Economic Valuation of Environmental Benefits and the Targeting of Conservation Programs

The Case of the CRP

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Introduction

The goal of maximizing the net benefits of rural land conservation programs through an appropriately designed acreage selection process is continually growing in public importance. The Conservation Reserve Program (CRP) provides an excellent example of an evolving process to select appropriate acreage to conserve. At the program's outset, environmental quality improvements were viewed as correlated with reducing soil erosion, a view that led to program rules that restricted eligibility primarily to highly erodible lands. In recent years, this view has evolved to recognize the value of a broader set of attributes that characterize our rural lands. To capture this complexity, a panel of experts devised, and periodically modify, a system that awards points to potential program acres based upon multiple attributes of the land. Actual enrollment is limited to the acres with the highest scores. This system, in which points represent the panel's assessment of the attributes' importance to society, is an example of a targeting mechanism.

This report will demonstrate how economics can help target farm program acres so that the greatest net benefits are captured. This analysis measures the public's willingness to pay (in dollar terms) for a variety of environmental impacts. This approach uses nonmarket valuation techniques to quantify the environmental impacts of the CRP. Specifically, the CRP converts cropland into grasslands or forest lands, which can enhance the natural environment in ways that people care about. For example, soil erosion reductions from the CRP can improve fishing opportunities, and habitat preservation can help protect endangered species. Nonmarket valuation techniques offer a means of measuring the dollar value of these enhancements.

This report will demonstrate how estimates of nonmarket values provide a far more robust set of information for the targeting of agricultural conservation programs. This in turn, can lead to improvements that strengthen program evaluations by facilitating the comparisons of costs against a full range of benefits.

The range of benefits provided by the environment is both broad and difficult to measure. The limited literature on the valuation of the environmental impacts of the CRP is often characterized by large-scale regional analysis and fails to account for the broad array of natural resources affected by the CRP. This report expands upon prior work by demonstrating how recent improvements in economic valuation techniques provide a way in which environmental targeting mechanisms, such as those used to allocate the CRP, can be more rigorously evaluated. In addition, this analysis can be used to indicate modifications to targeting mechanisms that may increase environmental benefits relative to program cost.

The analysis specifically examines how one form of environmental targeting of the CRP can affect the Nation's enjoyment of outdoor recreation. Although there are nonenvironmental[1] and many other environmental effects of the CRP (aside from outdoor recreation), recreational activities are highly valued and frequently involve market-based activities (such as travel) from which dollar-based benefits can be derived. For example, one-third of the U.S. population engage in wildlife viewing, one-quarter engage in freshwater fishing, and over half visit a beach or

[1]Although this report focuses on nonmarket benefits, the CRP has many nonenvironmental impacts (such as farm income support) that may also be important when targeting program acres.

waterside (Cordell and others, 1998). The economic impact of these activities can be substantial. For example, Americans spent approximately $100 billion on fishing, hunting, and wildlife-watching activities in 1996 (U.S. Dept. of the Interior, Fish and Wildlife Service and U.S. Dept. of Commerce, Bureau of the Census, 1997), and the net benefit of freshwater recreation has been estimated as $32 billion per year (Mitchell and Carson, 1989).

To fully capture the effects of the CRP on recreation, we faced two practical considerations that dictate the choice of modeling techniques. First, many of the public benefits from the CRP result from changes in land-use patterns that occur in their immediate surroundings. Furthermore, given the size and extent of the CRP, changes in program acreage are likely to affect local conditions in areas across the Nation. Hence, this analysis uses spatially disaggregated models that are applicable across a wide geographic area to capture the impacts of variations in CRP enrollment. Second, when estimating the benefits of the CRP, one must account for the multiple-site nature of rural recreation. This report introduces several new models that recognize this need. It also takes advantage of new sources of survey data on recreational choices and incorporates recent advances in econometrics and geographic information systems.

We focus on three activities that are thought to be significantly affected by enrolling environmentally sensitive lands into the CRP: water-based recreation, pheasant hunting, and wildlife viewing. The data and models used in this analysis are prototypes, and as such, are not meant to deliver definitive policy analysis. With that caution in mind, we draw several conclusions from this limited analysis:

- Using an Environmental Benefits Index (an EBI) can substantially increase environmental benefits of the CRP (relative to use of erodibility-based criteria).
- The wildlife benefits of the CRP are larger than the water-quality benefits.
- Considering the proximity of environmental impacts to human populations improves the ability to target areas with the highest environmental benefits per dollar of program cost.

This report begins with an overview of how agriculture affects the Nation's environment. We present a short summary of programs and policies designed to ameliorate the negative environmental effects of agriculture, followed by a longer description of the Conservation Reserve Program, the largest such program. The main analysis of this report concludes with a discussion of future research needs to provide information for improved targeting using economic criteria.

Geography of Agricultural Land Use

Agriculture is a resource-intensive industry, with over half of the land in the contiguous 48 States and three-fourths of freshwater withdrawals devoted to agricultural purposes. The broad extent of agriculture leads to widespread environmental effects on surface- and ground-water quality, air quality, fish and wildlife habitats, species diversity, and land characteristics. Box 1 summarizes these effects.

Agricultural lands are not necessarily located in remote, sparsely populated areas. Approximately one-half of the American population lives in a county that is at least 25 percent agricultural, and over two-thirds live in counties where agriculture comprises at least 10 percent of the landscape (table 1). Even in metropolitan (Butler and Beale, 1994) counties, almost one-third of the population lives in counties composed of at least 25 percent agricultural land. In

Table 1—Percentage of U.S. population living in counties with varying levels of farmland[1]

Item	Percentage of county that is farmland (average)	Percentage of U.S. population that is living in counties with at least—			
		10-percent farmland	25-percent farmland	50-percent farmland	75-percent farmland
All	50	70	46	23	9
Metro[2]	39	49	30	14	4

[1]Excludes Alaska and Hawaii.
[2]Metro counties defined by Butler and Beale, 1994.
Source: Data from the 1992 Agriculture Census and the 1990 United States Census of Population.

Box 1—Environmental Impacts of Agriculture

Impacts on Surface-Water Quality and Quantity

Agriculture is a primary source of nutrients in impaired surface waters; nutrients are the leading cause of water-quality impairments in lakes and estuaries and the third leading cause in rivers (USEPA, 1995). Siltation is one of the leading pollution problems in U.S. rivers and streams; and among the top four problems in lakes and estuaries (USEPA, 1995).

The most frequently detected herbicides in surface waters include several triazines (atrazine, cyanazine, and simazine), acetanilides (metolachlor and alachlor), and 2,4-D. These are among the highest in current agricultural use (USGS, 1997).

Impacts on Ground-Water Quality

The drinking water of an estimated 50 million people in the United States comes from ground water that is **potentially** contaminated by agricultural chemicals (Nielson and Lee, 1987).

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

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

Impacts on Air Quality

Soil particulate and farm chemicals are carried in the air we breathe. The highest concentration of commonly used agricultural herbicides, triazine and acetanilide, has been found in the areas where they are used most frequently and in the highest amounts (Goolsby and others, 1993).

Impacts on Wildlife Habitat and Ecological Diversity

Habitat loss associated with agricultural practices on over 400 million acres of cropland is the primary factor depressing wildlife populations in North America. Modern farming methods brought about dramatic reductions in many species, including cottontail rabbits and ring-necked pheasants (Risley and others, 1995; Wildlife Management Institute, 1995).

Annual wetland loss fell from the 458,000-acre average of the mid-1950's through the mid-1970's, to a 290,000-acre average between the mid-1970's and mid-1980's (U.S. Dept. of the Interior, 1994). Wetland losses often reduce biodiversity because many organisms depend on wetlands and riparian zones for feeding, breeding, and shelter (NRC, 1995).

Agriculture is thought to affect the survival of 380 of the 663 species listed federally as threatened or endangered in the United States (USDA/ERS, July 1997).

Source: USDA, ERS.

fact, many State and local governments have developed programs that provide incentives to preserve farmland near populated areas. The landscape amenities offered by some types of agricultural land use furnish open spaces and visual prospects that are increasingly valued by growing suburban populations (American Farmland Trust, 1997).

Because such a large proportion of the U.S. population resides near agricultural land and because agriculture significantly affects the environment, the way agricultural land is managed is likely to affect human health, recreational activities, and general well-being. The challenge of designing an environmental targeting mechanism that brings the greatest benefits relative to costs is not merely to identify agricultural land uses causing the largest ecological impacts, but also to consider how important these impacts are to the American public.

Improving Agriculture's Environmental Performance

Farmers and the Federal Government support a variety of actions that mitigate the potentially adverse effects that agriculture may have on the environment and on human health. Some of these actions include adopting more environmentally benign practices, or removing environmentally sensitive land from active production. Most of these actions incorporate some aspect of environmental targeting, defined by a focus of effort and expense on selected areas. A few examples of these practices include:

Erosion reduction: Conservation tillage, reduced tillage, and other crop residue management practices help reduce soil erosion (Conservation Technology Information Center) and improve habitat for some wildlife populations (Best, 1995).

Nutrient and animal waste management: Careful planning of fertilizer application, constructing of manure storage facilities, and other improvements can limit surface-water runoff and ground-water infiltration of nitrates and other potentially harmful chemicals (Feather and Cooper, 1995; Glover, 1996; Letson and Gollehon, 1996).

Irrigation efficiency and waste-water management: Monitoring soil moisture, improving water application

Box 2—USDA Programs That Encourage Farmers To Use Environmentally Benign Practices

Environmental Quality Incentives Program: Encourages farmers and ranchers to adopt practices that reduce environmental and resource problems. Producers who enter into 5- to 10-year contracts are offered technical assistance, education, cost sharing, and incentive payments.

Wildlife Habitat Incentives Program: Provides cost sharing to landowners for developing habitat for upland wildlife, wetland wildlife, threatened and endangered species, and fish and other types of wildlife.

Conservation Technical Assistance: Provides technical assistance to farmers for planning and implementing soil and water conservation and water-quality practices.

Extension Education: Provides landowners and farm operators with information and recommendations on soil conservation and water-quality practices.

Wetland Compliance (Swampbuster): Makes landowners ineligible for any Federal assistance, loans, insurance, or disaster payments for any year in which an annual crop is planted on converted wetlands.

Conservation Compliance: Requires producers who farm highly erodible land to implement a soil conservation plan to remain eligible for certain farm program benefits.

Wetland Reserve Program: Provides easement payments and restoration cost-shares to landowners who return previously converted, or presently farmed, wetlands to wetland conditions.

Source: USDA, ERS.

technologies, and capturing wastewater can limit salinization and related impacts on ground and surface waters (Aillery and Gollehon, 1997).

Integrated pest management: Using scouting, spot applications, and biological and cultural pest management may reduce damages from agricultural chemicals (Zalom and Fry, 1992).

Land retirement: Permanent and semi-permanent retirement of cropland to more environmentally benign land uses reduces erosion and creates habitats for wildlife. Grass filter strips, wetland preserves, and cropland retirement are primary examples of land retirement.

USDA has initiated several programs that rely on education, financial assistance, and technical assistance to encourage farmers to adopt environmentally benign practices (see Box 2). Another way to achieve these goals is through land retirement. Land retirement is relatively easy to administer (in terms of monitoring for compliance) and is more likely to produce anticipated improvements in environmental quality than approaches that seek to modify agricultural production practices (Young and Osborn, 1990). However, it can require relatively large financial incentives to farmland owners.

In terms of magnitude of cost and acreage, the largest American land retirement program is the Conservation Reserve Program (CRP). First authorized by Title XII of the 1985 Food Security Act (USDA/ASCS, 1986), the CRP pays for long-term idling of approximately 36 million acres (about 10 percent) of the Nation's cropland (see Box 3). The volunteer owner and/or operator receives 50 percent of the cost of establishing permanent perennial cover on the land and an annual rental payment in return for leaving the land idle for 10 or 15 years. The original goals of the CRP were (P.L. 99-198):

(1) Reducing soil erosion.
(2) Protecting soil productivity.
(3) Reducing sedimentation.
(4) Improving water quality.
(5) Improving fish and wildlife habitat.
(6) Curbing production of surplus commodities.
(7) Providing income support for farmers.

The original (1986 to 1989) CRP contracts based eligibility, and thus acceptance, primarily on reductions in soil erosion. The Food, Agriculture, Conservation, and Trade Act of 1990 (P.L. 101-624) redirected the enrollment selection to include a variety of factors that explicitly considered water quality, soil erosion, and other environmental concerns (USDA/ERS, 1994, p. 177).

Economics of the CRP

The idling of millions of acres of cropland under the CRP has affected virtually all citizens in some manner. The impacts of the CRP occur both on and off the farm and affect public and private parties. Potential costs and benefits can be divided into two categories: private and public. Public costs and benefits occur primarily off the farm while private costs and benefits occur primarily on the farm. The former category captures off-site changes in water quality, air quality, and wildlife habitat that accrue to society in general. The latter category captures changes in the welfare of agricultural producers themselves, such as changes in income, production costs, and soil productivity.

Table 2 summarizes previous estimates of the costs and benefits of the CRP. These estimates were computed shortly after the program started. While not a

Box 3—The Conservation Reserve Program

The Conservation Reserve Program is a long-term land retirement program designed to mitigate agriculture's adverse affects on the environment. When originally established under Title XII, Subtitle D of the Food Security Act of 1985, its purpose was to conserve and improve soil, water, and wildlife resources by establishing cover on highly erodible and other environmentally sensitive land through 10- and 15-year leases. The Food, Agriculture, Conservation, and Trade Act of 1990 continued the program's enrollment authority through 1995 and redirected enrollment criteria to include factors other than erodibility. The Federal Agricultural Improvement and Reform Act of 1996 gave the Secretary authority to conduct signups through 2002 with a 36.4-million-acre cap on enrollment.

Source: USDA, ERS.

Table 2—Estimated costs and benefits of the Conservation Reserve Program[1]

Type of cost or benefit	Benefit/ <Cost>	Source
	Million dollars	
Public:		
Public works[2]	3,029	Ribaudo
Air quality[3]	548	Ribaudo and others; Huszar and Piper
Recreation[4]	8,676	Ribaudo and others; John and others
Commodity Credit Corporation cost savings	17,850	Young and Osborn
Increased food costs	<18,950>	Young and Osborn
Direct program costs	<23,700>	Young and Osborn
Private:		
On-farm income[5]	20,300	Young and Osborn
Timber production[6]	5,400	Young and Osborn
Establish cover crops	<1,600>	Young and Osborn
Increased soil productivity	1,600	Ribaudo
Irrigation ditch maintenance	41	Ribaudo
Reduced industrial costs[7]	1,021	Ribaudo

[1]Costs and benefits for the entire program over a 10-year period discounted at a 4-percent rate. All estimates are based on the anticipated enrollment of 45 million acres when the analyses were conducted unless otherwise noted.

[2]Includes cost savings associated with reduced maintenance on roadside ditches, navigation channels, water treatment facilities, municipal water uses, flood damage, and water storage.

[3]Includes reduced health risks and cleaning costs associated with blowing dust.

[4]Includes sport-fishing, small-game hunting, nonconsumptive viewing, and waterfowl hunting. The latter two categories are based on the prevailing 34-million-acre CRP.

[5]Estimates vary from $9,200-$20,300 million.

[6]Estimates vary from $4,100-$5,400 million.

[7]Includes reduced costs associated with industrial uses, steam cooling, and flood damage.

Source: USDA, ERS.

complete accounting of all costs and benefits, they illustrate the economic magnitude of the program's effects. The two largest benefits are increases in the value of market sales of farm commodities and reductions in commodity deficiency payments from the Commodity Credit Corporation (CCC).[2] These effects are the result of higher market prices caused by the idling of formerly cultivated farmland. Offsetting these benefits are the two largest costs: direct CRP costs and increased consumer food costs. At the Federal Government level, the reduction in commodity payments is more than offset by the addition of the CRP's costs.

In addition to these effects on agricultural income and government expenditures, other effects have been quantified that largely occur in the public sector of the economy, and primarily accrue to individuals living off the farm. Of these, the largest estimated benefit is from improved recreation resulting from the environmentally enhancing effects of the CRP. Links between CRP lands and environmental improvements are fairly well documented at the aggregate level (see Box 4). For example, improved water quality leads to increased enjoyment of water-based recreation activities while the improved species habitat provided by the CRP results in better hunting and wildlife-viewing opportunities.

If the CRP, or other conservation programs, could be targeted to provide more societal benefits for the same costs, these programs would use resources more efficiently. Some efforts have already been made in this direction. In the initial signup periods that occurred between 1986 and 1989, selection of land into the CRP depended primarily on erodibility criteria, which were assumed to coincide with the first five (environ-

[2]Income support through deficiency payments linked to crop prices no longer exists, but did exist through 1996.

mental) goals listed on page 5. In signups since 1990, acceptance criteria have been broadened with a combination of environmental indicators factored into the bid process (USDA/ERS, 1997). It is believed that these environmental indicators provide a more accurate and comprehensive prediction of land retirement benefits than simply relying on erodibility.

The question of where to place future CRP acreage to obtain greater benefits can be answered by examining the magnitude and location of these benefits. Identifying and quantifying where large recreational benefits could occur and targeting land retirement to these areas would increase the outdoor recreation benefits of the CRP.

Box 4—Environmental Benefits of the Conservation Reserve Program

Much of the land entering the CRP had previously been devoted to row crop production. Extensive row crop production is known to be detrimental to many wildlife populations. By converting row crop lands into grasslands, the CRP positively affects many wildlife species. Most of the species listed below benefit from improved habitat and reproductive success.

The relationship between the CRP and water quality is less well understood, but appears to be significant. Suspended sediment and nutrient run-off generated from farming have been cited as the most damaging nonpoint sources of harm to the U.S. environment (Smith and others, 1987). By retiring highly erodible croplands, it is assumed that the CRP creates large water-quality improvements by reducing soil erosion and nutrient run-off. Based on the original projection of a 45-million-acre CRP, Ribaudo and others (1990) estimate that the program will reduce soil erosion by almost 750 million tons per year. This translates into large reductions in pollutants. Weitman (1994) estimated that nitrate loadings have declined by 90 percent, sediment and herbicide loadings by 50 percent, and phosphorous loadings by as much as 30 percent in some U.S. agricultural regions as a result of the CRP.

Species	Reference
Ring-necked pheasant	Allen (1994), Anderson and David (1992a,b), Berthelsen (1989), Little and Hill (1993)
Non-game birds	Campa and Winterstein (1992), Dunn and others (1993), Kimmel and others (1992), King (1991), Lauber (1991), Sample and Mossman (1990a,b)
Raptors	Evrard and others (1991)
Upland nesting waterfowl	Berthelsen (1989), Kantrud (1993), Reynolds (1992)
Game birds	Kimmel and others (1992), King (1991), Lauber (1991)
Neotropical migrant land birds	Rodenhouse and others (1993)
Elk and deer	Allen (1993), Newton and Beck (1993)
Eastern cottontail rabbit	Allen (1994)

Source: USDA, ERS.