Chapter 4

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.