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 (-108.1)	-0.0992 (-90.0)
Percent forest (PF)	-1.4271 (-18.4)	-0.4545 (-5.0)
Percent privately owned (PO)	-1.0778 (-19.3)	-0.3101 (-4.5)
Erosion (ER)	-0.1511 (-18.1)	-0.1308 (-2.1)
Log(size) (M)	0.0141 (5.5)	0.1150 (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	-0.7567
	(-1.59)	(-4.36)
Family income	0.0067	0.0035
	(3.59)	(1.49)
Age	-0.0178	-0.0186
	(-7.30)	(-6.05)
Gender	0.3679	0.6567
	(4.71)	(6.79)
College	0.2191	0.0827
	(2.51)	(0.76)
Intensity parameters[5]		
Constant	3.6353	6.2761
	(37.28)	(37.09)
E(Cost)	-0.0214	-0.1044
	(-5.30)	(-20.65)
E(percent forest)	-0.3466	0.8621
	(-4.59)	(12.98)
E(percent privately owned)	-0.3784	1.1479
	(-2.53)	(8.29)
E(erosion)	-0.0462	-0.0309
	(-2.47)	(-2.99)
E(size)	-0.0413	-0.1927
	(-4.21)	(-16.1)
Family income	-0.0021	-0.0057
	(-3.70)	(-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	0.4970
	(1.376)	(1.633)
Permale	0.9956	0.3104
	(0.625)	(0.565)
Age	-0.0361	-0.0081
	(-2.849)	(-1.863)
Highsc	0.3041	0.0588
	(1.084)	(0.607)
Inc20	-2.1149	-0.5982
	(-2.766)	(-2.268)
Income	-0.0050	-0.0007
	(-0.592)	(-0.235)
Agege65	3.2893	0.5452
	(2.935)	(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.