Economic Valuation of Environmental Benefits and the Targeting of Conservation Programs: The Case of the CRP. By Peter Feather, Daniel Hellerstein, and LeRoy Hansen, Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 778.

Abstract

The range of environmental problems confronting agriculture has expanded in recent years. As the largest program designed to mitigate the negative environmental effects of agriculture, the Conservation Reserve Program (CRP) has broadened its initial focus on reductions in soil erosion to consider other landscape factors that may also be beneficial. For example, preserving habitats can help protect wildlife, thus leading to more nature-viewing opportunities. This report demonstrates how nonmarket valuation models can be used in targeting conservation programs such as the CRP.

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Summary

Many conservation programs, such as USDA's Conservation Reserve Program, improve environmental quality. Improving environmental quality leads to enhanced ecosystem health, in general, and also augments the public's enjoyment of recreational activities. This report examines the effect of environmental targeting of the CRP on the magnitude and type of environmental benefits and outdoor recreational opportunities created by an agricultural land conservation program.

Environmental targeting refers to the practice of directing program resources to lands where the greatest environmental benefit is generated for a given expenditure, or alternatively, specific environmental goals are achieved for the least cost.

Ecosystem health and many outdoor activities, such as water-based recreation, hunting, and nature viewing, are likely to have substantial value to individuals, but these activities typically have no explicit price (or market value) associated with them. In practice, therefore, environmental targeting presents the difficult problem of how to value and aggregate the benefits derived from environmental improvements.

Prior to 1990, CRP targeting was primarily based on soil erodibility. The current CRP targeting method is based on a broader range of environmental effects. Central to the current targeting method is a land-scoring process known as the Environmental Benefits Index (EBI). After the CRP signup period closes, each parcel of land offered under the program is scored based on the EBI. Parcels with the highest score are given priority for acceptance into the program. The EBI includes physical characteristics of land (erodibility, soil leachability, proximity to waterbodies, etc.), and measures of locally affected populations (number of well-water users).

What happens if alternative specifications of the current EBI are used to target the CRP? This report uses nonmarket valuation models for three activities that the CRP is likely to affect—freshwater-based recreation, wildlife viewing, and pheasant hunting—to demonstrate an alternative approach for targeting the CRP. The results are as follows:

- Switching CRP targeting criteria from erodibility to the EBI approximately doubles the benefits of freshwater-based recreation and wildlife viewing.

- CRP wildlife recreation benefits are significantly larger than freshwater-based recreation benefits. Based on the distribution of enrollment as of 1992, benefits include $348 million per year for wildlife viewing, $80 million per year for pheasant hunting, and $36 million per year for freshwater-based recreation.

- Natural resources that are near populated areas are likely to generate larger recreational use benefits simply because they give residents relatively easy access to natural resources. Taking affected populations into account when targeting CRP lands could increase the benefits of several types of outdoor recreation.

- Valuation-based targeting of the CRP is feasible and might improve its performance if public preferences are known and explicit. The major advantage of a valuation-based targeting system is that it is directed by public preferences. Although there will always be some benefits that are difficult to quantify in monetary terms, developing a valuation-based targeting system is feasible.

To fully implement valuation-based targeting of the CRP, more research is required. Nonmarket benefit models would need to be estimated for all of the primary nonmarket activities that are sensitive to the location and characteristics of the CRP. These activities include:

- The remaining recreational uses significantly affected by the CRP,

- Public works and industrial operations that are affected by reduced sediment loadings,

- Improved air quality,

- The public willingness to pay for the existence of wildlife augmented by the CRP,

- Landscape amenities associated with the CRP, and

- The effect of CRP on the quality of surface and ground water used for drinking.

Economic Valuation of Environmental Benefits and the Targeting of Conservation Programs

The Case of the CRP

Peter Feather, Daniel Hellerstein, and LeRoy Hansen

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 non-point 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.

Estimating Nonmarket Benefits of the Conservation Reserve Program

The basic goal of economic targeting of the CRP is to retire lands that result in the greatest net social benefits. To accomplish this, knowledge of the benefits of all activities that are influenced by the CRP is required. Aggregated measures of benefits for the whole Nation will not allow land to be targeted at a desirable, field-level parcel. Instead, these benefits need to be known at the local or "micro" level to effectively target lands to retire. This requires using models based on *individual* human preferences.

This report describes three models that account for selected environmental effects associated with broad changes in agricultural practices. We focus on how enrolling cropland into the CRP has affected freshwater recreation, pheasant hunting, and wildlife viewing. Due to differences in data availability, and in the nature of each activity, different approaches are used to analyze these three activities. However, in each case, the goal is to estimate the value of natural resource quality at a disaggregated level. Environmental targeting, which leads to differential impacts at the micro level, can then be investigated.

Before presenting the modeling results, we outline the basic theory underlying the measurement of "amenity" values of natural resources, as it pertains to rural land uses (Ribaudo and Hellerstein, 1992). Next, we review previous CRP valuation studies, and then discuss how these studies could be improved with better data and estimation techniques. The three models featured in the study are then introduced, along with a discussion of the data sources used. We use the models to determine the recreational value (from freshwater-based recreation, pheasant hunting, and wildlife viewing) of the CRP as it presently exists, and to determine the consequences of adopting an alternative targeting mechanism.

Background: Measuring the Value of Natural Resources

The net economic benefit an individual receives from consuming a market good (or service) is defined as the excess, over and above the market price, that an individual would pay to consume the good (or service). This net benefit is often referred to as a "consumer surplus" (Deaton and Muelbauer, 1980). Although not directly measurable, methods of determining consumer surplus are well known in the case of conventional goods (or services) traded in a market with observable prices (see Box 5). Once the consumer surplus associated with consuming the good (or service) is measured, valuation of quality changes can be accomplished by comparing consumer surplus before and after the change.

Valuing a change in natural resources, such as those that may be affected by environmental targeting of the CRP, is based on the same principle as for a good or service that is sold in the marketplace. The main difference is that natural resources often lack a fully developed market, hence they have no observable price (Freeman, 1979). The lack of observable prices complicates construction of measures such as consumer surplus that are based on an "excess over observable price" criterion. To address these complications, analysts often employ the concept of the "total economic value" an individual may derive from a natural resource (Randall and Stoll, 1983). Total economic value is essentially the same as net benefit, but recognizes that the value derived from the quality of the environment can be subdivided into two main categories:

(1) *Use value*—the value an individual derives from directly using the resource.

(2) *Nonuse value*—the value given to the existence of an environmental resource even though it is not currently used.

Use values are associated with activities such as swimming, hunting, and viewing nature where the individual comes into direct contact with the environment. These values also include commercial uses of natural resources, such as fishing, and consumptive uses, such as clean air and drinking water. Nonuse values are less tangible since they arise from environmental preferences rather than direct use. Three categories of nonuse values are (Smith, 1996):

(1) *Existence value*—the value derived from knowing that the resource is maintained.

(2) *Bequest value*—the value the current generation gains from knowing that the resource is preserved for future generations.

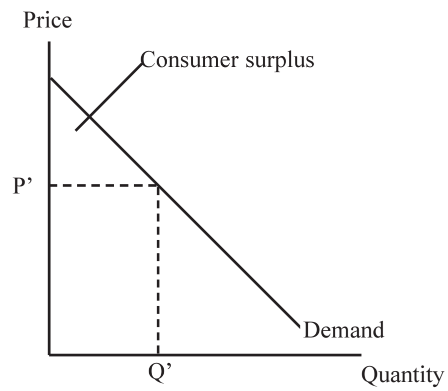
Box 5—What is Consumer Surplus?

Measuring the contribution to human welfare due to the availability of a good, or service, is a common problem in applied economics. One approach is to compute consumer surplus. Loosely speaking, consumer surplus is the amount of money, above and beyond the market price, that a consumer would be willing to pay for a given good. If an individual buys a good for $X, but would pay a maximum price of $X+$Y, then that individual's consumer surplus is $Y. Most individuals experience consumer surplus in almost every good they purchase.

Policies that change prices, income, or the quality of goods can be evaluated in terms of how they affect individuals' consumer surplus. Simply put, desirable policies increase consumer surplus more than they increase other costs.

To compute the consumer surplus for a good, the demand function for that good must be specified. For example, the figure below (a linear demand function), shows that at market price P', the quantity demanded will be Q'. The consumer surplus is the area below the demand function and above the price.

Demand and consumer surplus



Source: USDA, ERS.

(3) *Option value*—the value of preserving the resource so that the option of using it at some future date is maintained.

Table 3 lists approaches for obtaining these values. Inferred approaches based on market behavior such as averting expenditures, changes in production costs, and revealed preference are commonly used to determine use values. The most commonly used method, revealed preference, assumes that a relationship between environmental quality and observable behavior exists. Presently, the only method that can be used to recover nonuse values is contingent valuation. Although contingent valuation has been criticized as unreliable (Diamond and Hausman, 1994), it has been upheld in the United States District Court of Appeals (U.S. Dept. of the Interior, 1989) and approved for use by Federal agencies performing benefit-cost analysis (Arrow and others, 1993; United States Water Resources Council, 1984).

Modeling CRP Impacts: A Stylized Framework

To apply the techniques of nonmarket analysis to environmental targeting of the CRP, we incorporate the relationship between land retirement and the flow of nonmarket benefits. This process involves several steps. For example, figure 1 outlines the relationship between the CRP and two potentially large "use value" impacts: impacts on water quality and impacts on wildlife.

- **Water Quality—**
  In the case of water quality, retiring croplands reduces soil erosion and runoff, which results in lower levels of nutrients, sediments, and pesticides entering water bodies. This changes the biological conditions of the water and directly affects what users of the water body value. Anglers benefit from larger fish populations, and boaters, swimmers, and non-

Table 3——Methods of valuing nonmarket goods

Method	Value assessed	Description
Averting or defensive expenditures	Use value	Measuring expenditures made by individuals to reduce or negate pollution damages. Purchasing water filters or bottled water in response to polluted water are two examples (Bartik, 1988).
Changes in production costs	Use value	Inferring the cost of pollution by observing changes in firm profits, input costs, or output prices due to changes in environmental quality. Changes in output prices of marketable goods to consumers are one way to measure changes in environmental quality. It is also possible to measure this cost through changes in incomes of owners of factor inputs, or by changes in input expenditures (Freeman and Harrington, 1990).
Revealed preference	Use value	Observing individual behavior and inferring the demand for environmental quality (Mendelsohn and Brown, 1983). Typically, recreational trips are used to measure the demand for environmental quality and the travel cost serves as the price. Conventional demand equations are then estimated to determine the value of environmental quality. This is known as the travel cost approach.
Stated preference	Total value	Directly asking individuals their willingness to pay for a change in environmental quality (Mitchell and Carson, 1989; Randall and others, 1983). Individuals are either asked to state their willingness to pay for a change in quality (open-ended format contingent valuation), or asked to vote yes or no to a set amount (referendum format contingent valuation), or asked to order scenarios involving varying prices and levels of environmental quality (conjoint contingent valuation analysis).

Source: USDA, ERS.

contact recreationists benefit from clearer, more aesthetically appealing water.

- **Wildlife Habitat—**
  The relationship is similar in the wildlife case. Establishing grassland or forest cover creates suitable habitat for birds, small game, and large game. This, along with improvements in water quality, increases wildlife populations. Hunters and wildlife viewers then benefit from these increased populations.

In both cases, there is a causal relationship between a possible distribution of the CRP (as mediated through a targeting mechanism) and nonmarket benefits. More specifically, the size, placement, and management of CRP lands affect physical variables. These decisions then change biological parameters, which impact habitat quality and fish and wildlife populations. These altered environmental conditions ultimately are reflected in the values the public places on the environment.

The analyses in this report focus on the values the public places on the enhanced recreational activities. *This does not imply that CRP affects only recreational values*. However, recreational activities serve as good examples, because they are often associated with environmental amenities. Recreational activities tend to be high-valued activities, so are very relevant when addressing the value of environmental impacts. And finally, recreational activities include market-based activities, such as the travel costs associated with obtaining access to the natural resource, where the strength of individuals' preferences is demonstrated in dollar-based terms.

As environmental targeting evolves, determining the changes in welfare caused by the ensuing changes in land retirement patterns may involve directly estimating each of these steps in the causal relationships. In the water-quality case, a physical model translating changes in soil erosion into changes in observable biological criteria such as water clarity and fish populations would be required. Similarly, the wildlife case involves estimating changes in populations of wildlife species resulting from habitat changes.

Figure 1

Links between CRP acreage and economic benefits

Step 1: CRP acreage creates physical effects

↓

Water quality:	Reductions in erosion decrease nutrient, pesticide, and sediment loadings.	**Animal habitat:**	Creates beneficial grassland habitat for animals.

Step 2: Physical effects translate into biological results

↓

Water quality:	Decreases in loadings are beneficial for fish populations and improve the appearance of the water for recreational purposes.	**Animal habitat:**	Populations of many wildlife species increase due to better habitat and water quality.

Step 3: Biological results affect consumer welfare

↓

Water quality:	Improved appearance and smell of water make it more desirable for contact recreation. Increased fish populations reduce angler effort. Surface-water bodies are more visibly appealing for noncontact users.	**Animal habitat:**	Increased wildlife populations enhance hunting and wildlife-viewing activities through reduction in effort.

Source: USDA, ERS.

Ideally, these physical/biological models would be readily available. Unfortunately, the data required to estimate these relationships, and the knowledge of exactly how physical and biological interactions occur, are generally not available. Devising approaches to overcome these deficiencies is the major challenge facing the applied analyst. Often, an approach is adopted where a set of "environmental indicators" is used to represent the various physical and biological impacts of some policy. Although not ideal, this so-called "reduced form" approach allows the analyst to partially abstract from the ideal bio-physical models, while still incorporating available biophysical information.

Underlying the use of environmental indicators is the assumption that the link between physical effects and what recreationists value can be approximated by these indicators. In other words, since these indicators are proxies for the underlying environmental quality ultimately valued by recreationists, individuals are assumed to indirectly respond to them. For example, measures of the distribution of land types, such as "percent of land in cultivated crops" or "land in transitional wetlands," may be used as indicators of the overall abundance of wildlife-viewing opportunities.

Review of Prior Studies of the Recreational Value of the CRP

When considering where to target the CRP, analysts need to study how the CRP will affect recreational activities. Several studies have provided some limited economic analysis on this topic. Perhaps the best known are ERS studies that give national estimates of CRP's effect on freshwater fishing and small-game hunting from the late 1980's (Ribaudo and others, 1990). The National Biological Survey in the early 1990's (Allen, 1994; John, 1993, 1994) further analyzed the CRP's impact on the value of waterfowl hunting and bird watching.

Tables 4-6 describe the important features of these studies. These studies share a few common features:

- Most of these studies, except Ribaudo and others (1990), employ land use measures as environmental indicator variables. This land use information is generated from

Table 4—The 1990 ERS Freshwater Fishing Study

Environmental indicator	An “acceptable” water-quality (WQ) variable is defined for approximately 100 sub-State Wildlife Management Zones. This variable is based on sediment and chemical concentrations detected in surface waters at water-quality monitoring stations.
Econometric model	Using 1980 FHWAR* data, the authors estimated a two-stage probability-of-participation/quantity-given-participation model. Both stages use the WQ variable and personal characteristics as explanatory variables; the quantity stage also uses reported distance to most visited site as a price proxy.
Impact of CRP	A set of models are used to link erosion (and chemical runoff) rates from CRP land to levels of in-stream loadings of pollutants.
Effect of impact	By using multi-State data at the multi-State farm production region scale, in-stream loading changes are used to estimate a predicted WQ variable. With results from the econometric model, the analyst computes a new average quantity of trips (by multiplying the predicted probability of participation by the predicted number of trips).
Value of impact	The difference between the new quantity and the observed quantity is multiplied by an average value per trip; where the average value is obtained from a review of the valuation literature.

*1980 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. Source: Ribaudo and others (1990).

Table 5—The 1990 ERS Small-Game Hunting Model

Environmental indicator	Several land-use proxies for habitat variables (such as percent forest land) are computed at the State level.
Econometric model	Using FHWAR* data, the authors estimated the probability of being a hunter, and the probability of being a small-game hunter; using the habitat variables and personal factors as explanatory variables.
Impact of CRP	Adjust the various habitat measures, based on the enrollment of land into the CRP.
Effect of impact	The probabilities of being a hunter, or of being a small-game hunter (given that one is a hunter) were predicted. Using average number of small-game hunting trips (assumed the same for all small-game hunters), a total number of small-game hunting trips is computed.
Value of impact	The difference between the new quantity and the observed quantity of small-game hunting trips is multiplied by an average value per trip; where the average value is obtained from a review of the valuation literature.

*1980 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. Source: Ribaudo and others (1990).

Table 6—The 1992 NBS Waterfowl Hunting and Bird Watching Models

Environmental indicator	Several land-use proxies for habitat variables (such as percent forest land) are computed at the Wildlife Management Zone level. To account for congestion, these were divided by the population of the area.
Econometric model	Using FHWAR* data, the authors estimated a quality of experience/quantity of trip model. Both stages use the habitat measure, the distance to most preferred site, the distance to farthest site, and personal factors. In addition, the quantity model uses the predicted quality.
Impact of CRP	Adjust the various habitat measures, based on the enrollment of land into the CRP.
Effect of impact	For current participants, the quality measure is re-estimated, and then used to compute a predicted number of trips.
Value of impact	Using reported distance as a proxy for price, a “marginal value” of the habitat variables is computed. More important, the demand curve is integrated to compute a consumer surplus.

*1980 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. Source: Allen, 1994; John, 1993, 1994.

USDA's Natural Resources Conservation Service's National Resources Inventory (NRI), and is commonly incorporated as sub-State averages such as the percentage of farmland in a Wildlife Management Zone. Because Ribaudo (1989) was estimating water-quality benefits, his model employed measures of water quality.

- All of the studies rely on the U.S. Fish and Wildlife Service's National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (FHWAR) as a primary source of data on individuals' recreational activity (i.e., behavioral data). This survey is one of the few nationwide sources of data devoted to outdoor recreation. Unfortunately, due to confidentiality and other factors, the geographical specificity of the data is limited to sub-State regions.

- In each study, the fishing and small game models use per-trip values, obtained from the travel cost literature, to impute changes in value due to the CRP. The waterfowl-hunting and wildlife-viewing models directly compute a consumer surplus from their estimated demand curves.

- These studies used econometric methods that were based on highly simplified statistical models and aggregated data.

Features of the Nonmarket Benefit Models

These prior analyses of the nonmarket impacts of the CRP relied on highly aggregated data and relatively unsophisticated estimation methods. Measures of resource availability were based on regional averages instead of smaller more localized areas. Some of the studies extrapolated benefit measures from related studies rather than determining the benefits from behavioral data. The imputation of trip prices was often based on the most recent destination visited rather than a consideration of the entire set of choices made by the respondent. The econometric models employed had limited scope and handled quality changes at substitute sites in a simplified fashion.

In the context of environmental targeting, the final point is crucial. That is, environmental targeting is driven by the notion that careful placement and management of the CRP (or other similar programs) will increase per acre (or per program dollar) benefits. An "all or nothing" analysis of the entire CRP, which typifies the above models, is ill suited to examine the more subtle and place-specific changes likely to arise by variations in a targeting mechanism.

The models constructed for this study are designed to circumvent some of the shortcomings of prior models and are formulated to allow a focus on the effects of environmental targeting.[3] The foremost change is an improvement in the resolution of the geographical and behavioral data; the models are better suited to deal with substitute sites. Additionally, the range of activities analyzed is extended from earlier studies in the case of freshwater-based recreation (as opposed to freshwater fishing), and all wildlife viewing (as opposed to bird-watching). The single activity model (pheasant hunting) is also presented as an example of an environmental amenity (the size of the pheasant population) that is thought to be heavily affected by the CRP. Each of the three separate models incorporates some of the improvements listed in Box 6.

Data Used in the Nonmarket Benefit Models

Examining the nonmarket impacts of environmental targeting requires information about recreational behavior and the natural resource base (see Box 7). In this study, three primary databases are used: the 1995 National Survey of Recreation and the Environment (NSRE), the 1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (FHWAR), and the 1992 National Resources Inventory (NRI).

In the water-quality component of this study, behavioral information is derived from an ERS-funded component of the 1995 NSRE. The component of the NSRE used in this analysis was undertaken specifically to collect data on water-based recreation. Four sub-State regions located in Washington, Nebraska, Indiana, and Pennsylvania were sampled. Respondents were asked to recall the number of trips

[3]Presently, much of the environmental valuation literature is poorly suited for this type of problem. Most travel cost models focus on a single site or incorporate a relatively small number of substitute sites that include no measures of site quality. These models are good at examining demands in localized areas, but less effective at considering changes at the national level. Contingent valuation models often examine global changes with minimal focus on geographic variability.

Box 6—Improvements in Nonmarket Benefit Models in This Study

Better measures of recreational choice.

The 1991 FHWAR survey contains more accurate demographic data. This version of the survey contains more detailed information on residential location (i.e., ZIP Codes) than was previously available. This aids in a more exact description of the resources available to each individual. Additionally, because the survey was conducted after the CRP was in place, it reflects changes in behavior that occurred due to this program. The ERS component of the 1995 National Survey of Recreation and the Environment was used to measure freshwater recreation. This survey, although drawn from a limited geographical area, was designed to highlight the relationship between land use and recreational behavior.

More accurate measures of landscape diversity.

Using sub-county location information in the NRI, in combination with geographical information system techniques, estimates of relevant landscape features were derived throughout the United States at higher resolution than otherwise possible. In addition to providing a more accurate description of an individual's environment, this higher resolution permits local variations in the landscape to be accounted for.

Better estimation techniques.

Recent advances in estimation methods allow quality variations to directly influence consumer behavior. In addition, these models are better able to simultaneously account for both the decision to engage in a recreation activity and the intensity of participation.

Individual based benefits measures.

Economic theory dictates that marginal measures should be used to compute the impacts of changes in an individual's choice set. In practice, this suggests using individual specific demand curves whenever possible, rather than average trip values derived from studies of similar populations. Using estimators that can exploit higher resolution data, the ability to obtain and use individual specific demand curves is enhanced.

Source: USDA, ERS.

taken to wetlands, lakes, and rivers less than 100 miles from their residences within the last 12 months in cases where water was an important reason for the trip. The sample contains information on 1,510 persons evenly divided among the four areas. About 50 percent of the respondents participated in at least one freshwater-based activity, with participants averaging 10 trips per year.

The pheasant-hunting model and the wildlife-viewing model use the 1991 FHWAR, which measures participation in wildlife-based outdoor recreational activities. A two-stage sampling design is used, with a quarter of a million people asked screening questions regarding their overall participation in hunting, fishing, and wildlife viewing. A followup survey, using those judged most likely to be active participants, was then conducted. Approximately 50,000 individuals reported wildlife-associated recreation, with about half reporting nonconsumptive activities (i.e., wildlife viewing) and half reporting fishing and hunting activities. For purposes of the analysis, 5,851 individuals sampled were identified as potential pheasant hunters and more than 18,000 individuals sampled were identified as potential "wildlife-viewers."

Unlike earlier studies that used FHWAR data, the version of the survey used here contains the ZIP Code location of each respondent's home. This information helps construct a more accurate description of the recreational amenities available to each respondent. The result is a better identification of resource qualities affecting recreational behavior. One drawback is the lack of precise information about the location of

Box 7—Data Requirements for Recreation Demand Models

Recreation demand models require information about recreational behavior and the natural resource base. In this study, three principal sources of data are used:

(1) Data on the natural resource base from the **National Resources Inventory**
- More than 800,000 locations sampled nationwide.
- Extensive land use information.
- Soil and land cover information.

(2) Water-quality model behavioral data from the **National Survey of Recreation and the Environment**
- Sampled 1,500 respondents in four dispersed regions of the United States.
- Focused on water-based recreation.
- Information on up to nine locations visited over the past year.

(3) Pheasant-hunting and wildlife-viewing model data from the **National Survey of Fishing, Hunting, and Wildlife-Associated Recreation**
- Extensive sample of more than 50,000 individuals nationwide.
- Sophisticated sampling and data collection techniques.
- Information on a wide variety of activities.

Source: USDA, ERS

the destination visited by each respondent. The only information pertaining to destinations is the State visited and the distance traveled.[4]

We used the 1992 National Resources Inventory (1992 NRI) to describe the natural resource base in all three studies. The 1992 NRI is the most recent of a series of inventories conducted every 5 years by the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS). The NRI contains information on the status, condition, and trends of land, soil, water and related resources on non-Federal land in the United States. The survey is scientifically designed and based on recognized statistical sampling methods.

To obtain a national sample of land use characteristics, NRCS samples more than 800,000 locations. Each datum, or point, represents a homogenous area of land. Because the location of these points is not available due to confidentiality restrictions, the point data are aggregated into larger areas which this analysis uses. These areas, termed "NRI polygons" are constructed by aggregating points found in 14,414 nonoverlapping subcounty regions formed by the intersection of county boundaries, NRCS Major Land Resource Areas, and USGS hydrological units in the continental United States.[5]

Freshwater-Based Recreation Results

The NRI, which describes the physical conditions where recreation occurs, contains information on erosion levels but not on pollutant loadings. In terms of the links between CRP acreage and economic benefits highlighted in figure 1 (pg. 11), only the information describing the physical effects of CRP acreage measured by soil erosion is available (Step 1). In the absence of detailed data describing how those physical effects impact the health of the ecosystem (Step 2) and ultimately affect consumer welfare (Step 3), it is assumed that erosion influences recreational behavior via unspecified biological and physical processes.

Models of lake- and river-based recreation were estimated from the regional NSRE data described in the preceding section. NRI polygons served as possible sites that recreationists might visit, and are described by average soil erosion and other physical data found

[4] An earlier version of the FHWAR contains slightly better information on destination location. Instead of identifying destination by State, a sub-State "wildlife management zone" was identified.

[5] The average size of an NRI polygon is 132,365 acres; with sizes ranging from 100 acres to over 3 million acres.

in the NRI (see Appendix A for details). The regional models were then transferred to the entire United States using benefit-transfer techniques. These techniques involve transferring the actual demand equation rather than a single point estimate as was done in earlier studies. Table 7 shows the total annual consumer surplus estimates. The combined benefits of all water-based recreation in lakes and rivers throughout the United States are slightly over $37 billion per year. Recreation occurring at lakes accounts for the majority of these benefits. This estimate of the value of water-based recreation is similar in magnitude to estimates by Carson and Mitchell (1993). They calculated that the annual benefits of achieving a "swimmable" water-quality goal at all water bodies in the United States range from $24 billion to $40 billion.

The CRP's contribution to these benefits is determined by calculating the difference in consumer surplus with and without the program. To predict consumer surplus without the program, subsequent erosion levels were predicted using the universal soil loss equation found in the NRI. These new erosion estimates were then used in the recreation demand model to predict consumer surplus without the CRP. The difference between consumer surplus levels with existing and no-CRP erosion rates appears in table 7. Again, the majority of the benefits are to lake-based recreation. The total annual contribution of CRP to all freshwater-based recreation is approximately $35.4 million. This estimate is of the same magnitude as Ribaudo's (1989) estimate of $21.4 million, but larger because Ribaudo considered only fishing whereas this model considers all freshwater recreation. Compared with the total consumer surplus estimates, the (1991) CRP's contribution to benefits of water-based recreation is small. Total benefits are highest in the South Eastern, Pacific/Mountain, and North Eastern regions. Both total CRP benefits and benefits per acre are highest in the South Eastern and North Eastern regions. This is not surprising since these regions contain a large portion of the U.S. population and a large number of surface-water recreation sites.

Pheasant-Hunting Recreation Results

Biological evidence indicates that the CRP mostly affects avian species (Allen, 1994). Ring-necked pheasants, in particular, have been shown to be influenced by use of agricultural lands and the presence of CRP lands (Basore and others, 1987; Hill, 1976; Jahn, 1988; Messick, and others, 1974, Minn. Dept of Natural Resources, 1985; Warner, 1979 and 1984; Warner and others, 1984). Furthermore, data from the 1991 FHWAR indicate that the pheasant is the most popular upland game bird throughout the Midwest. For these reasons, pheasant hunting, a component of small-game hunting, is presented as a species-specific special case.

Like the freshwater-based recreation model, an ideal pheasant-hunting demand model would contain a component linking biological activity with human behavior. Establishing a model linking CRP to pheasant popula-

Table 7—Freshwater-based recreation: Consumer surplus by region

Region[1]	Total consumer surplus[2]		Consumer surplus due to CRP[3]		Consumer surplus[4]
	Lake	River	Lake	River	
	Million dollars per year				*$/Acre/year*
Pacific/Mountain	7,423.93	1,004.65	1.27	0.42	0.21
Northern Plains	685.66	95.71	2.13	0.34	0.28
Southern Plains	2,628.66	353.49	1.34	0.13	0.29
South Eastern	6,743.19	1,364.27	8.90	1.87	2.93
North Eastern	14,524.97	2,570.00	17.33	2.61	2.45
Total	32,006.41	5,388.12	30.98	5.37	1.07

[1]The Pacific/Mountain region contains WA, OR, CA, MT, ID, WY, NV, UT, CO, AZ, NM; the Northern Plains region contains ND, SD, NB, KS; the Southern Plains region contains OK, TX; the South Eastern region contains AR, LA, MS, AL, GA, SC, FL, TN, NC, VA, KY, WV; the North Eastern region contains MN, WI, MI, IA, MO, IL, IN, OH, PA, NY, VT, MD, DE, NJ, RI, CT, MA, NH, ME.

[2]Annual consumer surplus evaluated at estimated erosion levels resulting from acres in the CRP in 1992 (signups 1-11). Lake and river refer to recreation occurring at lakes and rivers (respectively).

[3]This is the difference between total annual consumer surplus with CRP and the total without CRP. Erosion levels observed in 1982 were used in place of observed erosion in the latter case.

[4]Consumer surplus attributable to the CRP on a per acre basis.

Source: USDA, ERS.

tions, which actual and potential hunters value, would be desirable in this case. Unfortunately, the data required to accomplish this are not available. However, given the numerous studies documenting the improvements in pheasant habitat from CRP land, a reduced-form model such as was used in the water-based recreation demand case is defensible. In this study, it is assumed that hunters value pheasant populations, which are directly affected by availability of CRP land.

The model was estimated from the recreational data in the FHWAR and the environmental data from the NRI (see Appendix B for details). Because pheasant hunting is not significant across the Southern Plains and South Eastern regions of the United States, this study assumes that pheasant-hunting benefits in these areas are insignificant. Therefore, this study calculates no pheasant-hunting benefits in these regions.

Based on the population-weighting information (provided in the FHWAR survey), total consumer surplus associated with pheasant hunting is estimated to be $184 million annually (table 8). Dividing this total by the number of trips observed in the survey shows that the average value of a day spent pheasant hunting is approximately $23. This result is consistent with Walsh, Johnson, and McKean who found that, across the Nation, the value of hunting upland game birds averaged $27 per day.

To determine (the 1991) CRP's contribution to the benefits of pheasant hunting, the consumer surplus associated with pheasant hunting without the CRP must be predicted. The first step in doing this was to determine the agricultural land use patterns that would likely exist with no CRP. Following Osborn (1993), it was assumed that any areas with CRP land would have the land use observed when the 1982 NRI was conducted (which was before the CRP was implemented). The difference between the predicted consumer surplus without CRP and the previous estimate generates a consumer surplus of $80.3 million. Dividing the regional estimates by CRP acreage gives per acre benefits of $0.33 in the Pacific/Mountain region, $3.00 in the Northern Plains region, and $6.24 in the North Eastern region.

Comparing table 7 with table 8 indicates that, first, the total consumer surplus estimate for freshwater-based recreation is much larger than the total consumer surplus estimate for pheasant hunting. The popularity of freshwater-based recreation compared with pheasant hunting explains this. Freshwater-based recreation includes a wide range of activities involving a substantial proportion of the population across the United States. Pheasant hunting, on the other hand, is a single activity confined to a limited area. The results also indicate that the gain in consumer surplus associated with the CRP is larger for pheasant hunting than for freshwater-based recreation. This reflects the large impact the CRP has had on pheasant populations compared with the CRP's impact on freshwater quality. The CRP has had a tremendous positive impact on pheasant populations (Allen, 1994), which play a critical role in the hunting experience. The effect on water quality is less dramatic. This may explain why the

Table 8—Pheasant hunting: Consumer surplus levels by region

Region[1]	Total consumer surplus[2]	Consumer surplus due to CRP[3]	Consumer surplus[4]
	- - - - - - - - Million dollars per year	*- - - - - - - -*	*$/Acre/year*
Pacific/Mountain	6.50	2.70	0.33
Northern Plains	58.36	26.69	3.00
Southern Plains	N/A[5]	N/A[5]	N/A[5]
South Eastern	N/A[5]	N/A[5]	N/A[5]
North Eastern	118.85	50.86	6.24
Total	183.77	80.28	2.36

[1]The Pacific/Mountain region contains WA, OR, CA, MT, ID, WY, NV, UT, CO, AZ, NM; the Northern Plains region contains ND, SD, NB, KS; the Southern Plains region contains OK, TX; the South Eastern region contains AR, LA, MS, AL, GA, SC, FL, TN, NC, VA, KY, WV; the North Eastern region contains MN, WI, MI, IA, MO, IL, IN, OH, PA, NY, VT, MD, DE, NJ, RI, CT, MA, NH, ME.
[2]Annual consumer surplus evaluated at 1992 CRP levels.
[3]This is the difference between total annual consumer surplus with the CRP and total without the CRP.
[4]Consumer surplus attributable to the CRP on a per acre basis.
[5]Negligible pheasant hunting occurs in these regions.
Source: USDA, ERS.

CRP-induced benefits of pheasant hunting are so much larger than in the freshwater-based recreation case.

Wildlife-Viewing Results

Like the two preceding models, the impact of the CRP on nonconsumptive, wildlife-oriented recreation (wildlife viewing) would be best modeled in a multistep process, with changes in wildlife populations, induced by the CRP, influencing public participation. Again, the requisite biophysical models and behavioral data are not readily available. Hence, this study assumes that some relationship exists between land use and recreational trip taking.

In particular, a "representative trip" model is used. This model estimates the total number of trips taken to all locations as a function of indicators of landscape characteristics. These indicators, derived from NRI data, proxy for the size and health of wildlife populations (and other ecological attributes) at recreational sites that may be available to an individual. Specifically, measures of the level of CRP, cropland, forest land, grassland (range and pasture), urbanization, and landscape diversity are used.

As with the water-quality and pheasant models, a reduced-form model is used to control for variations in environmental characteristics. For each individual, five distance zones are constructed (see appendix figure 1 in Appendix B). For each of these distance zones, a weighted average of each of the several landscape characteristics is generated.[6] In addition to the zonal landscape characteristics variables, several personal characteristics were also included, such as sex, race, education level, and household income. Lastly, distance to most-visited site was used to construct a proxy for trip price.

The three models presented in this study illustrate different means of accounting for variations in the price and quality of recreational sites. The water-quality model uses explicit information on the location of visited sites while the pheasant-hunting model uses ancillary information on bird populations to impute the location of visited sites. The wildlife-viewing model uses data that contain neither explicit site information nor secondary information that can be used to impute a site choice. Therefore, a more complex econometric model using the observed data to proxy for site choice is needed.

To estimate welfare impacts, a benefits-transfer approach is used.[7] The predicted number of trips is multiplied by a per trip value obtained from a contingent valuation question included in the FHWAR survey. Further description of the model and a detailed discussion of results are included in Appendix C.

Table 9 shows the regional and national estimates of consumer surplus values. As with the pheasant-hunting model, the population-weighting information provided in the FHWAR survey is used to derive a change in consumer surplus due to the adoption of the CRP. The value of this change, $348 million for the entire Nation, is fairly close to the $380-million value realized by the NBS estimates of bird-watching.

The largest total benefit and benefit per acre is in the North Eastern region, followed by the Southern Plains, Northern Plains, and South Eastern regions. The model uses an anomalous negative benefit for wildlife viewing in the Pacific/Mountain region associated with the distribution of CRP acres. One possible explanation is that the Pacific region contains little CRP land in highly populated States (such as California) where intensive recreation occurs, and large amounts of CRP land in relatively unpopulated States (such as Montana and Wyoming). This results in the appearance that CRP is negatively correlated with recreational activity.

Discussion

The results of these three models indicate that CRP acres enrolled as of 1992 have had a beneficial effect on recreational activities. The largest effects are associated with increased wildlife-viewing recreation ($348 million), followed by pheasant hunting ($80 million), and freshwater recreation ($36 million). The effects on a per acre basis are similar in magnitude. The largest average per acre benefit is associated with wildlife viewing ($10.02), followed by pheasant hunting ($2.36) and freshwater-based recreation ($1.07).

[6] As described in Appendix C, to increase the flexibility of the model, the parameter used to compute the weighted average is an estimable parameter.

[7] The coefficient on the proxy price could have been used to directly estimate consumer surplus measures of the value of these trips. However, the price coefficient was not stable, resulting in coefficients with the incorrect sign in a few regions.

Table 9—Wildlife viewing: Consumer surplus levels by region

Region[1]	Total consumer surplus[2]	Consumer surplus due to CRP[3]	Consumer surplus[4]
	- - - - - - - - Million dollars per year	*- - - - - - - -*	*$/Acre/year*
Pacific/Mountain	1,385.31	-34.98	-4.27
Northern Plains	122.68	26.75	3.01
Southern Plains	315.25	62.35	12.14
South Eastern	1,260.52	4.89	1.33
North Eastern	3,616.74	288.70	35.44
Total	6,700.48	347.71	10.02

[1]The Pacific/Mountain region contains WA, OR, CA, MT, ID, WY, NV, UT, CO, AZ, NM; the Northern Plains region contains ND, SD, NB, KS; the Southern Plains region contains OK, TX; the South Eastern region contains AR, LA, MS, AL, GA, SC, FL, TN, NC, VA, KY, WV; the North Eastern region contains MN, WI, MI, IA, MO, IL, IN, OH, PA, NY, VT, MD, DE, NJ, RI, CT, MA, NH, ME.

[2]Annual consumer surplus evaluated at 1992 CRP levels.

[3]This is the difference between total annual consumer surplus with the CRP and total without the CRP.

[4]Consumer surplus attributable to the CRP on a per acre basis.

Source: USDA, ERS.

Although these models offer a number of improvements over prior research, they are subject to several criticisms. In particular:

- Instead of specifying the complete physical, biological, and behavioral relationships between land retirement, environmental quality, and recreational nonmarket benefits, these models use a less desirable dependence upon environmental indicators. This reduced-form approach is adopted due to both a lack of knowledge about how these interactions occur and a lack of data required to represent them. This problem is not uncommon in the valuation literature and is likely to continue until comprehensive physical and biological models are available.

- The lack of exact destination location information in the FHWAR hindered further refinement of the wildlife-viewing and pheasant-hunting models. In nonmarket valuation models, recreational trips are assumed to be associated with the environmental quality of the destination. Imprecise knowledge of the location and environmental characteristics of destinations will thereby lessen the precision of the estimates.

- Although not unique to the problem of valuing the CRP, it can be difficult to separate the demand for CRP-influenced recreation from the demand for other goods. For example, it is assumed that freshwater trips were solely for recreation, hence the cost of a trip can be attributed to the recreation experience. The models do not separate other enjoyable activities aside from recreation that may occur on a trip. This is a common drawback found in most nonmarket valuation models.

Despite these problems, the models basically succeed in identifying plausible relationships between land use and recreational values based on observed behavior. Additionally, the flexibility of the models offers the advantage of improved accuracy. Being based on behavioral and biophysical micro-data, one can apply the models' results to new scenarios relatively easily. Thus, the impacts of changes in targeting mechanisms can be potentially quantified by carefully applying the models' results.

We note that the per acre magnitude of these benefits (~$13 per acre) is smaller than the average CRP rental rate (~$50 per acre). Of course, these benefits are only a subset of the positive impacts of the CRP; hence they should not be used as a justification (or critique) of program funding. In fact, the major use of these findings is to provide a baseline for an analysis of a simulated targeting mechanism conducted in the next chapter.

Applications of Nonmarket Valuation in Land Use Policy

The results shown in the preceding chapter are useful as components of a benefit-cost economic evaluation of the program (see Box 8). In addition, the models that generate these results can be used to compare alternatives. Comparing alternative programs can be accomplished by comparing the potential benefits generated by each program. Of particular interest is the comparison of different mechanisms for targeting land retirement. Here, nonmarket valuation models can be used to suggest where to retire land in order to achieve greater recreational benefits.

Environmental targeting mechanisms are currently used to select CRP acreage. This selection process is based on an "environmental benefits index" (EBI). The EBI translates several measures of environmental quality into a single number that allows analysts to compare different parcels of land with each other, even if they have differing characteristics. Constructing an EBI involves weighting primary physical characteristics that describe the land offered for enrollment (Osborn, 1997). Relative weights are chosen to give equal consideration to the three primary components of the EBI: wildlife, water quality, and soil erosion, with lesser weights given to the remaining environmental components.[8]

The 1990 Farm Bill reauthorized the CRP when the bulk of the CRP lands were already in place. Previous acreage selection had been based primarily on erosion and erosion potential, but USDA sought to increase the benefits of land retirement by considering additional factors. As a result, a more comprehensive environmental targeting mechanism (which considers more than erosion) is currently used to select CRP acreage.

Beginning in 1991, bids were ranked using an EBI.[9] A recent version of the EBI, which was used for the 15th signup (March 1997), included six categories of environmental characteristics and a cost factor. (Appendix D describes the criteria used for the 15th CRP signup.)

The EBI for the 15th signup weighted the wildlife, water-quality, and soil erodibility factors equally. Lesser weight was given to factors for 15-year tree, shrub, and wetland retention; air quality; and conservation priority areas. The water-quality and wildlife EBI components were composed of several subfactors that comprised the total weight for that category. In addition, a cost factor accounted for approximately one-third of the total maximum score.

Analysts currently use an EBI that is similar, but not identical, to the 15th signup EBI, to classify and rank land offered for enrollment in the CRP during a general signup.[10] With each signup, applicants submit offers and the EBI scores each submission based on its characteristics.[11] Submissions are then ranked nationally by EBI score, and the highest ranked submissions are accepted. Particularly environmentally sensitive lands, such as riparian areas, may be accepted outside of general signup periods through a continuous signup.

The Relative Benefits of the EBI Targeting

To examine the benefits resulting from retiring lands using an EBI as an environmental targeting mechanism, we generated a simulated distribution of CRP acreage based on the 15th signup EBI. This simulated CRP was constructed by calculating 15th signup scores for 1992 National Resource Inventory (NRI) points. NRI points with the highest EBI scores were then "selected" for a hypothetical 34-million-acre CRP (Osborn, 1993). The hypothetical selection was limited to NRI records that were considered eligible and likely to bid, based on partial budgeting and certain land uses (i.e., irrigated land was considered unlikely to bid since CRP rental rates are dry-land rates, which are generally lower than irrigated-land rental rates). To retain comparability with the analysis

[8]An EBI score consists of the summation of several factor and subfactor scores. Therefore, the range of scores that may be granted (to a given factor) can be interpreted as an implicit weight. For example, if factor A is assigned a score between 0 and 10, and factor B is assigned a score between 0 and 100, then factor B has a 10 times larger "implicit" weight then factor A.

[9]Bids with acceptable rents employing certain practices (e.g., filter strips, grass waterways, windbreaks, etc.) were accepted without the EBI stage.

[10]For example, following the 15th signup a number of refinements were made to the EBI's treatment of environmental inputs.

[11]Actually, there is potential for some within-State flexibility—although the total acreage awarded to a State is based on this "national" EBI, a State-specific EBI can be used to reallocate this total to different acres if the State is approved prior to signup.

Box 8—Three Uses of Nonmarket Valuation Models in Land-Use Programs

The nonmarket benefits attributable to changes in land use are sensitive to where the changes occur. Retiring equal amounts of cropland in two different areas will likely result in different benefits. This difference, which can be significant, depends on factors such as the characteristics of the surrounding population and the environmental quality of the retired lands. Models that recognize these factors can help explain why the benefits vary.

Three potential uses of nonmarket valuation models in the analysis of land-use policy are:

1. **Program Evaluation:** Every land use program generates benefits and costs. Often, programs are required to be evaluated using benefit-cost analysis. Nonmarket valuation models provide a means of incorporating benefit estimates for otherwise unmeasurable impacts.

2. **Program Selection:** In cases where several programs, or variations of the same program, compete for funding, these models can aid in the decision of which variation or program to implement.

3. **Acreage Selection (targeting):** The benefits of a change in land use are location specific. Nonmarket valuation models can be used to identify where the largest benefits would occur. This information could be used to improve the implementation and administration of a land-use program.

Source: USDA, ERS.

of the 1992 CRP, a 34-million-acre limit was maintained, and the constraint that CRP acreage could not exceed 25 percent of the cropland in any county was imposed.[12]

The subsequent redistribution of CRP lands resulted in a slight decrease in acreage in three regions, and increases in the North Eastern and South Eastern regions (table 10). Using this new distribution of CRP acreage, we used the previously described models to calculate the associated environmental benefits.

Table 11 lists the changes in benefits, with a breakdown by region and by activity. For each activity, the table reports the additional benefit that would be realized if a 34-million-acre CRP were selected using the 15th signup EBI, as compared with the 1992 distribution of CRP acres.

The average benefit per acre differs across regions (table 12). On average, retiring lands in the North Eastern and South Eastern regions produces more benefits (from the three activities we examined) than retiring lands in other regions. This may indicate that further increasing land retirement in these areas would increase the overall benefits of the CRP.

In general, the 15th signup EBI criteria increase freshwater-based recreation and wildlife-viewing benefits, and decrease pheasant-hunting benefits compared with CRP acreage accepted prior to 1992. Summarizing the results:

- Large increases in benefits result in all regions for freshwater-based recreation and wildlife viewing. Total water-based recreation benefits attributable to the CRP increase from $36.35 million to $128.97 million, a difference of $92.62 million (a 255-percent increase).

- The benefits of wildlife viewing increase significantly. The contribution of the CRP to the value of this activity increases from $347.71 million to $634.99 million, a difference of $287.28 million (an 83-percent increase).

[12] Another reasonable constraint would be to construct a simulated CRP with the same cost as the actual (1992) CRP. However, constructing a simulation with the same acreage allows the models to focus on how benefits change. CRP's legislative constraint is acreage, not total dollars spent.

Table 10—Comparison of baseline and hypothetical CRP distributions

Region	1992 baseline CRP	Hypothetical CRP
	Million acres	
Pacific/Mountain	8.196	7.966
Northern Plains	8.884	7.999
Southern Plains	5.136	4.975
South Eastern	3.678	4.290
North Eastern	8.146	8.810
Total	34.040	34.040

Source: USDA, ERS.

Table 11—Changes in benefits resulting from a hypothetical redistribution of the CRP[1]

Region[2]	Freshwater-based recreation[3]	Pheasant hunting	Wildlife viewing
		Million dollars per year	
Pacific/Mountain	2.61	-0.19	38.76
Northern Plains	5.76	-4.07	0.20
Southern Plains	2.45	N/A[4]	52.67
South Eastern	22.08	N/A[4]	143.32
North Eastern	59.72	-5.78	52.51
Total	92.62	-10.05	287.28

[1]Change in consumer surplus, in millions of dollars: the consumer surplus under the hypothetical 34-million-acre CRP distribution using the 15th EBI minus the consumer surplus under the baseline CRP.

[2]The Pacific/Mountain region contains WA, OR, CA, MT, ID, WY, NV, UT, CO, AZ, NM; the Northern Plains region contains ND, SD, NB, KS; the Southern Plains region contains OK, TX; the South Eastern region contains AR, LA, MS, AL, GA, SC, FL, TN, NC, VA, KY, WV; the North Eastern region contains MN, WI, MI, IA, MO, IL, IN, OH, PA, NY, VT, MD, DE, NJ, RI, CT, MA, NH, ME.

[3]Sum of lake recreation and river recreation benefits.

[4]Limited pheasant hunting occurs in these regions.

Source: USDA, ERS.

Table 12—Benefits per acre resulting from a hypothetical redistribution of the CRP[1]

Region[2]	Freshwater-based recreation[3]	Pheasant hunting	Wildlife viewing
		Dollars/acre/year	
Pacific/Mountain	0.54	0.31	0.47
Northern Plains	1.02	2.83	3.35
Southern Plains	0.79	N/A[4]	23.12
South Eastern	7.63	N/A[4]	34.55
North Eastern	9.04	5.12	38.73
Total average	3.79	2.06	18.65

[1]Average consumer surplus per acre of CRP under the hypothetical 34-million acre CRP distribution using the 15th EBI. Calculated as the consumer surplus under the hypothetical minus the consumer surplus in the absence of the CRP, divided by the hypothetical CRP acreage. These are the per acre benefits if a 34-million-acre CRP were distributed using the 15th EBI signup criterion.

[2]The Pacific/Mountain region contains WA, OR, CA, MT, ID, WY, NV, UT, CO, AZ, NM; the Northern Plains region contains ND, SD, NB, KS; the Southern Plains region contains OK, TX; the South Eastern region contains AR, LA, MS, AL, GA, SC, FL, TN, NC, VA, KY, WV; the North Eastern region contains MN, WI, MI, IA, MO, IL, IN, OH, PA, NY, VT, MD, DE, NJ, RI, CT, MA, NH, ME.

[3]Sum of lake recreation and river recreation benefits.

[4]Limited pheasant hunting occurs in these regions.

Source: USDA, ERS.

- Pheasant-hunting benefits decline modestly. Total benefits attributed to the CRP decline from $80.27 million to $70.23 million, a difference of $10.05 million (a 13-percent decrease).

The benefits analyzed here are not comprehensive. However, this examination of several nonmarket effects indicates that a multi-objective EBI used as a targeting mechanism (rather than criteria based primarily on erodibility) can increase CRP's environmental benefits. The next section explores how targeting can be further refined using nonmarket valuation models.

The Impacts of Population

Improving the environment near heavily populated areas results in more recreational benefits than the same change in a sparsely populated area. Comparing the benefits of a CRP based primarily on erosion criteria (the 1992 34-million-acre CRP) with the hypothetical CRP distribution based on the 15th signup EBI demonstrates this.

The 15th signup EBI includes population as part of the surface-water, ground-water, and air-quality benefits. Table 13 shows that including population moves CRP lands from less populous regions to more populous regions, leading to large increases in benefits. Even regions that lost total CRP acreage had some increase in benefits, a result likely due to CRP land being moved to more populous areas within the region.[13]

Figures 2-4 further illustrate the impact of population. Figure 2 shows the distribution of water-quality benefits resulting from the observed (1992) CRP. The benefits appear most concentrated in the North Eastern and South Eastern regions. Comparing this map with the distribution of CRP lands, shown in figure 3 and in table 10, indicates that most of the benefits do not coincide with the location of the CRP. The majority of the CRP acreage lies outside of these two regions. The distribution of the U.S. population, shown in figure 4, explains this phenomenon. Areas that have both CRP acreage and dense populations coincide with the high-benefit areas shown in figure 2. Considering population when choosing the size of weights in an EBI is likely to improve recreational benefits.[14]

Using Economic Techniques To Improve Environmental Targeting

Development of an optimal environmental benefits index requires a sound basis for determining the weights applied to each of the many benefits produced

[13]See appendix table 5 in Appendix C for further evidence on the net "movement of CRP toward population centers."

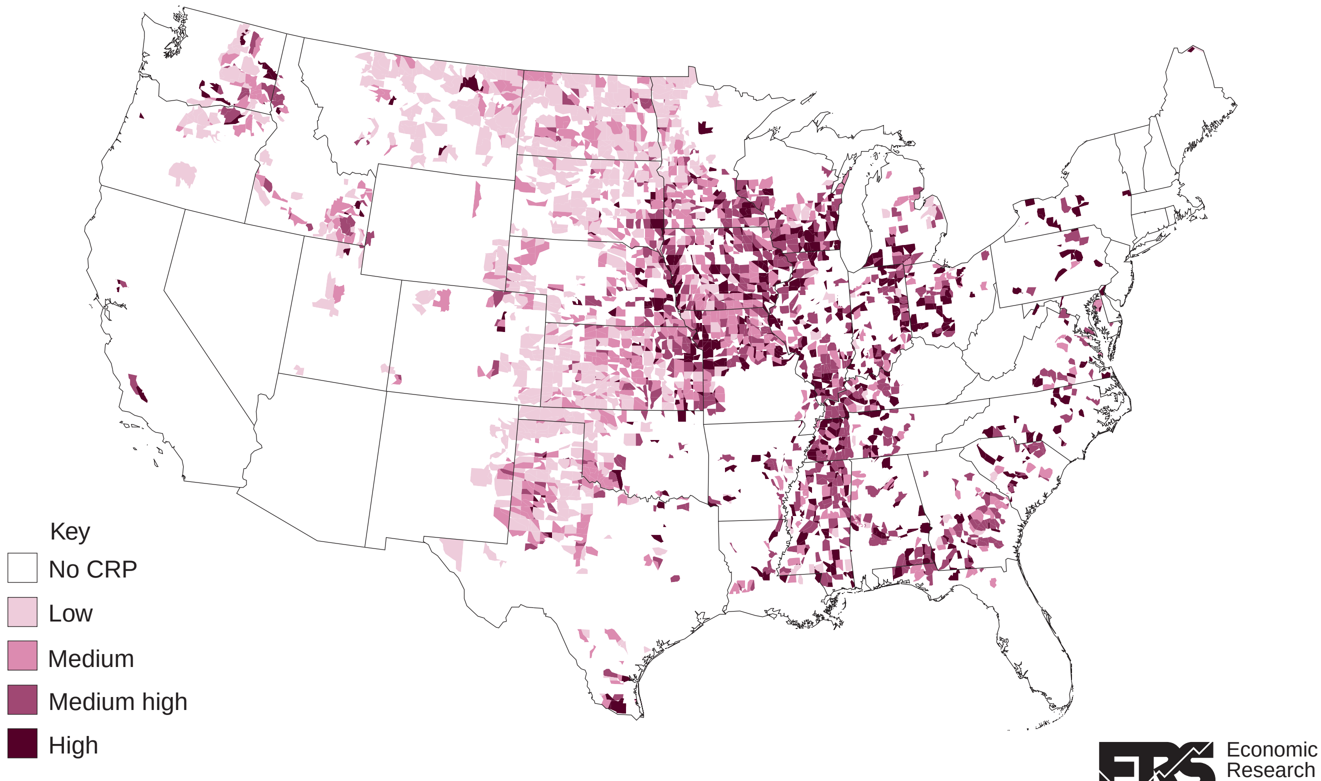
[14]Moving CRP land may increase average rental rates, have impacts on commodity production, or have other environmental impacts. Any of these may reduce net benefits.

Table 13—Results of a redistribution of the CRP[1]

Region[2]	Change in acres[3]	Total change in benefits[4]	Population[5]
	Million acres	*$ Million/year*	*Million persons*
Pacific/Mountain	-0.230	41.18	51
Northern Plains	-0.790	1.89	5
Southern Plains	-0.161	55.12	20
South Eastern	0.612	165.40	59
North Eastern	0.664	369.85	111

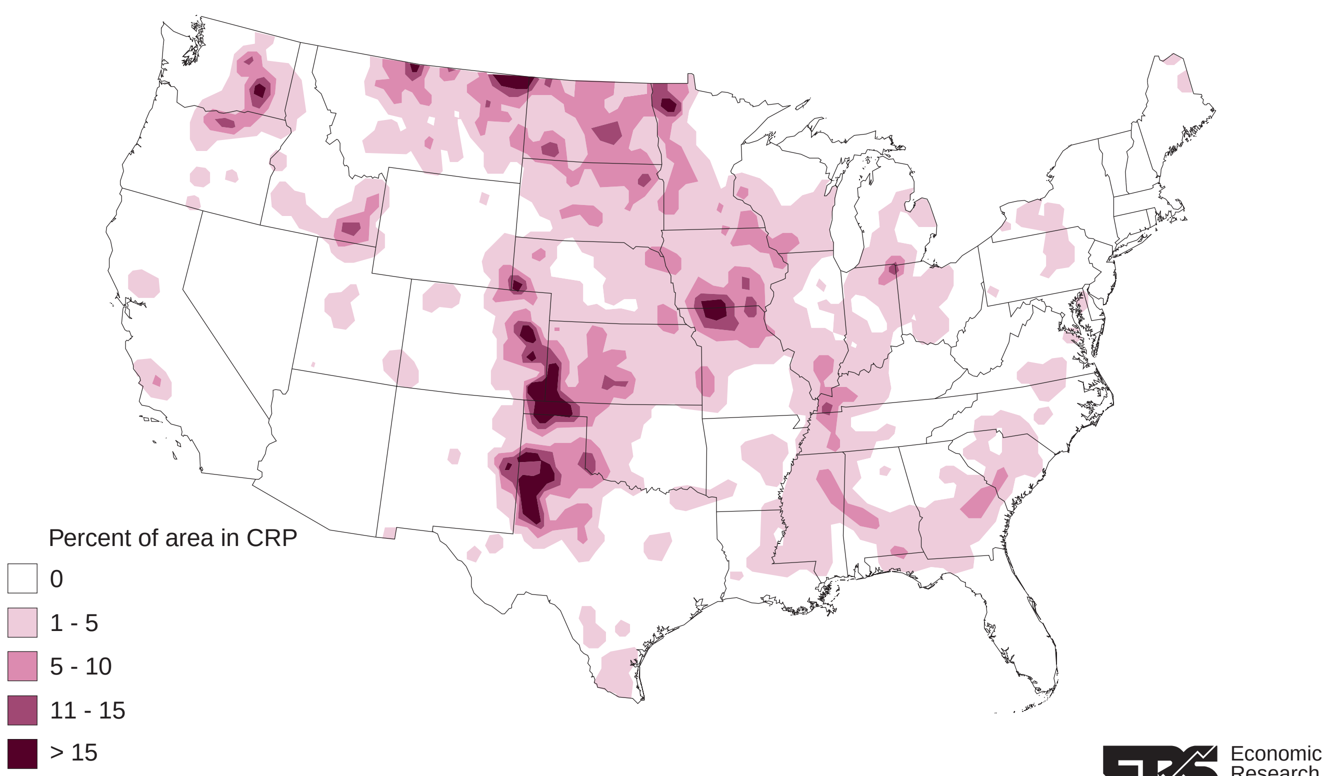
[1]Comparison of the baseline CRP and the hypothetical CRP generated based on the 15th signup EBI.
[2]The Pacific/Mountain region contains WA, OR, CA, MT, ID, WY, NV, UT, CO, AZ, NM; the Northern Plains region contains ND, SD, NB, KS; the Southern Plains region contains OK, TX; the South Eastern region contains AR, LA, MS, AL, GA, SC, FL, TN, NC, VA, KY, WV; the North Eastern region contains MN, WI, MI, IA, MO, IL, IN, OH, PA, NY, VT, MD, DE, NJ, RI, CT, MA, NH, ME.
[3]Hypothetical CRP acres less actual CRP acres in million-acre units.
[4]Benefits from the hypothetical CRP distribution less benefits from the actual CRP distribution in million dollars.
[5]Population in millions of persons.
Source: USDA, ERS.

Figure 2
Average water-quality benefits from 1992 CRP by NRI polygon



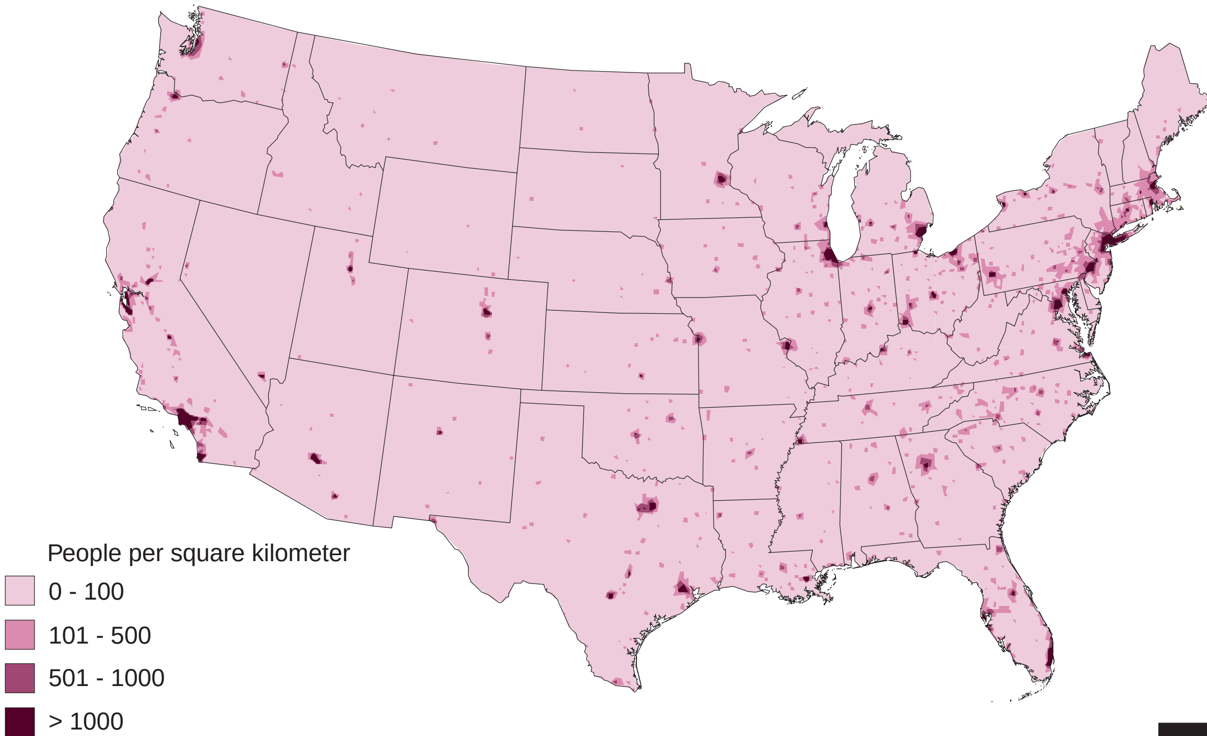
Source: USDA, ERS, based on NRCS 1992 National Resources Inventory data.

Figure 3
Percent CRP lands, 1992



Source: USDA, ERS, based on NRCS 1992 National Resources Inventory data.

Figure 4
U.S. population density, 1992



Source: USDA, ERS, based on data from the 1990 Census of Population.

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by the environment. Monetary valuation techniques of nonmarket goods and services, which have been developed expressly to compare what would otherwise be disparate impacts and consequences, is one such basis. These economic techniques offer several advantages, including objectivity, standardization of measurement, and cost effectiveness:

- **Objectivity:** Policy prescriptions are formulated in a scientific fashion. Replicability, empirical corroboration, and transparency of design serve to minimize political and other biases.

- **Standardization of measurement:** The dollar-valued estimates, which are derived from observations on individuals' choices, provide a clear measure of the strength of people's preferences. With these measures, comparison of an array of program effects is a straightforward financial exercise.

- **Cost effectiveness:** Economic models are designed to answer what-if questions. Mathematical optimization techniques, when applied to economic models, can automate the process of maximizing program benefits relative to program size (where the size, as defined by acreage or dollars, may be predetermined).

In short, using economic techniques to accomplish environmental targeting involves replacing indirect proxies (such as the EBI) with a direct procedure that uses economic models, along with biophysical information, to determine where the net benefits of land retirement are largest, and retire those lands first.

A Direct Procedure

The direct procedure employs a comprehensive measure of the environmental goods and services relevant to individuals, and models how these goods and services influence their behavior. This direct procedure, or *CRP Valuation Function*, incorporates two classes of models:

(1) Biophysical models generate measures of environmental goods and services as functions of land use patterns.

(2) Economic models take this bundle (of environmental goods and services) and return a net benefit expressed in dollar terms.

Roughly speaking, a direct *CRP Valuation Function* might consist of models similar to those presented in this analysis, but would account for a broader array of environmental goods and services and would use more accurate measures of biophysical impacts and behavioral responses to these impacts.

For targeting purposes (that is, for ranking candidate CRP acreage from greatest to least net benefit), a direct *CRP Valuation Function* would generate a schedule of the benefits of potential CRP acres (see Box 9 for an outline of how this could be done). Such a schedule could be used as a basis for optimal environmental targeting. At its simplest, the acres with the highest values (or highest relative to cost) would be chosen.

Box 9—Using Economic Valuation Models To Rank CRP Acres

An Example of a *CRP Valuation Function*:

Assuming the requisite biophysical and economic models are available, a multi-step process could be used to rank candidate CRP acres:

1) Compute a baseline net benefit, using the current distribution of rural land uses.
2) Generate a new total value by enrolling a single candidate acre into the CRP.
3) The value of entering this candidate acre into the CRP is computed as the difference between the baseline and new values.
   Note that one could test a given acre under several different management regimes (that is, under different cover mixes).
4) Obtain a schedule of values by repeating this three-step process for all fields offered in CRP bids.
   Due to non-linearities in the valuation function, the value of a given acre will often depend on how many other nearby acres are in the CRP. To account for this may require updating the baseline as one repeats the first three steps.

An Example of a Simulation Approach:

Valuation models can be used to aid the development of an EBI. In particular, a set of simulations can be used to compare alternative EBI's, and to suggest improvements in factors and subfactors, specifications, and weights. Much like the analysis on pages 20-22, this approach relies on generating several hypothetical CRP distributions from differing factor weights and then computing the benefits. The following outlines the necessary steps:

(1) Use existing data to estimate a baseline model (such as presented in chapter two) that links environmental characteristics to amenity values.
(2) For each of candidate EBI's, generate a simulated CRP. This requires knowledge of how the EBI scores of enrollable acres change as weight factors (scoring criteria) change. In general, acres with the highest (simulated) scores are assigned to the (simulated) CRP.
(3) Using this simulated CRP, generate a new distribution of *environmental characteristics*. For example, generate new values for a "county-level %CRP" variable for use in a reduced-form model.
(4) Using these the new *environmental characteristics*, and the parameters generated in step 1, compute a set of net benefit numbers.

Each iteration of the above produces a set of net benefit numbers, which can be added up to generate a value that is a function of the scoring criteria used in the candidate EBI. Using a broad set of candidate EBI's (with each EBI in this set characterized by its own set of scores), a "surface of values" can be generated. This surface can be used for several purposes: such as quickly comparing alternative EBI's, or for evaluating the effect that changes in a factor score will have on net benefits.

Source: USDA, ERS.

The direct CRP valuation function requires sophisticated biophysical models and exhaustive valuation models. Although simplifications to this process that retain most of the accuracy are possible,[15] constructing a direct *CRP Valuation Function* is a demanding task. The size of the problem is illustrated in table 14, which lists all existing CRP-related national valuation studies, organized around the factors of the 15th signup EBI. In many cases, and especially for environmental characteristics with nonuse values, there are no estimates of the benefits, or the estimates that are available are ill-suited for use as inputs into the design of an environmental targeting mechanism.

A Practical Approach

Given these difficulties, it is worth considering simpler mechanisms. In particular, economic models can help to construct an EBI that may provide more nonmarket benefits. As illustrated in table 15, EBI's and economic valuation models have many similarities. An EBI expresses the value of landscape variation as changes in the factor and subfactor scores. Economic models focus on how individuals value the change in the quality of environmental amenities. Thus, to quantify the relationship between an EBI and environmental amenities, a means of linking measures of resource quality (used in the valuation models) and factor and subfactor scores (used in the EBI) is required.

For example, a simulation approach can be used to link economic models to a spectrum of possible EBI's. The goal is to capture the effects of changes in the landscape due to alternative EBI's. As detailed in Box 9, this approach is an expansion of the methodology used in this analysis. Simple rules applied to small-scale data (such as NRI records) are used to simulate a land-use distribution under a proposed EBI; reduced-form models are then used to compute the recreational benefits of this simulated land-use distribution. Repeated over many different EBI's, the effects of changes in factor scores (in terms of changes in the value of recreational benefits) can be observed.

In summary, whether the construction of a comprehensive direct procedure is the goal, or if one tackles the more modest task of using valuation models to improve an EBI, the need for accurate and complete measures of amenity values is essential. The next chapter discusses in greater detail these deficiencies and the research directions they imply.

[15]For example, a literal implementation of the process described in Box 9 requires solving a *CRP Valuation Function* separately for each of the millions of potential CRP acres. This can be simplified by using a set of representative acres, in conjunction with weights measuring their geographic extent.

Table 14—CRP benefits within each EBI factor[1]

EBI factor and associated benefits	Estimates in the literature	Value	Maximum EBI
		$ million/year	*Factor score*
Wildlife: Use value			
Small-game hunting[2]	Young and Osborn (1990)	443.8	
Waterfowl hunting	John (1993)	175.2	
Wildlife viewing	John (1994)	382.8	
	This analysis	347.0	
Pheasant hunting	This analysis	80.0	
Big-game hunting	None	Unknown	
Wildlife: Non-use value	None	Unknown	100
Water quality: Use value			
Sport fishing[2]	Ribaudo (1989)	21.4	
Freshwater-based recreation	This analysis	39.6	
Saltwater-based recreation	None	Unknown	
Ground-water quality	None	Unknown	
Water quality: Non-use value	None	Unknown	100
Erosion: Use value			
Soil productivity[2]	Young and Osborn (1990)	227.5	
Ditch maintenance, municipal, and industrial uses	Ribaudo (1989)	125.1	
Water storage, navigation, and flooding	Ribaudo (1989)	122.2	
Erosion: Non-use value	None	Unknown	100
Air quality: Use value			
Health/cleaning costs[2]	Ribaudo and others (1990)	51.1	
Cleaning costs	Hughes (1994)[3]	0.1	
	Sperow (1994)[4]	1.8	
Carbon sequestering	Parks and Hardie (1996)	--[5]	
Air quality: Non-use value	None	Unknown	25
Long term retention of trees, shrubs and wetlands	None	Unknown	50
Conservation priority	None	Unknown	25

[1]Estimates for benefits associated with 15th signup factors and scores. Dollar estimates are at the national level unless otherwise noted.
[2]In some cases, the original data was discounted over a longer time period. When this occurred, the figures were re-computed to reflect annual measures.
[3]For Colorado only.
[4]For New Mexico only.
[5]A rough net present value estimate of $65 billion is based on all CRP acreage being planted to forests.
Source: USDA, ERS.

Table 15—Similarities between the EBI and valuation models

EBI	Valuation models
Points are assigned to environmental categories, which are specified as factors and subfactors (see Appendix D). These points may vary in different parts of the country.	Biophysical factors (or indirect measures of these biophysical factors) are used to model the quantity of environmental amenities.
Land characteristics, as measured using the factors and subfactors, determine the points given a potential CRP acre.	Land characteristics, as measured by the independent variables included in valuation models, directly influence the net benefit of a potential CRP acre.[1]
Acres with highest points, after factoring in costs, are chosen.	Acres with highest dollar value, after accounting for costs, are chosen.

[1]For example, the points assigned to a landscape characteristic could be derived from its “marginal product:” the change in the quantity of an environmental amenity given a change in the level of environmental characteristics, multiplied by the unit value of the amenity.
Source: USDA, ERS.

Future Research Directions

As the Nation's largest user of land and water resources, agriculture significantly affects the natural environment. The Conservation Reserve Program is one of the more important mechanisms for mitigating the negative effects. The Federal Agriculture Improvement and Reform Act of 1996 (FAIR) encourages the USDA to use the program to achieve the greatest environmental benefits relative to costs. Targeting the program will be important to its future success.

This report describes how one can use natural resource valuation models, which are driven by observable public preferences, to select those program acres that maximize environmental benefits relative to cost. Using economics in environmental targeting requires an understanding of the extent to which non-market activities are sensitive to the location of CRP lands. The models developed here illustrate how "state of the art" models allow one to compute sub-county-level estimates of environmental benefits, both under current and alternative distributions of the CRP. With results at this level of geographic disaggregation, dollar-valued measures of the impacts of variations in targeting mechanisms (such as changes in an EBI) can be constructed, helping to shed light on critical environmental attributes.

This report focuses on three activities that the CRP affects: freshwater-based recreation, wildlife viewing, and pheasant hunting. Using currently available bio-physical and economic data, we created several non-market valuation models that estimated how the net benefit (as measured by consumer surplus) of these activities is influenced by the current (circa 1992) CRP. We also used these models to investigate the environmental benefits of a simulated 34-million acre CRP generated from a recently employed EBI.

Although benefit estimates are not comprehensive, the output from these models provides several insights, including:

- The benefits associated with targeting CRP lands using a multi-objective EBI are substantially higher than those associated with targeting CRP lands using eligibility criteria based on erosion, as was done in early CRP signups.

- The CRP produces significantly larger benefits for wildlife viewing ($348 million per year) and for pheasant hunting ($80 million per year), than for freshwater-based recreation ($36 million per year). This difference is observed under both the "erosion" and "15th EBI signup" criteria.

- Natural resources that are near populated areas generate large benefits simply because more people can easily enjoy the resources. By favoring acres that generate positive impacts for more people, explicitly taking affected population into account when targeting CRP lands would increase the benefits of several types of outdoor recreation.

Our results suggest that it is feasible to develop a targeting system based on economic valuation models. However, to fully implement economic targeting of the CRP, research efforts are needed to (1) increase the number of environmental benefits that are evaluated; and (2) improve technical/theoretical approaches used to estimate the benefit models. Priorities in each of these areas are discussed below. Furthermore, some expected advances outside of economics and their importance to benefit estimation are also discussed to suggest additional directions that economic analyses may continue to improve.

Priorities in Environmental Benefits Related to Agriculture

To evaluate the CRP comprehensively, a number of improvements in available data, in modeling physical and economic relationships, and in statistical modeling are necessary.

What is needed:

- Obtain better and more complete survey data to determine all the benefits the CRP offers.

- Fully understand the impacts of the EBI.

- Incorporate new environmental goods and services into the EBI.

- Refine the estimated relationships between physical land characteristics and human well-being through advances in statistical and economic estimation techniques.

In addition, expanding the noneconomic knowledge base, as regarding how to measure and predict environmental changes as land-use policies change, can be expected to open new opportunities.

Other Environmental Benefits Recognized by the EBI

The EBI used in the 15th signup contains numerous factors that account for a range of environmental goods and services. Comprehensive analysis of the efficacy of the EBI requires some accounting for these goods and services. These include:

Wildlife. The wildlife models of this report did not incorporate a number of potentially important environmental goods and services, including:

- Other upland game species, such as quail and grouse. A derivative of the pheasant model, augmented by population estimates of these species, could be used to analyze these issues.

- Large game, such as deer and elk. A model fashioned after the wildlife-viewing model was estimated for large-game hunting, with inconclusive results. Future improvements, especially regarding resource availability and site choice, are required.

- Waterfowl hunting and viewing. Waterfowl impacts of CRP are geographically dispersed, and are ill-suited to the "local impact" analysis used in this report. A proper analysis requires construction of models that generate changes in waterfowl populations at sites throughout the Nation as the distribution of CRP changes (nationwide).

- The effect of trees on wildlife. Although the wildlife models include forest land variables, a better gauge should be developed that more closely links forest qualities to wildlife densities.

- Threatened and endangered species. Analysis of threatened and endangered species requires consideration of nonuse values, such as existence, option, and bequest values (Boyle and Bishop, 1987; Loomis and White, 1996).

- The effect of establishing native grass mixes on lands.

Ground-water quality. Ground-water quality does not directly affect recreational opportunities; however, it does have impacts (such as bequest values) that may be best quantified with nonmarket valuation techniques (Crutchfield, Cooper, and Hellerstein, 1997) or avoidance costs (Nielsen and Lee, 1987).

Long-term soil productivity. Standard economic theory suggests that long-term productivity impacts should be captured in land prices. However, differences between social and private discount rates (due to factors such as taxes or borrowing constraints), and the tendency of single producers to overlook widespread productivity losses when making production decisions, may lead to sub-optimal levels of soil protection. Public intervention may be justified to correct these problems (Boadway, 1979).

Wind erosion. To measure the benefit of reductions in wind erosion, better models of the geographic distribution of changes in air quality, given changes in land uses, are required. There is some promise that estimates from traditional air-quality models can be used (Huszar and Piper, 1986).

Priority areas. Conservation priority areas represent regions that are likely to have special features that yield extra benefits. Specifying and estimating nonmarket demands for these features allows the use of their values (rather than a "regional" correction).

Other water-quality benefits. Additional water-quality impacts may be substantial, including impacts to bays and estuaries, effects of coastal sediments on private and public water uses, and impacts of erosion on public works (such as dams and reservoirs).

Climate change. Significant organic matter buildup on CRP lands can sequester atmospheric carbon dioxide.

Environmental Benefits Not Recognized by the EBI

The EBI includes factors that are presumed to directly impact a number of environmental goods and services. However, many of these environmental goods and services were not considered when developing the EBI. In particular, scenic and existence values of rural landscapes were not considered.

The landscape variation imparted by the CRP may positively affect the scenic values of rural landscapes. This may be significant, especially in urbanized environments. Measuring such impacts is largely unexplored in the United States, though work in farmland preservation (and European work on cultural amenities) may be applicable.

Existence values of wildlife species, as impacted by the CRP, may also be quite large. Given that existence values may be held by a significant fraction of the U.S. population, even small, per individual values can yield large aggregate benefits. For example, the abundance of a variety of nongame birds is likely to have been increased by the CRP. Although some of these species may be enjoyed by bird watchers, it is possible that many people will value the fact that the environment is more conducive to avian species in general. In fact, there is evidence (Hagler Bailley, 1997) that many individuals hold non-negligible values for this "existence" value.

Improving the Technical and Theoretical Approaches

Technical advances in both behavior modeling and empirical approaches have been critical in allowing current research to provide more location-specific benefit estimates. Although research advances have resulted from agency efforts (Feather, Hellerstein, and Tomasi, 1997; and Hellerstein, 1992), advances have also been based on work outside of USDA/ERS.

The 1996 FHWAR survey will provide an immediate improvement in estimating benefits. This survey contains information that will improve the identification of sites visited by individuals. Since the location of a visited site underlies our measures of environmental characteristics consumed by a recreator, this will improve our modeling capability—both in terms of precision and scope. New sources of data will need to continue to address this need for precise geographic specificity. For example, due to the lack of precise information about site choice, longer trips were not analyzed (in either the water-quality or the wildlife models). Although longer trips do not comprise the bulk of trips taken, they may represent particularly high-valued trips. With better information on the location of long trips (as provided by the 1996 FHWAR), analysis of longer trips becomes feasible.

Expected Advances Outside the Area of Economics

Advances outside the area of economics are expected to provide a much-improved measure of the physical/environmental impacts of changes in agricultural land use. Improved computer capabilities will facilitate complex analyses of very large data sets. This includes applying improved geographic information systems (GIS) models to refine measures of environmental amenities.

This report uses environmental indicators instead of direct measures of biophysical impacts. The current indicators, while useful, are fairly simple. We expect richer sources of indicators to continue to develop, especially as GIS tools mature. In addition, research outside of economics is expected to continue to provide better models of environmental characteristics, such as how water quality and wildlife populations respond to changes in the CRP.

The Future of Environmental Targeting

Environmental targeting, as mediated through mechanisms like the Environmental Benefits Index, will always be a dynamic process. This report, which focuses on the use of the EBI to allocate CRP lands, illustrates the potential of economic analysis to provide objective assessments based on observable data. Based on the results in this report, we believe that economic valuation methods can contribute to the development of more refined targeting measures.

Further research will provide more comprehensive measures of the value of the CRP's environmental impacts. Better measures of biophysical responses are expected, and can affect direct measures of value (such as changes in recreational behavior due to CRP-induced changes in wildlife populations) and indirect measures (such as the existence value of rural wildlife that the CRP may augment).

Many of the prerequisites for future research are in place. Data that will help expand the analysis of CRP are becoming available, such as the 1996 FHWAR and a national contingent-value analysis of the value of Midwestern avian species. Biophysical models are also increasing in scope, such as USGS models relating stream quality to land uses. Lastly, continual improvements in the power of GIS data manipulations, and the refinement of comprehensive econometric models, should also help implement heretofore prohibitively complex models.

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Appendix A—Description of the Water-Quality Valuation Model

This section briefly describes the discrete-continuous model used to value the nonmarket benefits of the CRP.[16] The survey data are from an ERS-sponsored component of the 1992 National Survey of Recreation and Environment in which 1,510 respondents were asked to recall the number of trips taken to up to three wetlands, three lakes, and three rivers less than 100 miles from their residences within the last 12 months in cases where the presence of a water body was an important reason for the trip. Trip destinations were determined either by self-reported location names, or by the self-reported distance and direction from the respondent's residence. Destinations themselves are small, subcounty areas termed polygons found in the 1992 National Resources Inventory (NRI) database. It is assumed that individuals face a choice set of all NRI polygons within 100 miles of their residence (approximated by the centroid of their resident ZIP Code zone). Lake/wetland and river recreation are modeled separately. Each polygon is described by five variables:

1. **Trip cost (TC)** is the round-trip travel cost (distance*$0.35) plus the round-trip time cost ((personal income/2000)*0.333*distance/50).

2. **Percent forest (PF)** is the percentage of the polygon in forest cover.

3. **Percent privately owned (PO)** is the percentage of land in the polygon that is privately owned.

4. **Erosion (ER)** is the average 1992 NRI sheet and rill erosion rate in tons per acre estimated using the universal soil loss equation in each polygon.

5. **Log(Size) (M)** is the natural logarithm of acres of lake area (meters of river length) for the lake (river) model in each polygon.

The first stage of the recreation demand model is a random utility model (RUM) describing the choice of destination on a recreational outing. The probability that the k-th person visits the i-th destination is:

(A.1)—

$$P_k(i)=\exp\{V_{ik}+(1/\mu)\ln(M_i)\}/\Sigma_j\exp\{V_{jk}+(1/\mu)\ln(M_j)\},$$

(A.2)— $V_{ik}=\beta_1*TC_{ik}+\beta_2*PF_i+\beta_3*PO_i+\beta_4*ER_i$

where $\beta_1,...,\beta_4$ and μ are parameters that are estimated using maximum likelihood techniques. Results of this stage of the estimation appear in appendix table 1. The destination probabilities shown in equation (A.1) are then used to compute expected trip costs E(TC) and trip qualities E(Q) for each individual:

(A.3)— $E(TC_i)=\Sigma_i P_k(i)TC_{ik}$,

(A.4)— $E(Q_i)=\Sigma_i P_k(i)Q_k$,

where $Q_k = [PF_k, PO_k, ER_k, M_k]$. Total trips are then written as a function of income (Y_i), socio-economic variables (S_i), expected costs, and expected qualities:

(A.5)— $T_i = f(Y_i, S_i, E(TC_i), E(Q_i))$.

Equation (A.5) is estimated using a double-hurdle count model. Separate sets of parameters explain the decision to participate and the intensity of participation. Results appear in appendix table 2. Changes in welfare resulting from a change in site quality are computed by assuming that equation (A.5) is a demand function. The welfare measure is the consumer surplus at the initial state minus the consumer surplus at the final state.

Using the model at the national level requires a national data set of environmental quality and demographic information. The NRI supplies national environmental quality data while the U.S. Census supplies national demographic information. A "representative individual" was constructed in each of the 3,071 counties in the 48 conterminous States using the 1990 U.S. census. By assumption, this individual resides in the geographic centroid of the county, has the average income, age, gender, and education found in the county, and faces a recreational choice set of NRI poly-

[16]For more information, Feather and Hellerstein (1997) describe the model and data in detail.

gons within 100 miles of the county centroid.

Preliminary analysis of the consumer surplus measures in the study area showed large differences between consumer surplus measures computed using the survey data (W_1) and consumer surplus measures computed using the census data (W_2). The former measures (W_1) are believed to be correct while the latter measures (W_2) are believed to be biased. This bias is likely to result from the nonlinear nature of the consumer surplus function. Since W_2 is used as an estimate of unknown W_1 in the national analysis, a calibration procedure was used to attempt to remove this bias. First, both W_1 and W_2 were computed for each county in the study area (where both survey and census data are available). Next, the ratio W_1/W_2 is regressed on county demographic information from the census (see appendix table 3). This "calibration function," along with the estimated demand relationship equation (A.5) is used in each U.S. county to determine the welfare changes for the representative individual. In each county, W_2 and W_1/W_2 are estimated from the census data. These are multiplied together and then multiplied by county population to arrive at a county welfare estimate.

For purposes of welfare estimation, several erosion levels had to be predicted from the NRI data. Erosion was predicted for each of the proposed CRP scenarios in the following manner.

For each NRI point, erosion is estimated to be:

1. Observed 1992 NRI USLE erosion if the point is either:

   a. currently in the CRP and included in the proposed scenario;

   b. currently not in the CRP and not included in the proposed scenario.

2. Compute USLE=RK*LS*C*P using observed RK and LS and the average C and P factors from pasture land in the county including the point if the point is not currently in the CRP, but is included in the proposed scenario.

3. Compute USLE=RK*LS*C*P using observed RK and LS and the average C and P factors from highly erodible land in the county including the point if the point is currently in the CRP, but is not included in the proposed scenario.

Appendix table 1—Random utility models of lake and river recreation[1]

Parameters[2]	Lake recreation model[3]	River recreation model[4]
Trip cost (TC)	-0.0834	-0.0992
	(-108.1)	(-90.0)
Percent forest (PF)	-1.4271	-0.4545
	(-18.4)	(-5.0)
Percent privately owned (PO)	-1.0778	-0.3101
	(-19.3)	(-4.5)
Erosion (ER)	-0.1511	-0.1308
	(-18.1)	(-2.1)
Log(size) (M)	0.0141	0.1150
	(5.5)	(16.4)

[1]Random utility models based on water-oriented recreational activities at lakes and rivers. T-statistics for the null hypothesis that the parameter equals zero appear in parentheses.

[2]*Trip cost* is the round trip travel cost (distance*$0.35) plus the round trip time cost ((personal income/2000)*0.333*distance/50). *Percent forest* is the percentage of the polygon in forest cover. *Percent privately owned* is the percentage of the polygon that is privately owned. *Erosion* is the 1992 NRI sheet and rill erosion rate in tons per acre estimated using the USLE. *Log(size)* is the natural logarithm of acres of lake area (meters of river length) for the lake (river) model.

[3]Estimated using a sample of 706 individuals averaging 9.78 lake-based trips per person. Most participants visited more than one location over the year; the number of unique respondent/location pairs is 1,323.

[4]Estimated using a sample of 447 individuals averaging 10.81 river-based trips per person. Most participants visited more than one location over the year; the number of unique respondent/location pairs is 772.

Source: Feather and Hellerstein, 1997.

Appendix table 2 — Double-hurdle Poisson models of lake- and river-based recreation[1]

Parameters[2]	Lake recreation model[3]	River recreation model[4]
Participation parameters[4]		
Constant	-0.2183 (-1.59)	-0.7567 (-4.36)
Family income	0.0067 (3.59)	0.0035 (1.49)
Age	-0.0178 (-7.30)	-0.0186 (-6.05)
Gender	0.3679 (4.71)	0.6567 (6.79)
College	0.2191 (2.51)	0.0827 (0.76)
Intensity parameters[5]		
Constant	3.6353 (37.28)	6.2761 (37.09)
E(Cost)	-0.0214 (-5.30)	-0.1044 (-20.65)
E(percent forest)	-0.3466 (-4.59)	0.8621 (12.98)
E(percent privately owned)	-0.3784 (-2.53)	1.1479 (8.29)
E(erosion)	-0.0462 (-2.47)	-0.0309 (-2.99)
E(size)	-0.0413 (-4.21)	-0.1927 (-16.1)
Family income	-0.0021 (-3.70)	-0.0057 (-9.85)

[1]Double-hurdle Poisson models of lake- and river-based recreation participation and intensity.
[2]Estimated using a sample of 1,510 survey respondents consisting of 706 participants and 804 nonparticipants.
[3]Estimated using a sample of 1,510 survey respondents consisting of 447 participants and 1,063 nonparticipants.
[4]*Constant* is a constant term. *Family income* is the respondent's family income in dollars. *Age* is the respondent's age in years. *Gender* equals one if the respondent is male, zero otherwise. *College* equals one if the respondent has completed a college education.
[5]*Constant* is a constant term. *E(Cost)* is expected trip cost. *E(percent forest)* is expected percentage of land in forest cover. *E(percent privately owned)* is expected percentage of land privately owned. *E(erosion)* is expected erosion. *E(size)* is expected lake area (river length) for lake (river) trips. *Family income* is the respondent's family income in dollars.
Source: Feather and Hellerstein, 1997.

Appendix table 3—Calibration function estimates[1]

Variable[2]	River recreation[3]	Lake recreation[4]
Constant	1.2144 (1.376)	0.4970 (1.633)
Permale	0.9956 (0.625)	0.3104 (0.565)
Age	-0.0361 (-2.849)	-0.0081 (-1.863)
Highsc	0.3041 (1.084)	0.0588 (0.607)
Inc20	-2.1149 (-2.766)	-0.5982 (-2.268)
Income	-0.0050 (-0.592)	-0.0007 (-0.235)
Agege65	3.2893 (2.935)	0.5452 (1.410)
R^2	0.229	0.232
R^2-Adjusted	0.189	0.193

[1]Least squares regression. Analysis is conducted in the study area. Dependent variable is the observed county calibration factor. The calibration factor is the average consumer surplus in each county from individual NSRE data divided by the consumer surplus of the representative individual from the U.S. census. Sample size is 126.

[2]*Constant* is the constant term; *Permale* is the proportion of the county that is male; *Age* is the average age of persons in the county in years; *Highsc* is the proportion of persons in the county who have graduated from high school; *Inc20* in the proportion of households in the county who have incomes less than $20,000 per year; *Income* is the median annual household income in the county in $1,000.00 dollar units; *Agege65* is the proportion of persons in the county who are 65 years old or older. R^2 (R^2-*Adjusted)* is the (adjusted) coefficient of determination. T-statistics for the null hypothesis that the parameter equals zero are in parentheses.

[3]For the river-recreation model.

[4]For the lake-recreation model.

Source: Feather and Hellerstein, 1997.

Appendix B—Description of the Pheasant-Hunting Valuation Model

This analysis values changes in environmental benefits associated with changes in farmland use. The empirical analysis estimates the demand for pheasant hunting with a travel cost framework that combines a random utility model with a travel cost demand model (Feather, Hellerstein, and Tomasi; 1995). This approach is similar to that discussed in Appendix A.

While agriculture affects many wildlife species, this study looks at pheasants for two reasons. First, it is a very popular game bird. Data from the 1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (FHWAR) indicate that the pheasant is the most popular upland game bird throughout the Midwest. Second, pheasants are sensitive to changes in uses of agricultural lands. The continued specialization in agriculture and increased use of insecticides and herbicides have cost pheasants cover and food sources, thereby reducing nesting success and chick survival (Basore, Best, and Wooley, 1987; Hill, 1976; Jahn, 1988; Messick and others, 1974; Minn. Dept of Natural Resources, 1985; Warner, 1979 and 1984; Warner and others, 1984). Thus, pheasant populations have trended downward. For example, pheasant populations in South Dakota fell from an estimated 16 million in the mid-1940's to less than 2 million by 1986 (S.D. Dept. of Game, Fish, and Parks, 1988). This study includes those States with the historically most suitable environment for pheasants, which are the Lake States (Wisconsin, Michigan, and Minnesota), the Corn Belt States (Iowa, Illinois, Ohio, Missouri, and Indiana), the Northern Plains States (the Dakotas, Nebraska, and Kansas), and Montana.

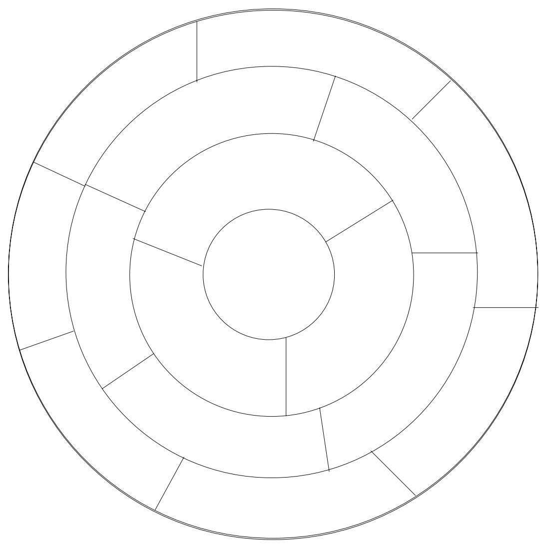
Ideally, we would like to estimate the travel cost demand model as a function of pheasant populations and use a biological model to quantify pheasant populations as a function of agricultural practices. However, biological studies on pheasants attempt to track habitat preferences of pheasants or the impact of habitat changes at single stages in their life cycle. While these studies indicate important environments for nesting, brood habitat, and winter cover and food supply, they do not model pheasant populations as a function of habitat. To overcome this lack of a biological model, we employ a "reduced-form" model, which is a combined biological-behavioral model. The reduced-form model includes the critical habitat variables that must be determinants of pheasant populations. Coefficients on the habitat variables represent both the biological and the subsequent behavioral responses.

Behavioral data used in this analysis come from the 1991 national FHWAR survey. To ensure that our sample included all potential pheasant hunters, we included those who indicated that they had hunted any species at least once in any of the past 10 years or thought they might hunt in the survey year. There is a total of 5,834 observations on potential hunters in the relevant States. The ZIP Codes of respondents were obtained for analytical purposes. Specifically, the latitude and longitude of the ZIP Codes served as an approximate geographic location of respondents' residences.

For each individual, a set of "possible destination sites" was constructed. Sites were defined by a geometric division of the surrounding land into semi-circular zones, with each of these zones treated as a possible destination "site." To be representative of potential sites, zones were large enough so that environmental quality might differ across sites yet small enough to ensure that environmental quality did not vary significantly within a site. For these reasons and because pheasants move a few miles throughout the year as habitat needs change, sites are defined in 25-mile increments around each ZIP Code center (Warner and Etter, 1985). The closest site is the area within 25 miles of the ZIP Code centroid. The next closest sites are those beyond 25 miles but within 50 miles. There are three sites defined in the 25- to 50-mile range, five sites in the 50- to 75-mile range, and seven sites in the 75- to 100-mile range. All sites are of equal area. A total of 16 sites is defined for each respondent (appendix figure 1).

A Geographic Information System (GIS) was employed to obtain statistically representative measures of relevant site-quality characteristics for each site. Specifically, the average shifted histogram (ASH) technique was used to estimate environmental characteristics across geographic locations based on observed environmental quality measures (Scott and Whittaker, 1996). The ASH technique generates a "surface" of data on characteristics at all grid points. The grid scale used in this analysis was approximately 3.9 miles. The environmental characteristics of each site are assumed to be represented by the characteristics of that site's central grid point.

Appendix figure 1
Delineation of Sites Around ZIP Code Centroids



Source: USDA, ERS.

As with the water-quality model, observed environmental quality measures are taken from the 1992 National Resource Inventory (NRI). Also, the 1990 Census of Population provides the population and size of each census tract from which population densities are determined. The latitude and longitude of each NRI centroid and census tract are used to identify the geographic locations of these environmental quality measures.

The specifics on the distance traveled and State visited reported by FHWAR survey respondents are enough detail to identify the site visited for approximately 70 percent of the observations. When more than one site fit the distance/State criteria, an allocation heuristic based on the potential site with the highest pheasant population is used to designate the visited site. Pheasant population estimates are obtained from the North American Breeding Bird Survey (BBS). The BBS is a national survey that attempts to obtain counts of all bird species observed along designated routes on scheduled days (Bart and others, 1995). The BBS data is processed in a GIS model as are the other environmental characteristics.

Many environmental characteristics have affected pheasant populations over time but not all affect pheasant populations across space. Those pheasant habitat characteristics that tend to vary across sites include: hay and small grain crops (oats, barley, and wheat), which provide marginal nesting cover (HAYGRN); corn and soybeans, which provide feed but poor early season cover (CRNSOY); pastures, which tend to be lesser disturbed than tilled soils and thus are a marginal nesting and feed source (GRASS); forest cover, which does not provide good habitat (FOREST); cropland not included in other variables, which tends to be a better source of habitat than excluded nonagricultural land uses (OTHCROP); and undisturbed cover, which provides good nesting cover, insects for newly hatched chicks, and winter cover (CRP) (Jahn, 1988; Kimmel and others, 1992; USDA, 1989; Warner and Etter, 1986). The percentage of all land in each of these uses is derived for each NRI polygon, converted to a geographic resource measure based on the latitude and longitude of the NRI polygon, and used in the GIS model to produce the site measures as outlined above.

As in Appendix A, Feather, Hellerstein, and Tomasi (1995) developed the modeling approach applied here. The first step in this approach uses a Random Utility Model (RUM) to model site selection. Important factors affecting site selection are the environmental amenities of the sites, the effect of crowding on the quality of recreational hunting at each site, and the travel cost to each site. Therefore, the independent variables of the RUM are:

1. **TC** represents the travel cost to the site.[17]

2. **lnCRP** is the natural log of the portion of a site's acres in CRP. The natural logarithm is taken to account for diminishing returns. To avoid a ln(0), 0.0001 is added to all CRP values.

3. **HAYGRN** is the portion of a site's acres in hay and small grain. The small grains included are oats, barley, and wheat as recommended in conversations with wildlife biologists.

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[17]Travel cost includes both the time cost and mileage cost. Time cost is based on the opportunity cost of time multiplied by the estimated travel time. The opportunity cost of time is set at one-third the hourly wage, and the hourly wage equals annual income/2000 hours per year. Travel time is estimated by dividing the distance traveled by an average speed of 42 mph where 42 mph is the average rate of speed of respondents in a recent recreation survey (Feather, Hellerstein, and Tomasi, 1995). Mileage costs are set at the American Automobile Association's estimated $0.30 per mile.

4. **CRNSOY** is the portion of the site's acres in corn and soybeans.

5. **GRASS** is the portion of acres in pasture.

6. **FOREST** is the portion of acres in forest.

7. **OTHCROP** is the portion of farmland in crops other than CRP, HAYGRN, CRNSOY, or GRASS.

8. **HAYGRNSQ** is HAYGRN squared.

9. **CRNSOYSQ** is CRNSOY squared.

10. **FORESTSQ** is FOREST squared.

11. **POP** is the site's human population density.

Following equation A.2, the systematic component of utility is given as:

(B.1) $$V_{ik} = \beta_1 * TC_{ik} + \beta_2 * \ln CRP_i + \beta_3 * HAYGRN_i + \beta_4 * CRNSOY_i + \beta_5 * GRASS_i + \beta_6 * FOREST_i + \beta_7 * OTHCROP_i + \beta_8 * HAYGRNSQ_i + \beta_9 * CRNSOYSQ_i + \beta_{10} * FORESTSQ_i + \beta_{11} * POP_i$$

All coefficients of the RUM are significant at the 99-percent confidence level and are of the expected sign (appendix table 4). The correct sign and statistical significance of the coefficients on lnCRP provide strong statistical support for the hypothesis that CRP acreage is critical to pheasant habitat. These results are used to estimate the expected travel costs, E(TC), and the expected site quality, E(Q), of the representative site visited from each ZIP Code. The quality vector, Q, includes lnCRP, HAYGRN, CRNSOY, GRASS, FOREST, OTHCROP, HAYGRNSQ, CRNSOYSQ, FORESTSQ, and POP.

With the number of trips an individual takes designated as T and the individual's socioeconomic characteristics and income contained in the vector S and variable Y, the participation model is specified in equation A.5. The participation model is estimated as a Poisson count data model because the dependent variable is a nonnegative integer (Creel and Loomis, 1990; Englin and Shonkwiler, 1995; Hellerstein, 1992). The parameters of the participation model are consistent with prior expectations. Coefficients are of expected sign, and all are significant at the 90-percent level (appendix table 4).

Both of the estimated models are directly employed to measure the change in consumer surplus to pheasant hunters due to a change in agricultural land use. The focus here is on changes in CRP acreage although the estimated models can also be applied to changes in acreage of corn/soybeans, hay/small grain, and pasture land.

To evaluate the change in consumer surplus resulting from a change in CRP enrollment, new NRI land use measures are derived with a simulation model that identifies those NRI observations that would be in the CRP under the new conditions and returns any NRI observations leaving the CRP to its use reported in the 1982 NRI (Osborn, 1993). The resulting new NRI land-use measures are used in the GIS to generate new land-use measures at grid points.

As with the original data, these simulated measures of land uses and populations at each site's center grid point are used to characterize the site. Using the RUM model, the expected travel cost, E(TC), and expected site characteristics, E(Q), are derived for each ZIP Code. Then, for each observation, the individual's E(TC), E(Q), income, and personal characteristics are used in the participation model to determine the consumer surplus. The change in an individual's consumer surplus associated with the change in CRP enrollment is the difference in consumer surplus before and after the change.

Appendix table 4—Empirical results

Variables	Random utility model[1]	Poisson model[1]
Constant		-1.97 (4.18)
COST	-0.148 (114)	-0.0424 (-4.57)
ln(CRP)	0.237 (11.1)	0.0713 (1.73)
HAYGRN	0.0645 (9.40)	0.0773 (5.35)
CRNSOY	0.0884 (18.2)	0.0559 (5.78)
GRASS	0.0458 (16.7)	0.0184 (3.86)
FOREST	-0.0448 (5.51)	-0.0433 (4.89)
OTHCROP	0.0647 (17.5)	0.0139 (2.21)
HAYGRNSQ	-0.000345 (3.26)	-0.00129 (6.60)
CRNSOYSQ	-0.000558 (11.9)	
FORESTSQ	0.000928 (6.43)	0.000875 (7.04)
POP	-0.00121 (11.2)	-0.00266 (5.50)
MALE		1.83 (17.0)
RURAL		-0.127 (1.84)
AGE		-0.0186 (8.39)
ED12		0.305 (3.35)
ED16		0.194 (2.82)
INCOME		$9.48*10^{-11}$ (8.70)
WEIGHT		-0.000925 (10.6)
WEIGHTSQ		6.60*10-8 (4.79)

See note at end of table.

—Continued

Appendix table 4—Empirical results—Continued

Constant	is a constant term;
COST	is the travel cost = ((1/3 INCOME/2000 hours/year)/42mph + $0.30) * distance traveled;
ln(CRP)	is the natural logarithm of the portion of acres in the CRP;
HAYGRN	is the portion of acres in hay, wheat, barley, and oats;
CRNSOY	is the portion of acres in corn and soybeans;
GRASS	is the portion of acres in pasture;
FOREST	is the portion of acres in forest;
OTHCROP	is the portion of farmland in crops other than CRP, HAYGRN, CRNSOY, or GRASS;
HAYGRNSQ	is HAYGRN squared;
CRNSOYSQ	is CRNSOY squared;
FORESTSQ	is FOREST squared;
POP	is the population density measured in people per square mile;
MALE	is a zero-one dummy variable equal to one when the respondent is male;
RURAL	is a zero-one dummy variable equal to one when the respondent resides in a rural community;
AGE	is the age of the respondent;
ED12	is a zero-one dummy variable equal to one when the respondent has completed high school but not college.
ED16	is a zero-one dummy variable equal to one when the respondent has completed college;
INCOME	is annual household income.
WEIGHT	is the sample weight of the observation;
WEIGHTSQ	is WEIGHT squared.

[1]t-statistics for the null hypothesis that the parameter equals zero appear in parentheses.
Source: USDA, ERS.

Appendix C—Description of the Wildlife-Viewing Valuation Model

In addition to pheasant populations, changes in the Conservation Reserve Program (CRP) may affect a variety of other wildlife populations, with resulting impacts on public participation in nonconsumptive wildlife-based outdoor recreation (wildlife viewing). To study this possible relationship, FWHAR data were used to model how the CRP influences the public's participation in wildlife viewing.

The nonconsumptive wildlife-associated recreation component of FHWAR data contains approximately 26,000 observations. This analysis uses the number of trips taken for the primary purpose of viewing wildlife, and focuses on the trips taken within the general vicinity of the individual's home, which roughly translates to all trips taken within approximately 100 miles of the individual's residence.

The size and extent of the FHWAR database are the primary features motivating its use. However, counterbalancing these positive features is the paucity of information on the recreational sites visited by respondents. As with the pheasant and water-oriented recreation models, site-specific information is very important, since landscape characteristics (that is, the extent of CRP) are likely to influence recreational behavior.

In contrast to the pheasant model, which used ancillary information (the Breeding Bird Survey) to designate visited sites, the available data could not be used to impute which (of several possible sites) the respondent visited. Thus, rather than select a particular site, the model examines how the aggregate trip-taking behavior of an individual is a function of the aggregated characteristics of all the sites available to that individual.

Briefly, the analysis involves the following steps:

1) Create "landscape characteristics" variables defined at a number of "semi-circular zones" around each respondent (**LC**), which are then aggregated into "circular-distance-band, aggregated" landscape characteristic variables (**Z**).

2) For each individual, extract visitation (**Q**), and socioeconomic (**X**), data from the 1991 FHWAR.[18]

3) Using the "distance to most frequently visited site" as a dependent variable, estimate a representative trip price (**P**).

4) Regress total number of trips against **X**, **P**, and **Z**.

5) Using coefficients from step 4, estimate predicted number of trips (and consumer surplus) under several scenarios.

The following sections provide greater detail on each of these steps.

Imputing Landscape Characteristics

Following the procedure used in the pheasant study, the ASH (Scott and Whittaker, 1996) technique is used to create a variety of landscape characteristics from National Resource Inventory (NRI) data. Several broad measures of land use as proxies for wildlife habitat (and potential populations) are created:

1) percentCRP. The percent of the land (in the sub-county region) that is in CRP.

2) percentCROP.

3) percentFOREST.

4) percentGRASS (rangeland and pasture).

5) RUC: Rural-Urban Continuum code (0 being most urban, 9 being most rural).

6) DIVERSITY: Landscape diversity, with higher values of DIVERSITY indicating a more variegated landscape (based on the interspersion of water bodies, forest land, grassland, and cropland).

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[18]This requires knowledge of a key piece of information: the individual's residence. Since public-use releases of FHWAR do not contain this information (due to privacy concerns), analysis of the data necessitated using raw data at U.S. Census facilities.

For each FHWAR respondent, 19 "zones" are defined. These zones are equivalent to those 16 zones generated for the pheasant study, but with the inner zone divided into 4 components.[19]

To simplify the model (and avoid problems with missing data), the landscape characteristics (**LC**) of the 19 zones are aggregated into 5 "distance-band-aggregated" measures (**Z**). To account for the possibility that landscape heterogeneity may be important, we use a "constant elasticity of substitution" functional form to compute an aggregate measure.

Specifically, this measure is defined as:

(C.1) $$Z_k = \left(\sum_{j=1}^{J_k} (LC_{jk})^{1/\alpha} \right)^{\alpha}$$

where:

α is a parameter to be estimated,

J_k is the number of zones in the k-th *distance band* (that is, the 62-mile distance band four has 5 zones),

LC_{jk} is the value of the characteristic in the j zone of band k,

and

Z_k is the aggregated measure of the land characteristic of the k-th *band*.

Note that when

$\alpha = 0$: Maximum matters
$\alpha = 1$: Sum (or average) matters
$\alpha >> 1$: Variations in characteristics do not matter

[19]These four zones are defined as zone 1 being within 12 miles of the "own ZIP Code" centroid; and zones 2 through 4 between 12 and 25 miles of the centroid.

Given the K=5 distance-zones, and six characteristics (listed above), this yields 30 separate distance-band-aggregated landscape characteristic (**Z**) variables.[20]

Individual Data

Data on nonconsumptive wildlife-associated recreation were obtained from the 1991 FHWAR. For each surveyed individual, the number of visits to "non-distant" sites was extracted. Operationally, this involved several steps:

1) Trips to one's own State, and to all States for which the "most visited location" was within 100 miles of the resident's home, were summed to obtain total "non-distant" trips (for all "potential wildlife viewers").[21]

2) Using information on past participation, and on current plans, observations on individuals who were not likely to be "potential wildlife viewers" were dropped.[22]

3) Several socioeconomic variables were extracted for each individual, including male, caucasian,

[20]The five distance zones could be further aggregated into an overall measure by using an endogenous distance decay. Although this yields a more parsimoniously specified model, it also complicates estimation.

[21]This focus on trips to "non-distant" sites is necessitated by modeling concerns; such as the large number of "sites" one would have to include in order to account for far away trips. However, note that trips to these "non-distant" sites account for over 90 percent of nonconsumptive wildlife-oriented trips.

[22]The following table contains the percent of observations in four categories.

	0 Trips	>0 Trips
Excluded observation	18 percent	7 percent
Included observation	45 percent	30 percent

Ideally, the "excluded-observation / >0 trips" category should contain 0 percent (since individuals who took a trip should not be *a priori* excluded). Conversely, the "included-observation / 0 trips" category may contain a large percentage, since it is possible for potential participants to choose 0 trips in any given season. Overall, approximately 85 percent of all trips were accounted for by individuals retained in the sample.

rural residence, high school graduate, college graduate and household income. All but household income are dummy (0/1) variables. Household income is an approximation based on the center of seven broad ranges (in the $0 to >$75,000 interval).

4) Individual weights were also obtained for each observation. These are demographic weights, computed by the FHWAR survey designers, that are used when creating population level predictions.

Constructing an Imputed Price

For several reasons, it is desirable to include an explicit price information in the analysis. First, if explicit price information can be obtained (say, a "representative" price), then welfare estimates using consumer surplus may be readily computed. Second, including such price information should improve the model's performance.

The problem is, as with landscape characteristics, the paucity of knowledge about which sites were visited implies a lack of explicit price information; a problem that is exacerbated when individuals took zero trips. As a substitute, an imputed "representative" price can be used.

The imputed "representative" price is based on the FHWAR's distance to the most frequently visited site variable. This distance variable is converted into a travel cost, using average cost per mile information, and a simple time cost (based on a fraction of household income). This travel cost is then used as the dependent variable in a sample selection model. The use of this predicted price offers two advantages: as a control for potential simultaneity between "price" and "quantity of trips," and to impute a price for the (many) individuals who consumed zero trips.

To predict this price, a sample selection model is used:

$$\text{i) } \Pr ob\left[\text{Participant}; \gamma\right] = \Phi(\chi, \gamma)$$

(C.2) $$\text{ii) } E\left[\ln(\text{Price}); \beta_\chi, \beta_v \mid Q > 0\right] = \chi\beta_\chi + \frac{\phi(\chi, \overline{\gamma})}{\Phi(\chi, \gamma)}\beta_v$$

where:

χ = X and Z variables

$\overline{\gamma}$ = Predicted value of γ from step 1

ϕ = Normal pdf

Φ = Normal cdf

The first equation is a Probit on whether the individual took any trips, with Z and X used as regressors. The γ coefficients from this Probit estimator are used to compute a Mills ratio. This Mills ratio, along with the Z and X variables, are regressed against the log of observed price (using observations with non-zero trips) in a standard semi-log OLS. Lastly, the predicted values of γ, β_χ, and β_γ are used with equation C.2.ii to impute a price for all observations (including individuals who took zero trips).

The Demand Estimator

Using the **X** (socioeconomic), **P** (imputed price), and **Z** (aggregated landscape characteristics) variables, a "representative trip" demand curve is estimated.

To clarify, lacking good information on where people went on their "wildlife-associated" trips, rather than selecting a "visited site" (using ancillary information) and estimating a RUM model (viz., the pheasant model), the wildlife-viewing model focuses on the total number of wildlife-associated trips within a few hours' drive of an individual's residence. Hence, the use of the aggregated landscape characteristic (**Z**) variables to estimate total trips is best interpreted as arising from a reduced-form model of the site-selection problem solved by an individual recreator. That is, the reduced-form model combines trips to all sites into a "total number of trips," and uses aggregated landscape characteristics to explain the total number of trips taken. Thus, the determinants of a set of chosen trips (to unknown-to-the-analyst sites) are "represented" by these aggregated characteristics.

To control for the prevalence of zero trips, a double-hurdle Poisson estimator is used to estimate the representative trip demand curve.

(C.3) $$\Pr ob(q; q > 0 \mid \lambda, \gamma) = \left(\frac{e^{-\lambda}\lambda^q}{q!}\right)(1 - e^{-\gamma})$$

$$\Pr ob(q = 0 \mid \lambda, \gamma) = e^{-\lambda} + \left((1 - e^{-\lambda})e^{-\gamma}\right)$$

where:

λ is the quantity parameter: $\lambda = \exp(R\beta)$

γ is the participation parameter: $\gamma = \exp(S\tau)$

β and τ are parameters to estimate

R are factors that influence the number of trips; including **P** (price information), **X** (socioeconomic factors), and **Z** (aggregated landscape characteristics)

S are factors that influence participation (a subset of **X** is used)

Note that, along with the imputed price term (**P**), the use of distance zone variables allows cost differences to affect demand.

Summarizing the Model

The model to be estimated is:

$$Z = Z(LC, \alpha)$$

$$P = P(X_2, Z; \gamma)$$

$$q = F(X_1, X_2, Z, P, W; \beta_1, \beta_2, \beta_p, \beta_z)$$

where:

q = Number of trips.

X_1 = Individual specific variables that influence probability of participation; typically socio-economic variables.

X_2 = Individual specific variables that influence quantity of trips; typically socioeconomic variables. Note that X_1 and X_2 may contain the same variables.

Z = Aggregated landscape characteristic variables, for z different variables and k=1..K bands. These will be a function of the 19 **LC** variables and **α** (the "CES" aggregation parameter).

P = The imputed price of a trip. Based on a sample selection model with the observed "distance to favorite site" as the dependent variable, and X_2 and Z as the independent variables.[23]

Z() = The "distance-band" landscape aggregation variables (equation i).

P() = The "sample selection" imputed price model (equation ii).

F() = The hurdle Poisson model (equation C.3).

W = Population weight correction factor.[24]

and

$\beta_1, \beta_2, \beta_p, \beta_z \alpha, \gamma$, = Parameters to be estimated.

Although simultaneous estimation of the above would be optimal, operational difficulties dictate a multi-stage model, to wit:

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[23]The observed price term is computed as the sum of an out-of-pocket cost and a time cost:

P= [0.3 * DIST] + [WAGE * 0.33 (DIST/50)]

Where:

DIS: Distance to site (in miles)

0.3: Approximate per mile cost of using a car

WAGE: Imputed wage rate = Household income divided by 2040.

DIST/50: Time required to travel DISTANCE

0.33: Fraction of travel time that is "onerous." The assumption is that recreational travel is not as unpleasant as work, hence should not be valued at the wage rate (Shaw, 1992).

Note that the following is assumed:

1) The WAGE rate assumes that the trip taker is the sole wage earner in the household; and freely chooses to work 2,040 hours. 2) Out-of-pocket costs (0.3 * DIST) assume a group size of one (no cost sharing, and no variation in fuel economy, depreciation rates, etc. 3) An average speed of 50 miles per hour.

[24]When using the FHWAR weights to scale up to the population, the desired equivalence between "observed" and "predicted" (using the baseline data) number of trips need not hold. There are several ways of addressing this inconsistency; including ex-post calibration, weighted estimation, or inclusion of the weight as a correction factor. Though all of these are problematic, the use of the weight as a correction factor involves the fewest ad hoc assumptions.

1) Using a grid search, select a candidate value of α.

a) For each candidate value of α, the $\mathbf{Z_k}$ variables are generated.

b) Given **Z**, **P** is imputed.

c) Given **Z** and **P**, estimate F(·).

d) Record the log-likelihood from c.

2) Reiterate step 1 for different values of α.

3) Given a set of coefficient vectors (one vector for each value of α) choose the one with the best log-likelihood. The β coefficients associated with this best log-likelihood are the estimated parameters of the model.

Since it might be expected that recreational behavior may vary across the country, this model was applied separately to the five sub-national regions: the West, Northern Plains, Southern Plains, North, and the South.[25]

Constructing Alternative Scenarios

Total recreational trips under different allocations of the CRP are estimated under the three scenarios discussed in the body of the paper: 1992 CRP (signups 1 to 11), a "no-CRP" scenario, and a "15th EBI" scenario.

[25]The five regions consist of:
1) West: CA, WA, OR, MT, ID, WY, NV, UT, CO, AZ, NM.
2) Northern Plains: SD, ND, NE, KS.
3) Southern Plains: OK, TX.
4) North: MN, WI, MI, IA, MO, IL, IN, OH, ME, VT, NH, CT, RI, MA, NY, PA, MD, NJ, DE, DC.
5) South: AR, LA, MS, AL, GA, SC, FL, KY, TN, WV, VA, NC.

Appendix table 5 lists the percentCRP (and percentCROP) "perceived" by the FHWAR sample under these scenarios. Since the FHWAR sample is not uniformly distributed geographically, these percentages will differ from the actual landscape distribution in the regions.[26]

Across scenarios, the **LC** variables for each observation will be different. The impacts of these changes are examined by recomputing the predicted number of trips, using equation C.1 to recompute the aggregated landscape characteristics (**Z**), equation C.2 to recompute **X** and **P**, and the estimated coefficients from the model (equation C.3) to generate new predictions of trip demand.

Some Results

Screening information (on past wildlife-associated recreation) was used to classify approximately two-thirds of the sample as being potentially interested in "nonconsumptive wildlife-associated" recreation; the remaining one-third of the sample was classified as uninterested and was not included in the estimation. About one-half of the potentially interested individuals (one-third of the sample) actually took at least one trip (appendix table 6 gives further details). Note that the average reported trip value is based on a contingent valuation question asked of everyone who took a nonconsumptive, wildlife-oriented trip (Waddington and others, 1993).

The canonical estimator for this model, as described above, is based on a double-hurdle Poisson model and an imputed price. Given the large number of

[26]These "perceived" values are derived in the following manner. First, for each respondent, compute an average percentCRP (and average percentCROP) in the 19 "zones" (in the approximately 100-mile band surrounding his/her residence). Second, average these "100-mile-band" averages.

Appendix table 5—Perceived percentCRP and percentCROP

	1991 CRP (34 million NRI acres)		15th EBI		No CRP	
Region	percentCRP	percentCROP	percentCRP	percentCROP	percentCRP	percentCROP
West	1.2	9.9	1.1	9.9	0	11.2
Northern Plains	4.5	52.3	4.3	52.4	0	56.9
Southern Plains	0.9	19.2	1.4	18.6	0	20.0
North	1.1	28.9	1.6	27.8	0	29.9
South	0.9	14.6	1.3	13.6	0	15.4

Source: USDA, ERS.

Appendix table 6—Regional summary of participation in nonconsumptive wildlife-associated recreation

	Number of observations	Number retained	Number of participants	Average number of trips	Average distance	Average reported trip value
West	5,561	3,391	1,624	9.33 (16.7)	22 (33)	30
Northern Plains	2,075	1,679	659	11 (23)	13 (18)	25
Southern Plains	992	785	270	8.9 (19)	25 (44)	31
North	9,827	7,878	3,122	13 (23)	14 (30)	32
South	6,451	4,699	1,547	10 (19)	15 (19)	31

Source: USDA, ERS.

variables, appendix table 7 lists some of the more important variables. We also list the "sum" of the β_z coefficients for each landscape characteristic, which can be interpreted as the effect given a uniform change in landscape characteristics.

Note that the coefficients are best interpreted as the percent change given a unit change in the variable. The probability variables range from 0 to 100; the RUC (rural-urban continuum code) ranges from 0 to 9, and the diversity variable ranges from 1 to 4.

These coefficients are somewhat difficult to interpret, as they show no strong pattern. PercentCRP seems to be more often positive then negative, with the exception of the Southern Plains.

As a measure of model quality, the correlation between the weighted observed and weighted predicted number of trips (based on the original scenario) can be used in lieu of an R-square statistic.

Ideally, the coefficient on the imputed price could be used to generate consumer surplus values. Unfortunately, the imputed price coefficients are often positive (or negative but very small in magnitude), which yields impossible (or implausible) consumer surplus values. It would appear that the distribution of quality sites obscures the price relationship.[27]

[27]If the distribution of site quality varies over the population (with some individuals living close to better sites, while others must travel long distances to attain better sites), then the imputed price should be correlated with number of trips. That is, better quality sites nearby should yield more trips to closer sites; hence a negative sign on the imputed price coefficient. On the other hand, if the shape of the distribution of site quality is similar across the population (say, increasing with respect to distance), but with some individuals having better all-around choices (say, the slope of the distance/quality relationship varies across individuals), then high prices may be associated with high number of trips. That is, individuals who can pay a high price for a "fabulous" site may take more trips than individuals who choose a closer "mediocre" site instead of a farther out "slightly better than mediocre" site.

Goodness of fit: Observed and predicted trips

	Correlation: individual trips	Correlation: weighted trips
West	0.18	0.40*
Northern Plains	0.31	0.15
Southern Plains	0.43	0.41
North	0.24	0.18
South	0.19	0.17

*When a large outlier was not removed from the West, the weighted correlation was 0.81.

However, since the "imputed price" does allow extra information (the "distance to last site" data) to be incorporated, we will retain the results with the understanding that the "imputed price" is to be interpreted loosely.[28]

Instead of directly computing consumer surplus, we use a benefit's transfer value. In particular, the "average per day" value of wildlife watching is used as a proxy for per-trip value. Although several sources for such a value exist, the "self-reported" value from the FHWAR is most appropriate for this exercise. The regional averages of these values are used to report the "consumer surplus" of wildlife-viewing trips under the three scenarios.

[28]A number of other specifications were attempted, including models without imputed price terms, and models that used the simple Poisson model. The results from these models were qualitatively similar to the double-hurdle, imputed "price" model.

Appendix table 7—Some coefficients from the double-hurdle model with imputed price (t-stats in parentheses)

	West	Northern Plains	Southern Plains	North	South
Aggregation parameter α	0.47	2.33	1.5	4.7	0.47
Some probability stage coefficients					
INCOME	-2.13e-7	-1.58e6	4.14e-6	-1.02	1.22e-6
	(-.19)	(-0.82)	(1.5)	(-1.3)	(1.0)
OWN_CRP	-0.019	-0.052	0.13	0.042	-0.047
	(-12.1)	(-2.3)	(3.4)	(4.1)	(-1.66)
Some quantity stage coefficients					
Income	-9.34e-6	5.13e-6	6.1e-6	-9.5	-5.0e-6
	(-10.7)	(8.4)	(4.4)	(-15.5)	(-6.5)
CRP0	1 0.352	0.023	-1.17	0.011	0.89
	(12.2)	(0.61)	(-5.8)	(1.17)	(17.4)
CRP02	-0.234	-0.002	0.30	0.00053	-0.65
	(-9.9)	(-0.44)	(5.7)	(7.7)	(-15.4)
CRP03	0.0077	0.0010	-0.13	-0.00066	0.15
	(0.86)	(0.40)	(-4.7)	(-9.0)	(8.3)
CRP04	0.061	0.0013	-0.004	-4.31	0.016
	(12.8)	(2.1)	(-0.42)	(-0.5)	(1.9)
CRP05	-0.028	-8.06e-5	0.037	1.6e-5	-0.003
	(-8.3)	(-0.4)	(-5.60)	(10.0)	(-0.056)
Price	0.029	-0.0093	-0.002	0.133	0.027
	(4.8)	(-0.90)	(-0.34)	(11.9)	(3.14)
Summation of landscape characteristic coefficients					
Σ percentCRP	0.16	0.02	-0.96	0.01 0.	40
Σ percentCROP	0.57	.10	0.02	-0.01	-0.001
Σ percentForest	0.15	.27	-0.04	0.003	0.008
Σ percentGrass	0.005	.03	-0.01	-0.03	0.02
Σ percentDiversity	-0.31	-2.58	.37	-0.02	1.6
Σ RUC	0.11	0.05831	0.29	0.06	-0.003
Log likelihood	17671	10733	3239	59802	20316

Source: USDA, ERS.

Appendix D—Description of 15th CRP Signup Criteria

Appendix figure 2 illustrates the weighting of the EBI factors.

Wildlife (100 points maximum; formula = (A/50)*(A+B+C+D+E+F)

A. Cover Factor (0-50 points): Points are awarded depending on which of the 40 possible cover types are expected to become established.

B. Endangered Species Area (0-15 points): If cover to be established is within the known present range of a listed, proposed, or candidate species and is expected to benefit that species then 15 points are awarded; otherwise 0 points are awarded.

C. Wetland Proximity (0-10 points): If semi or permanently flooded wetlands are within 1 mile of the site, 5 points. If wetlands within or adjacent to the bid area equal to more than 5 percent of the contract area, 10 points.

D. Adjacent to Protected Areas (0-10 points): If protected wildlife habitat within 1 mile of the site, 5 points. If protected wildlife habitat adjacent to the site, 10 points.

E. Contract Size (0-5 points): If the site is equal to the State average, or up to twice the area of average, 2 points. If the site is more than twice the State average, 5 points.

F. Upland/Wetland Ratio (0-10 points): This subfactor is based on the ratio of the acreage of uplands offered to the acreage of restored wetlands offered. If the ratio is less than 1:1 or greater than 10:1, 1 point. Ratios in the range of 1:1 to 3:1 or 6:1 to 10:1 get 5 points. Ratios between 3:1 and 6:1 receive 10 points.

Water Quality (100 points maximum; formula = A+B+C+D)

A. Priority Area (0-30 points): 30 points are awarded to acreage located in areas identified by State and local water quality plans, State-identified wellhead recharge areas, areas with coastal nonpoint pollution control programs developed under the Coastal Zone Act Reauthorization Amendments, or areas identified in plans developed in accordance with the Clean Water Act.

B. Ground-Water Quality (0-20 points): Points are awarded based on the average leaching potential (rounded to the nearest whole number) and by county population. The actual number of points for a given score is taken from a State/county table.

C. Surface-Water Quality (0-40 points): Points are awarded based on the average sheet and rill erosion index for all acres being offered, the distance to waterbodies of the nearest portion of the tract, and county population. The actual number of points for a given score is taken from a State/county table.

D. Cropped Wetland (0-10 points): If least 10 percent of the land enrolled meets the cropped wetland eligibility criterion, 10 points are awarded.

Erosion (100 points maximum)

Erodibility Index (0-100 points): The higher of the weighted average erodibility index for sheet and rill erosion (using the USLE), or erodibility indicator for wind erosion rounded to the nearest whole number is used to determine the overall erodibility index. Indices below 8 receive no points. Indices from 8 to 19 receive 25 to 80 points (= 25 + 5*(index-8)). A score of 20 (21) receives 90 (100) points.

Long-Term Retention of Trees, Shrubs, and Wetlands (50 points maximum)

Estimated Retention Period (0-50 points): Cover types such as trees and restored wetlands that are likely to remain after the contract has expired are awarded points. Partial tree plantings are prorated to the nearest whole point. Hardwood tree, long leaf pine, and white cedar plantings receive 50 points. Softwood trees receive 40 points. Restored wetlands with semi-permanent and permanently (temporarily and seasonally) flooded wetlands in the field receive 25 points.

Air Quality (25 points maximum)

Air-Quality Component (0-25 points): The ZIP Code and wind erodibility index (EI) of the tract (provided by NRCS) is used to determine a score based on numbers from an ERS county look-up table (weighted by population).

Conservation Priority Area (25 points maximum)

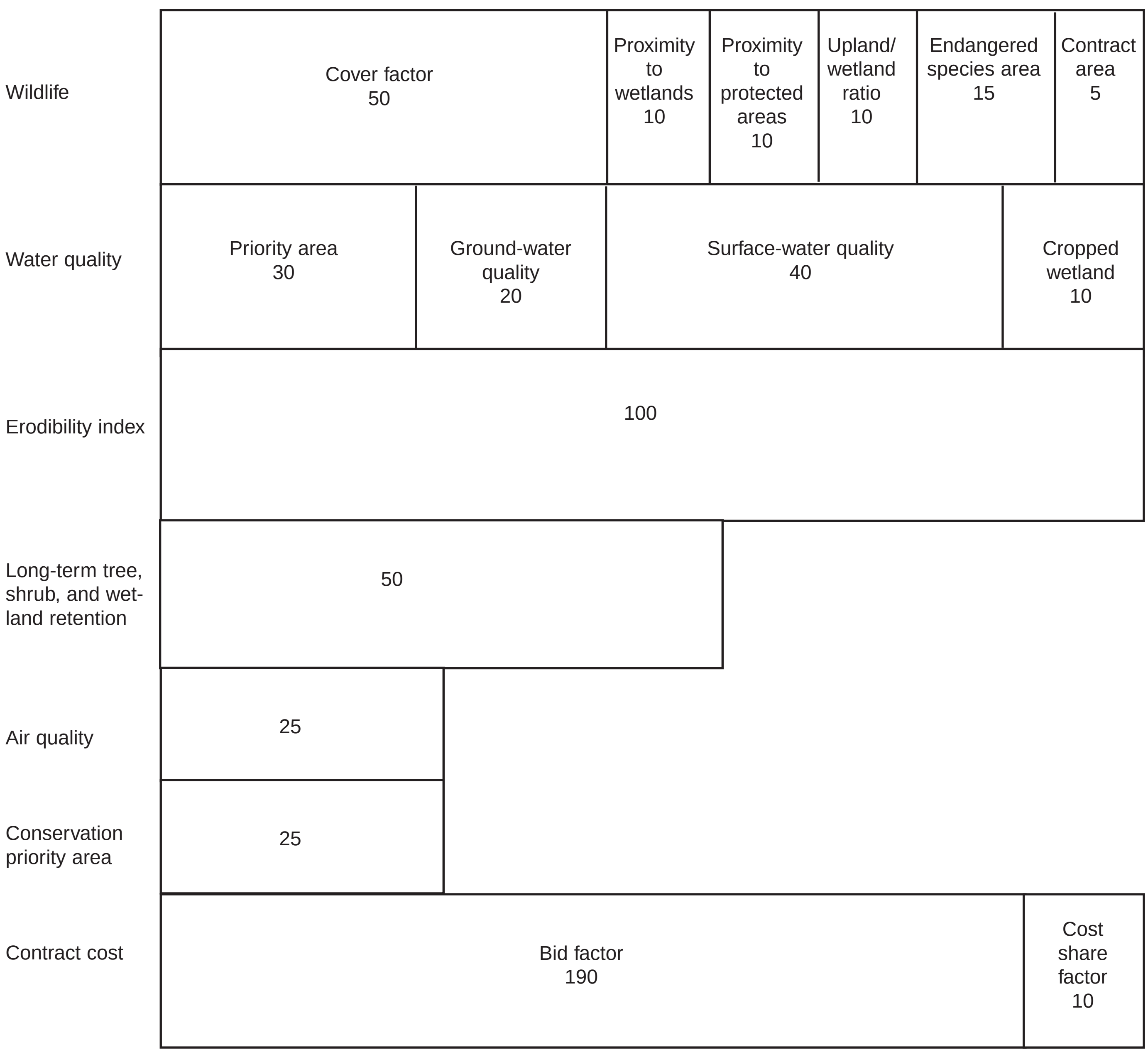
Conservation Priority Area Component (0-25 points): If the bid is located within an approved CRP State Conservation Priority Area, it receives 25 points (if the resource concern for which the CPA is selected would be addressed by enrolling the land).

Cost Component (200 points maximum; formula = A+B)

A. Rental Factor (0-190 points): The following formula based on the per acre bid is used: rental factor = 190 - 190*(bid amount/165).

B. Cost-Share Factor (0-10 points): If cost-share assistance is not provided, 10 points are awarded.

Appendix figure 2
Scoring criteria for CRP eligibility for enrollment (signup #15)



Note: The above is not to scale.
Source: USDA, ERS.