocate national program funds to States

Top 10 factors (accounting for about 50 percent of funds). These factors are measured in the appropriate units (such as tons of waste and acres of cropland):

- Animal waste generation
- Livestock animal units
- Impaired rivers and streams
- Air quality - wind erosion

- Cropland erosion > T
- Pastureland needing treatment
- Irrigated cropland

- Fair and poor rangeland
- Limited-resource producers
- Non-Federal grazing lands

Other factors (accounting for about 50 percent of funds):

- Phosphorous runoff potential
- Waste management system costs
- Cropland
- Wetlands
- Land with saline/alkaline problems (surface water vulnerability)
- Land with saline/alkaline problems (groundwater vulnerability)
- Forest land
- Federal grazing lands
- Acres subject to flooding

- Coastal zone lands
- Native American tribal lands
- Land in specialty crops
- At-risk species habitat conservation
- Potential pesticide and nitrate runoff
- Forest land erosion > T
- Commercial fertilizer/cropland
- Number of farms and ranches
- Population

- Carbon sequestration
- Combined animal feeding operations/animal feeding operations
- Water body acreage
- Livestock animal units/cropland
- Air quality nonattainment areas
- Other land in farms

For further details, see http://www.nrcs.usda.gov/programs/Env_Assess/EQIP/EQIP_EA_finals/EQIP%20Final%20EA%204-11-03.pdf

Source: Compiled by USDA's Economic Research Service using data from USDA's Natural Resources Conservation Service.

gives priority to reductions in soil erosion. Table A1.3 outlines a few State-level EQIP ranking systems.

Environmental concerns receiving priority in EQIP, and thus the environmental benefits likely to be achieved, vary significantly across States. Although factors affecting producers' incentives to apply to EQIP will affect outcomes (because, like the other programs discussed here, EQIP relies on voluntary participation), variation in local priorities likely contributes to the significant variation in types of practices that are ultimately funded. On a national basis, and prior to the Farm Security and Rural Investment Act of 2002 (2002 Farm Act), 33 percent of EQIP-funded activities involve water-related conservation practices. Soil erosion and land management practices account for 21 percent of funding, followed by livestock nutrient management with 19 percent of funds. Practices addressing wildlife habitat management, crop nutrient management, and other concerns account for the remaining 27 percent. Management of livestock waste receives most of the funding in the Northern Crescent, Eastern Uplands, and Southern Seaboard regions of the United States (fig. A1.3). Water quality and conservation practices receive most of the funding in the Basin and Range and Northern Great Plains regions.

Table A1.3
Examples of State-level EQIP weights

In the tables that follow, the EQIP weights assigned in 2003 to different environmental concerns are listed for a small subset of counties within selected States. For comparability across States, all scoring mechanisms have been rescaled so that points sum to 100 (more points mean the objective is more important). The States selected are meant to provide an overview of concerns, but they are not representative of the diversity of approaches to ranking applications in EQIP. In fact, the indices presented here were chosen also because of their simplicity and concise presentation. In many States, the ranking procedures are quite complex and are linked to details of specific conservation practices; in others, points assigned to an environmental concern are obtained by multiplying a unit score by the acres involved so that there is no predefined maximum score. Ranking criteria can change substantially from one year to the next.

Utah

For the purpose of managing EQIP, Utah was divided into seven zones by NRCS, and each zone in 2003 had its own ranking criteria. The ranking mechanisms reported in the table below vary between all points going to water—either quality or quantity concerns—in zone 3, and points being spread among multiple environmental concerns as in zone 7—which balances water quantity, soil erosion, grazing, and multiple resource concerns. In two areas (zones 4 and 5), the weight is allocated based on the share of applications addressing a resource concern: funding is allocated where there is most demand by producers. Wildlife habitat benefits are not used as a ranking criterion in Utah.

Item	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7
Water quantity	60	50	65			0	14
Water quality	0	35	35	Weight is	Weight is	35	0
Soil erosion	10	0	0	based on	based on	0	20
Grazing and rangeland	30	15	0	share of	share of	65	34
Multiple resource benefits	0	0	0	applications	applications	0	32

Source: Compiled by USDA's Economic Research Service from USDA's Natural Resources Conservation Service—FY 2003 ranking criteria for Utah.

Iowa

In Iowa, water quality in 2003 was consistently ranked highly by NRCS as a resource concern across counties, with soil erosion and/or livestock grazing as the other main concerns.

Item	Palo Alto	Benton	Union	Lee	Carroll	Winnebago	Allamakee
Water quality	66	48	25	37	40	38	45
Soil erosion	21	18	44	37	37	62	0
Wildlife habitat	14	12	0	4	7	0	0
Livestock grazing	0	15	31	22	17	0	55
Air quality	0	7	0	0	0	0	0

Source: Compiled by USDA's Economic Research Service from USDA's Natural Resources Conservation Service—FY 2003 ranking criteria for Iowa
(http://www.ia.nrcs.usda.gov/programs/stateeqipmap.html).

Minnesota

No single concern took priority throughout the State in 2003 as shown by the subset of counties reported below. The State provides a guideline for ranking EQIP applications, which counties can modify. The State ranking criteria express a balanced approach to resource concerns, with water quality and soil erosion ranked highest. The rankings at the local level can be considerably different from the State rankings, indicating considerable heterogeneity of resource concerns across the State. For example, Aitkin County's index demonstrates an even more balanced weighting scheme where water quality, soil erosion, wildlife habitat, forest management, and other local concerns all have nearly the same weight. By contrast, in Root River County's index, nearly 50 percent of all available points are assigned to erosion control.

Item	State ranking (advisory	County adaptation of advisory State ranking (subset of counties)					
		Aitkin	Beltrami	Cotton-wood	Murray	Root River	Traverse
Water quality	29	35	28	47	54	18	44
Erosion control	21	13	4	23	36	49	27
Wildlife habitat	11	15	11	2	2	10	9
Air quality	10	6	2	2	2	3	4
Grazing system	10	4	22	2	2	8	15
Forest management	10	12	11	2	2	13	2
Additional local concern	10	15	22	21	2	0	0

Source: Compiled by USDA's Economic Research Service from USDA's Natural Resources Conservation Service—FY 2003
ranking criteria for Minnesota (http://www.mn.nrcs.usda.gov/programs/eqip/).

Figure A1.3

Distribution of EQIP funds by region and environmental concern, 1997-2004

Percent
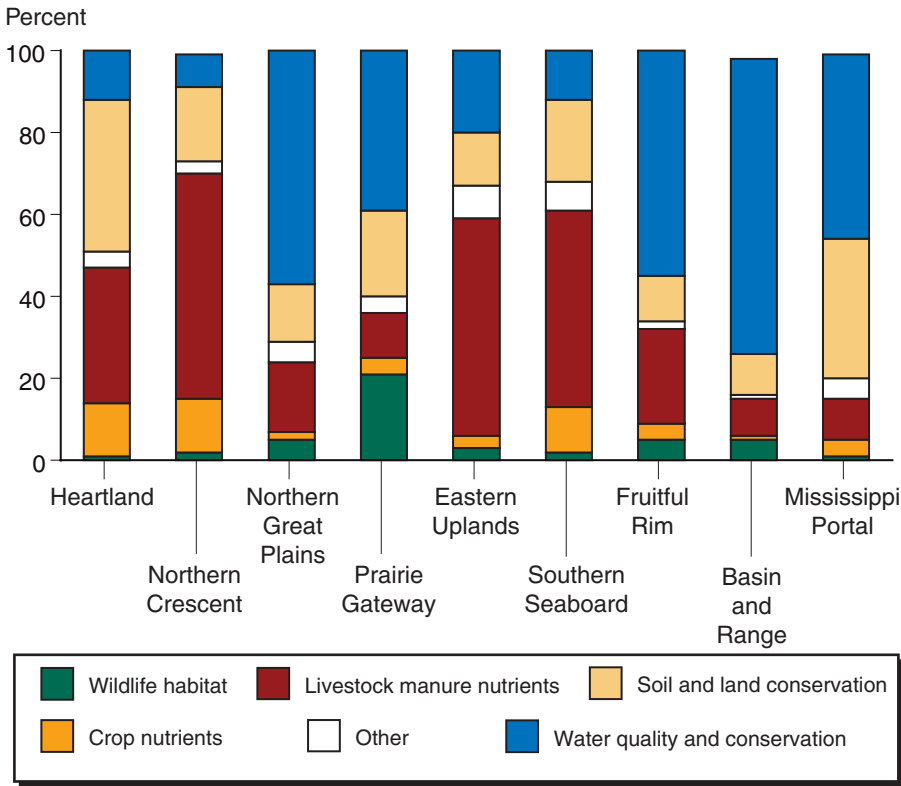
Note: Funding is presented according to the main environmental concern associated with implemented practices; however, in reality many practices address multiple concerns. Here, only the main concern addressed is taken into consideration.

Source: Compiled by USDA's Economic Research Service using data from USDA's Natural Resources Conservation Service and Farm Service Agency.

Cost considerations can influence the ability of a program to efficiently provide environmental benefits. Prior to 2002, program administrators used cost to rank otherwise similar applications. The 2002 Farm Act eliminated the provision that allowed producers to "bid down" the cost of implementing practices to improve their chances for being accepted into the program. Consequently, the significant additional funding authorized for EQIP may be buying less in terms of environmental improvements.[3]

While no longer used at the national level, many indices used by States and localities for ranking EQIP applications still consider cost. For example, Pennsylvania's index ultimately ranks parcels on the basis of a cost-benefit ratio (cost of implementing conservation practices relative to the environmental benefits provided). In Iowa, the cost-benefit ratio is only used to prioritize applications that offer the same total environmental benefits.

Conservation Security Program

The CSP provides financial and technical assistance to agricultural producers who are already conserving soil quality, water quality, air quality, wildlife, and energy on working agricultural land. Producers are eligible for

[3]An analysis of EQIP contract behavior found evidence that practices were more likely to be withdrawn or not implemented if they had lower cost-share payments (Cattaneo, 2003). If a larger share of contracted practices are now being implemented as planned due to higher cost-share rates under the "no bidding down" rules, the overall impact of this change may be less than expected.

CSP only if they have already achieved minimum standards for soil and water quality (often referred to as the "nondegradation" standard), that is, relative to conventional farming practices, significant environmental improvements have already been achieved. Furthermore, CSP stresses "enhancements"—the adoption of practices or activities that go beyond these minimum standards. In contrast, other programs, such as EQIP, do not require previous conservation effort and do not provide incentives for "enhancement" activities.

The CSP seeks improvements in many of the same environmental concerns as the CRP, EQIP, and WRP, but two program features set it apart in terms of how changes in program priorities might affect environmental outcomes. First, the CSP uses "enrollment categories" rather than an environmental benefit-cost index to rank and select applications. Producers with eligible land are assigned to one of eight enrollment categories, an assignation based on soil quality (which reflects past soil management), the amount of conservation effort expended by the producer to date, and the amount of additional effort the producer is willing to put forth. Producers are thus ranked on the basis of *effort* rather than benefits and costs. Second, CSP uses "benefits-based" payments: in addition to cost-share payments for the practices they implement, producers are paid more as they take on more enhancement practices. In many cases, these additional payments are based on expected improvements in measures of environmental performance—such as improvements in a soil condition index. Greater increases in environmental benefits thus lead to higher payment amounts—unlike other programs in which producers receive cost-based financial assistance. Taken together, these two provisions mean that if the relative priorities of different objectives change in the CSP, program administrators would need to adjust the definitions of enrollment categories and/or payment rates (rather than just the weights assigned in an index) to effect changes in environmental outcomes. The environmental tradeoffs that occur when these adjustments are made depend on the interrelation of the environmental benefits and their responsiveness to the changes.

Table A1.4 outlines the CSP enrollment categories to which applications are assigned. Applicants assigned to category H meet only the basic requirements of the program (i.e., they have addressed soil and water quality concerns)—and are thus least likely to be enrolled. Applicants assigned to category A agree to implement multiple enhancement practices and activities. These applicants are most likely to be enrolled.

Wetlands Reserve Program

The overall objectives of the WRP include maximizing wetland functions and values, such as providing quality wildlife habitat.[4] Though the WRP is a land retirement program like the CRP, WRP is operated as a decentralized program similar to EQIP: an index is first used to allocate national program funds to States, and then locally determined indices are used to compare and rank applications.

Unlike EQIP, the allocation of program funds to States in WRP is determined by more than just the potential for environmental gains. As noted in

[4]Although not a primary focus of the program, the CRP incorporates wetlands protection in several ways. First, wetlands are part of the wildlife and water quality factors of the EBI. Second, about 122,000 acres of land are enrolled as part of the Farmable Wetland "continuous CRP" initiative.

Table A1.4
Sample CSP enrollment categories for cropland stewards

Category	Criteria				
	Soil conditioning index	Soil tillage intensity rating[1]	Stewardship practices from list(*) in place for 2 or more years	Stewardship activities from list(**) in place for 2 or more years	Enhancement activities (to be completed by the third year of the contract)
A	At least 0.1	Less than 30	At least three practices	At least three activities	Agree to (1) move to the next tier[2] or to add two steward-ship practices or activities from list and (2) conduct onfarm project or assessment and evaluation activity
B	At least 0.0	Less than 30	At least three practices	At least three activities	
C	At least 0.1	Less than 60	At least two practices	At least two activities	Agree to (1) add two stewardship practices or activities from list and (2) conduct onfarm project or assessment and evaluation activity
D	At least 0.0	Less than 60	At least two practices	At least two activities	
E	At least 0.1	Less than 60	At least two practices	At least one activity	Agree to (1) add two stewardship practices or activi-ties from list and (2) conduct on-farm project or assess-ment and evaluation activity
F	At least 0.0	Less than 100	At least one practice	At least two activities	
G	At least 0.0	Less than 100	At least one practice	Any number of activities	Agree to add two stewardship prac-tices or activities from list
H	Must meet minimum program eligibility requirements as defined in the rule				Do not agree to do additional enhance-ment activities

* Stewardship practice list for cropland in this example:[3] contour buffer strips, cover crop, grade stabilization structure, irrigation water management.

** Stewardship activity list for cropland in this example:[4] Test soil and/or plant tissue on annual basis, precision application of nutrients, such as banding, side dressing, injection, fertigation, irrigation system efficiency evaluations and adjustments.

[1]STIR is an index used to evaluate the kind, severity, and number of ground-disturbing passes on soil quality. High STIR numbers indicate more disturbance.

[2]Moving to the next tier means the producer agrees to expand the amount of the farm under contract or the number of resources to be addressed.

[3]The list would contain all conservation practices identified in the *Field Office Technical Guide* for application to cropland to improve soil and/or water quality.

[4]The list would contain all applicable stewardship activities which, when applied to a cropland field, mitigate off-site resource damage or improve soil and/or water quality.

Source: Compiled by USDA's Economic Research Service using data from USDA's Natural Resources Conservation Service.

table A1.5, when allocating WRP funds, the Federal Government weighs ecological considerations against two program performance objectives: maximizing landowner participation and State performance in the program over time—that is, allocating funds to States with a history of easement purchases. As with EQIP, States place varying priority on different environmental benefits and program costs in the locally developed indices (see table A1.6 for an example of a State-level evaluation criteria).

Table A1.5
Criteria used for WRP fund allocations to States

Most important criteria:	• Ecological concerns: protecting bird migration routes, rate of wetland loss
	• State performance: program delivery and easement-closure
	• Landowner interest: level of unfunded applications
Less important criteria	• Cost

Source: USDA's Economic Research Service.

Table A1.6
Outline of Minnesota's Wetlands Reserve Program easement evaluation worksheet

Factor	Score			
Geographic priority	10			
Landscape significance	Number of restorable	Upland: Wetland ratio		
Depressional wetland	basins	>1:1	0.5:1-0.9:1	<0.5:1
	>5	15	10	5
	3-4	10	5	3
	<3	5	3	3
Floodplain wetland	Easement size	Frequently flooded		Other
	>120	10		5
	40-119	5		3
	< 40	3		0
Nondepressional wetland	Size			
	>120	3		
	40-119	1		
	<40	0		
Hydrological restoration	Practice	Points depend on current hydrological manipulation		
	Pothole restoration			
	• >80 potholes restored	• 35, 20, or 4		
	• 30-79% restored	• 20, 10, or 0		
	• < 30%	• 0		
	Floodplain restored	20, 10, or 0		
Vegetation establishment	Native ecosystem restoration	5		
	3-5 native species	2		
	<3 native species	0		
Cost	(2000- easement value) / 400			
Restoration cost	<$100 per acre	5		
	Otherwise	(2,000 - total per acre restoration cost)/400		

Source: USDA's Economic Research Service.

Farm and Ranch Lands Protection Program

Conservation programs can use indices regardless of their primary program goals. The primary goal of FRPP is to prevent the loss of existing agricultural production benefits—by purchasing easements to prevent farmland from changing use (primarily to an urban use). As with other USDA conservation programs, the FRPP uses indices to allocate national program funding and also to rank applications.

Like EQIP and WRP, the FRPP uses a decentralized funding approach. The index used to allocate national program funding to States includes objectives relating to maximizing production benefits (by protecting prime, unique, or important lands and lands that are most likely to be converted) and program performance (by supporting States with established histories of acquiring easements). Unlike those of EQIP and WRP, FRPP's funding allocation index also includes objectives relating to minimizing program costs. The weight assigned to production benefits has typically been about twice the weights assigned to cost or program performance factors.

The locally developed State indices include some of these same objectives, as well as environmental objectives and objectives relating to the provision of social amenity benefits—such as open space and maintenance of rural lifestyles (Hellerstein et al., 2002). These latter objectives are often measured in terms of protecting larger parcels, land used for particular farming types, and land in particular locations relative to environmental and urban features (USDA, 2003). Table A1.7 provides an outline of the FRPP's funding allocation formula index, and table A1.8 provides an example of a State farmland protection ranking system.

Table A1.7
Criteria used by the FRPP to determine 2004 allocations to States

Criteria	Source	Weight
Total acres of farm and ranch land converted to urban and built-up uses (1992 – 1997)	NRI	100
Prime farmland percent change (1992 – 1997)	NRI	150
Prime farmland gross acreage change (1992 – 1997)	NRI	150
FY-04 prime acres to be protected	State plans	300
Total acres to be protected	State pans	100
Percent of total land estimated to be protected that is prime and important farmland	State plans	300
Average total federal cost per acre	Calculated from State plans	200
Percent of easement cost (leveraging)	Calculated from State plans	200
Cooperating entities average number of staff years devoted to farmland protection	State plans	100
Average number of years of entities acquiring easements	State plans	100
Average annual FRPP easement expenditures	State plans	200

Source: Compiled by USDA's Economic Research Service using data from USDA's Natural Resources Conservation Service.

Table A1.8

Outline of Montana's farm and ranch land protection program ranking system

Criteria	Levels	Possible points
LESA score		100
Share of total dollars from FRPP	< 25%	30
	25 to 35%	20
	35 to 45 %	10
	45 to 50 %	5
Appraisal completed	Yes	20
	No	0
Sponsor's history in farmland protection	< 5 years	5
	5- 10 years	10
	> 10 years	15
Sponsor's staff years (SY) devoted to farmland protection	< 0.5 SY	5
	0.5-1.5 SY	10
	1.5-30. SY	15
Timely completion of conservation plan	Yes	5
	No	0
Project area has active watershed group, or a complete conservation needs assessment	Yes	10
	No	0

Source: Compiled by USDA's Economic Research Service using data from USDA's Natural Resources Conservation Service.

Multiple Objectives and Heterogeneity in Environmental Concerns: Above and Beyond the Use of Indices

In addition to using indices as a way of balancing multiple environmental objectives, some conservation programs use other strategies to focus enrollments and to minimize tradeoffs. For example, the CRP has adopted a number of strategies to complement its use of the EBI. Just a few years after implementing the EBI, the CRP identified certain high-priority conservation practices and allowed for noncompetitive enrollments while offering additional financial incentives for landowners to implement these practices. These enrollments occur in the "continuous signups," in which applications are not ranked according to the EBI.

EQIP, the WRP, and CSP have also targeted certain geographic areas as a strategy. Prior to the 2002 Farm Act, EQIP allocated more of its funding to designated Conservation Priority Areas (CPAs). While CPAs no longer influence funding allocations from the Federal level, some States have incorporated spatial location considerations into the index used to rank applications. In 2004, the first Wetlands Reserve Enhancement Program (WREP) partnership was established in Nebraska, with a focus on improving wildlife habitat and increasing the flood storage capacity of the Lower Missouri River (USDA, 2004b). The CSP has targeted a limited set of watersheds thus far, though this is mostly due to budgetary considerations.

In another strategy that helps direct the flow of program dollars, USDA partners with local entities. For example, the FRPP provides matching funds for easement purchases to State and local governments, tribal governments,

and nonprofit organizations that have existing farmland protection programs. Landowners must apply to FRPP through one of these entities. Because the applications must satisfy the local entity's farmland protection objectives, in addition to FRPP objectives, program outcomes are influenced by local priorities (which can vary widely across States). The Federal-State Conservation Reserve Enhancement Program (CREP) focuses a portion of CRP resources on specific local environmental problems. In New York and Maryland, for example, CREP is targeted to protecting water quality in specific watersheds. In Washington and Oregon, CREP focuses on endangered species habitat (Smith, 2000).

The simulations used in this study are designed to capture the impacts of changes in the EBI weights. A simple approach would assume that the same set of offers is made regardless of changes in the weights. Different outcomes would still be possible because a change in weights could change the total EBI score for each offer. As some scores increase and others decrease, the set of offers accepted into the program will change, leading to a new mixture of environmental benefits and costs.

However, it is not realistic to assume a constant set of offers. Instead, "incentive effects" are likely to be important. Two issues are of particular concern:

- If the EBI weight vector changes, it is possible that different sets of acres (out of the roughly 300 million currently eligible acres) would be offered to the CRP. Some current participants would no longer find the program attractive, while some current nonparticipants would become interested in the program.

- Lands currently available for enrollment may be systematically different from the full set of lands that are eligible. In particular, land currently enrolled in the CRP cannot be "re-offered," and this land may be different than land not currently enrolled.

This appendix outlines how the models used in scenarios 1 to 4 (chapter 3) address these concerns. Additional details are available from the authors. Major elements used in these models include the following:

- Each simulated enrollment is based on a "weighting" of the observations in the CRP offer file. That is, instead of assuming that each acre offered to the CRP represents 1 acre, each offer is assigned an *expansion factor*. The expansion factor measures how many eligible, but not offered, acres are identical to the acres covered by this offer.

- We simulated both a 2-million-acre enrollment in a single signup and a 33-million-acre program constructed from a multiyear series of signups.

The essential notion is that each observation in the CRP offer file is representative of a larger set of acreage that could be offered into the CRP. This implies that for a given offered acre, there are other observationally equivalent acres. Some of these observationally equivalent acres are already enrolled in the CRP, while others belong to landowners who have decided not to offer them to the CRP during this signup.

The expansion factor is estimated by first computing *predicted offer rates*. We assume that a landowner's decision to offer an acre to the CRP is influenced by an acre's EBI score, along with profitability and other concerns. By modeling the probability of making an offer, as a function of the EBI

score (hence as functions of EBI weights), we can estimate a new probability (of making an offer) when the EBI weights change.

This model involves two data sources:

- For each Major Land Resource Area (MLRA), the Farm Service Agency's likelihood-to-bid (LTB) model is used to simulate the acres eligible for the CRP. In addition to simulating total acreage, the LTB model also simulates the distribution of EBI scores across eligible acres in an MLRA.

- The complete set of offers made to the CRP's 26th signup includes data on the location (the MLRA) of all offers and each offer's EBI scores.

For each of these datasets, we define "cohorts" of similar points. Each cohort is defined by geography (its MLRA) and attributes (the EBI factor scores). For each cohort, an *offer rate (OR)* is computed:

OR = (acres offered in this cohort) / (eligible acres in this cohort)

where eligible acres does not include land currently enrolled in the CRP.

We regress the relationship between the *offer rate* and several explanatory variables.

(A) OR = $f(X,\beta)$,

where X is a vector of independent variables including EBI scores, measures of land productivity, and average landowner characteristics (such as county-wide median age), and $\beta)$ is a vector of coefficients to be estimated.

For a variety of reasons, we estimate the parameters of $f(\cdot)$ with a "boot-strapping" methodology that employs individual observation data rather than aggregated data:

(B) $OR_i = f(X_i, \beta)$,

where OR_i is an offer rate imputed to each observation i in the offer file. This estimator uses simulation techniques (repeated regressions on randomly drawn observations) to control for errors in variables, problems that may arise from aggregating offers into cohorts.

The results of this regression are then used to generate the *expansion factor* for all offers in a simulation. These expansion factors are used as follows:

- Each simulation is characterized by a unique EBI weight vector.

- For each observation (i) in the offer file, we predict

$$\overline{OR}_{i0} = f(X_{i0},\beta) \text{ and } \overline{OR}_{i1} = f(X_{i1},\beta),$$

where $\overline{OR}_{i0}$ and $\overline{OR}_{i1}$ are the "old" and "new" predicted offer rates, respectively. These predictions use each offer's attributes and the estimated values

of β from equation B. In particular, X_{i0} contains the actually observed EBI factor scores, and X_{i1} contains the EBI factors scores that this point would have under this simulation's "unique" EBI weight vector.

For each offer, an expansion factor is computed:

$$XP_i = \overline{OR}_{i1} / \overline{OR}_{i0}$$

Thus, if the old offer rate ($\overline{OR}_{i0}$) is 25 percent and the new offer rate ($\overline{OR}_{i1}$) is 50 percent, the XP will be 2.0.

- For each observation, the effective acres (EA) are computed as:

$$Ea_i = actual\_acres_i * XP_i.$$

  Where *actual acres* is the actual acreage included in offer *i*.

- All the offers are sorted by EBI scores.

  As with the base case, a simulated CRP is generated by "signing up" the best 2 million acres. Note that each offer's effective acres, rather than actual acres, are used when adding lands to the simulated CRP.

The above "single signup model" simulates the kinds of lands enrolled in a single signup (of a few million acres). We also consider how the entire CRP would change under different EBI weights. To address this question, we scale up the results of a single signup to approximate a 33-million-acre program.

To do this, it is useful to recall that the CRP was created from multiple signups. That is, landowners are given multiple opportunities to enroll their land into the CRP. We simulate this by iterating the single signup model with an expansion factor based on predicted offer rates until a specified enrollment limit has been reached. In each iteration, all acres with an EBI score that exceeds a cutoff are accepted. These acres are also removed from the set of eligible acres that may be accepted by future signups. Achieving the specified enrollment limit sometimes required adjusting the value of the EBI cutoffs used in the simulations; these adjusted cutoff values were close to but not always the same as the EBI cutoff actually used by FSA.

This process requires establishing "representative acreage" for each observation in the offer file. This representative acreage represents the total number of eligible acres (including land currently enrolled in the CRP) represented by the offer. The representative acres value, for each offer, is estimated using cohort level data from the LTB dataset and the offers dataset.

The actual acres that an observation *i* offer would contribute (to a simulated CRP), in round *r*, is:

$$(C)\ Offered\_acres_{ir} = (Prob\_offer_i * XP_i) * (representative\_acres_i - contracted\_acres_{ir})$$

where:

Prob_offer$_i$	The base probability of an acre, represented by this offer, is offered to the CRP. This is simply the observed offer rate for the cohort to which the offer belongs.
XP$_i$	The predicted expansion factor for this offer, given a proposed EBI weight vector.
Representative_acres$_i$	The number of acres this offer represents.
Contracted_acres$_{ir}$	Total acres that are represented by this offer, accepted in prior rounds. $$= \sum_{t=1}^{r-1} contracted\_acres_t$$ Note that in round *s*, *contracted_acres$_s$* is a subset of *offered_acres$_s$*. In particular, *contracted_acres$_s$* are the *offered_acres$_s$* that have EBI scores exceeding the cutoff used in round *s*.