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.

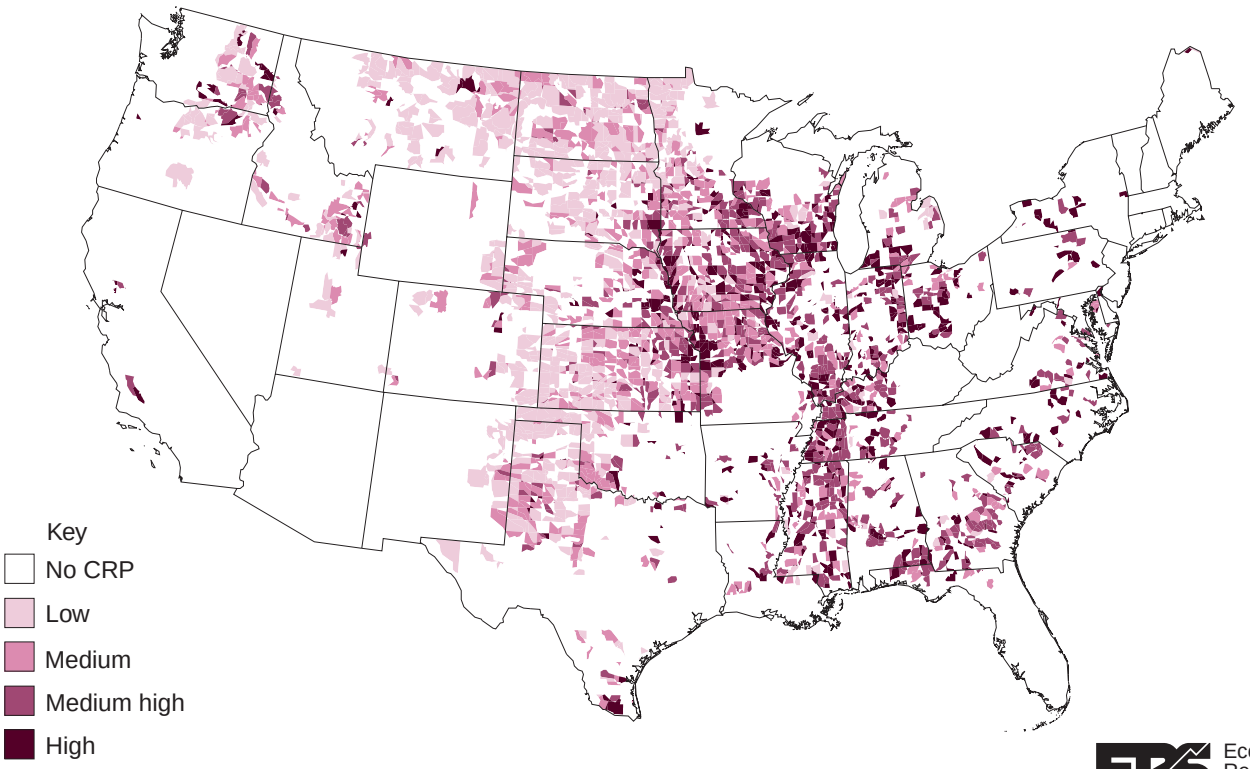
[3]Hypothetical CRP acres less actual CRP acres in million-acre units.

[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.

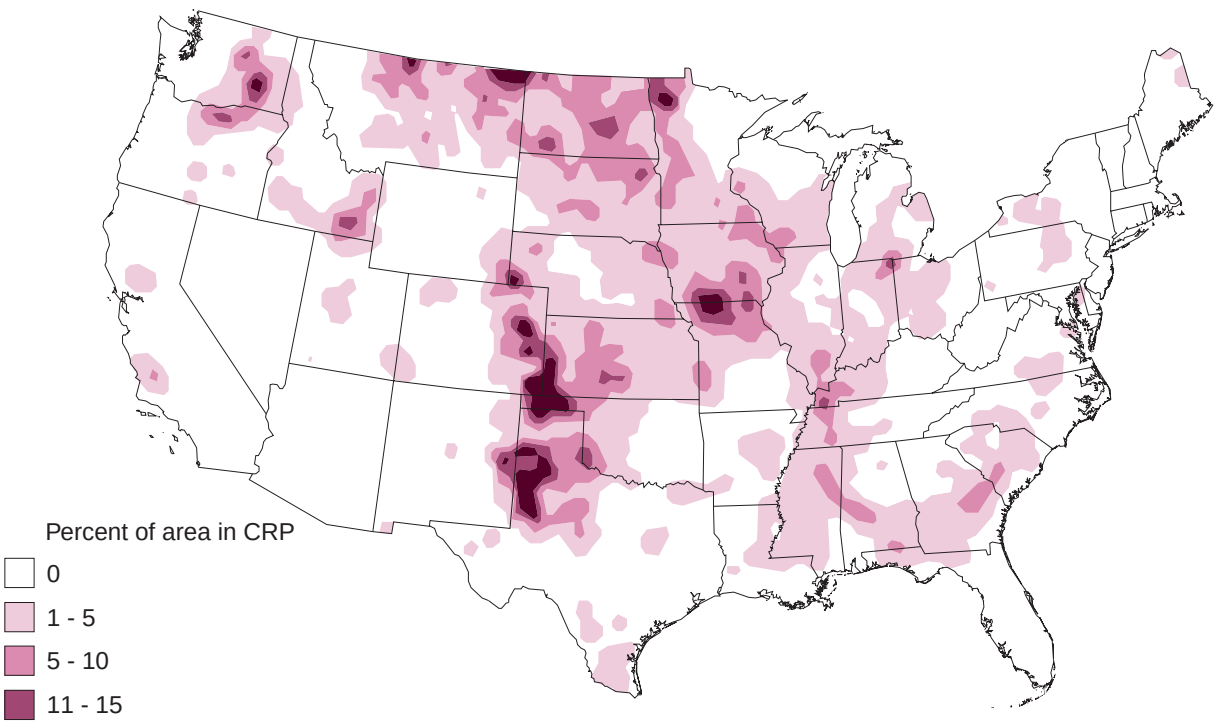
Figure 2
Average water-quality benefits from 1992 CRP by NRI polygon



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

Economic Research Service

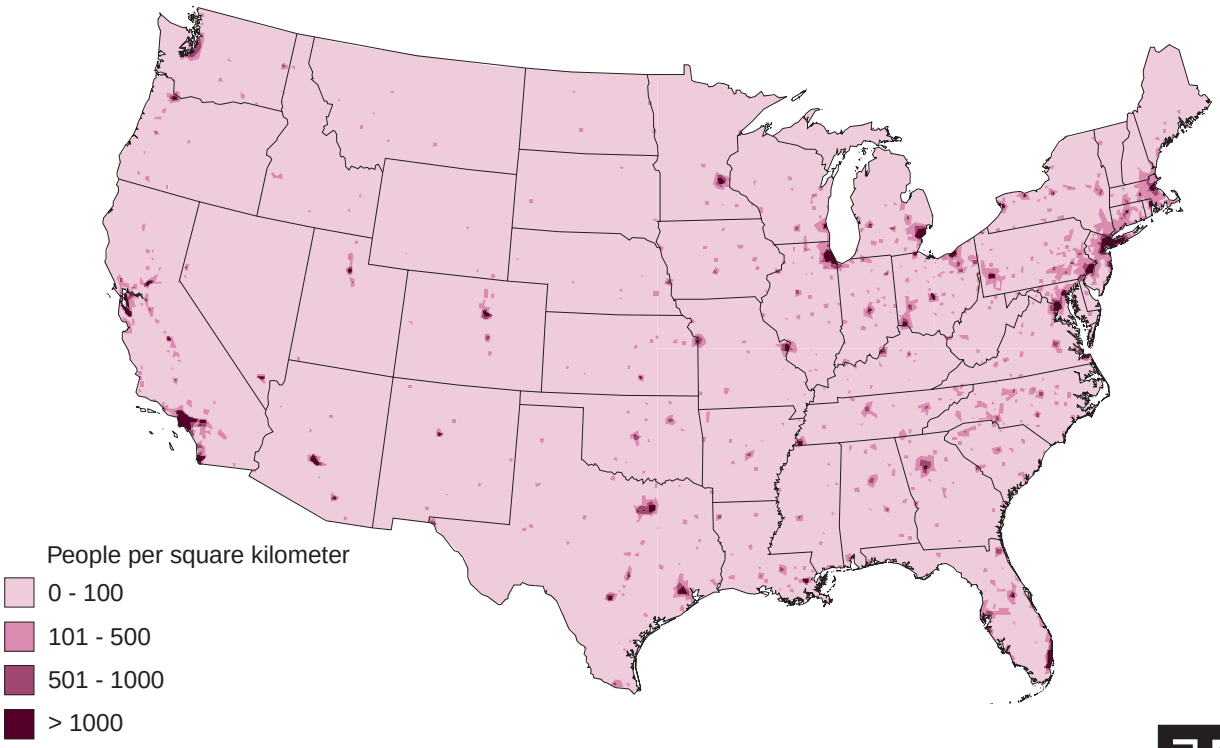
Figure 3
Percent CRP lands, 1992



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

Economic Research Service

Figure 4
U.S. population density, 1992



Economic Research Service

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

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.