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Effective Recreation Opportunity Set (EROS) Index: A Computable Measure of Recreation Supply

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Abstract

A measure of the supply of recreation opportunities, computable from available data, is presented in this Paper. The measure is based on the theory of the household production of recreation supply. It measures the availability of a set of recreation resources to households in a given location as an input to producing recreation trips, relative to the availability of the same set of resources to households in other locations.

The measure described is developed as an index, to allow for combining several different types of recreation resources into a more comprehensive metric of availability of a particular recreation environment. Recreation supply availability is shown to be positively related to the amount of resources, and negatively related to both competing populations and the distance separating households and resources The steps taken to calculate 1989 RPA recreation opportunity indices are described and illustrated with a hypothetical example.

Keywords: Supply, outdoor recreation, household production theory, effectiveness.

Introduction

Since the early 1960's, public policymakers have been concerned about the adequacy of recreation resources relative to the demand for the activities (Bureau-of Outdoor Recreation 1973; Cicchetti and others 1969; Cordell and others 1990; Outdoor Recreation Resources Review Commission 1962). Related issues include resource distribution compared with population distribution, trends in resource availability, comparison of resource availabiity across regions, and the role of available recreation opportunities as a recreation demand determinant. These issues are important in State and Federal resource planning efforts.

To meet the requirements of the Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974, the Forest Service assesses the current situation and projects future supplies of and demands for renewable resources, including outdoor recreation. In the most recent RPA Assessment of Outdoor Recreation and Wilderness (Cordell and others 1990), demand was analyzed with the theoretical model of the household production of recreation trips (Bockstael and McConnell 1981; Cordell and Bergstrom 1991). To do so, it was necessary to have a recreation opportunity supply measure that tit the theoretical model of household production and allowed comparison of recreation resource availabiity across locations. Development of such measures had been stilled by lack of available resource data and limited applicable theory. It therefore was necessary to develop a new measure of recreation supply, the Effective Recreation Opportunity Set (EROS) index, for the 1989 RPA Assessment. This paper describes the theory and method used to derive the EROS index.

Major sections of the paper describe:

- the theoretical model for the household production of recreation and the role of recreation resources
- the salient dimensions of the price of recreation resources to the household, drawing on recent measures of recreation supply
- the proposed supply measure and its relation to the foregoing theory
- an empirical example of a computable recreation supply measure
- a summary and suggestions for further research.

Theoretical Background

Household Production of Recreation

Over time, households maximize utility gained from consuming goods and services other than recreation trips and from recreation trips produced by the household (Bockstael and McConnell 1981). Number of trips taken has been shown to be the most appropriate economic measure of the output produced by the household (Bockstael and others 1987; McConnell 1975). The general form of the weakly separable utility function is:

$$U = U(X_Z, H_j) \tag{1}$$

where

X_Z = vector of nonrecreation goods and services consumed per year;

H_j = vector of the number of recreation trips of type j produced per year (j = 1,2,...n).

The optimal number of trips of different types is determined in two stages (Bockstael and McConnell 1981). First, households minimize trip costs for each trip type. The resulting cost structure is considered fixed for the entire planning period. Next, optimal numbers of trips are determined via constrained utility maximization.

Households produce recreation trips by combii inputs including recreation resources and facilities, market goods such as gasoline and equipment, and the household's knowledge, skills, and time. The production function for a recreation trip of type j has the general form:

$$H_j = h_j(X_{vj}\ ,\ E\ ,\ S_j) \qquad (2)$$

where

h_j = a production for j;
X_{Vj} = variable input vector, including time;
E = household characteristics, including skills, knowledge, and recreation equipment owned by the household, such as **RV's,** tents, and **skis;**
S_j = recreation opportunities for activity j, such as sites, facilities, and resources.

Inverting (2) yields per-trip requirements for inputs

$$X_{vj} = h'_j(\ E,\ S_j\ ) \qquad (3)$$

where
h'_j is the inverse of h_j.

Let P_j be the average cost per trip and let P_v be the vector of prices for variable trip inputs. Then the per trip cost can be specified as:

$$P_j = P_v h'_j(E,S_j) \qquad (4)$$

By substituting Equation (4) into the usual Marshallian demands, a household's demand for recreation trips, H_j, can be expressed as:

$$H_j = f(P_v,\ E,\ S_j,\ S_i,\ Y) \qquad (5)$$

where

S_i = recreation opportunities for activities other thanj;
Y = annual household income;
E, S_j = defined as before.

Recreation Sites and Prices

The EROS index was designed to measure the general **availability** of recreation opportunities that could be used in Equation (5). Common measures of recreation resources, such as raw facility counts or facilities per capita have been shown to be inadequate (Harrington **1987;** Randall **1987).** Economic concepts of recreation supply **(Clawson** 1984, Harrington 1987) can be quite difficult to calculate empirically. On the other hand, opportunity indices have been shown to be computationally efficient in accounting for the spatial structure of recreation opportunities and households (Fesenmaier and Leiber 1987, Kim and Fesenmaier 1990). Our plan was to develop a set of opportunity indices that were based on economic theory, especially on the work of Harrington **(1987).**

The household production model includes recreation sites and resources among inputs. Households do not 'buy' a site, but they do pay a cost to acquire its use. Harrington (1987) called it the 'effective price' for a recreation site. Effective price measures the availability of a recreation site to a household. That price includes entry fees, travel costs in both money and time, and congestion costs in both queuing time and experience quality.

A site's location relative to the household determines the cost of travel to the site, so travel costs are specific to an origin-destination pair. Entry fees, if any, are additional costs beyond travel. Travel costs are assumed to increase with distance. Sites beyond some threshold distance from the household become too expensive to use. Threshold distances can vary by trip type.

As the number of users at a site increases, congestion and queuing combine to reduce trip quality. Activity, setting, and desired trip quality level determine at what use level and how quality declines. Converting quality decline to an equivalent price variation allows congestion to be treated as a cost and to be included in the effective price of site use. Congestion costs depend on the total number of people at the site, the activity, and site characteristics including **size,** facilities, and capacity. Numbers of users at a site depend on the location and **size** of population centers within the appropriate threshold distance and on all other recreation opportunities serving each of those origins. That is, all origins and destinations are considered simultaneously in calculating congestion costs.

Harrington's effective price has a good theoretical basis and is a useful indicator of the availability of recreation opportunities. Effective price is specific to an activity, desired trip quality level, origin-destination pair, and the distribution of other users and other sites. Unfortunately, such specificity makes effective price difficult to use as an aggregate measure of recreation opportunity availabiity, as specified in Equation (5). Households face a vast array of prices even for a single activity, depending on the site and desired trip quality. Calculation of effective price requires a great deal of origin-destination data that are largely unavailable. All sites have different facilities and activity suitability, so some means of weighting various facilities must be found in the price calculations. Calculating congestion costs poses the largest problem, because objective manifestations of congestion are not well documented for nonwildemess recreation. Still, Harrington's work provided guidance for the development of our aggregate recreation opportunity supply measures.

Effective Recreation Opportunity Set (EROS)

The EROS measure of recreation opportunity was developed primarily for use in the 1989 RPA Assessment of outdoor recreation and wilderness, and was based on Harrington's (1987) effective price. ` EROS measures the relative availability of recreation opportunities to households in different locations. Such opportunities are provided by public agencies and private entrepreneurs, and are exogenous to the household's recreation production function. EROS uses available resource, population, and location data. In particular, EROS measures are based on data in the National Outdoor Recreation Supply Information System, a county-level inventory of resources, facilities, and services available for public recreation use. Using county aggregates of resource and population data precluded calculating origin-specific measures of recreation opportunity supply as proposed by both Clawson (1984) and Harrington (1987). An even distribution of both population and resources within counties was assumed. These data were combined into a measure that reflects the cost-increasing effects of both travel distance and congestion. EROS is origin-specific and can be defmed for any activity or setting.

The RPA Assessment classified recreation activities and settings according to two criteria. First was by resource base--land, water, and snow-and-ice (USDA Forest Service 1980). The second criterion followed the Recreation Opportunity Spectrum concept developed by the Forest Service to classify its lands according to accessibility, development, and likely human encounters, More developed resources like campgrounds, urban parks, or ski areas are often more easily accessible and have greater capacity to handle crowds. compared with less developed resources. The differences in both development and visitation capacity also suggest intracategory differences in the factors that determine congestion. EROS supply measures were developed for 12 distinct recreation environments as suggested in Cordell and others (1989).

EROS Calculation Method

This section outlines the steps for calculating EROS indices. Because a number of separate steps and several generations of acronyms are involved, a flowchart summarizing both the steps and acronyms is provided in the appendix.

Step 1

Recreation opportunity supply measures should account for the effects of likely congestion levels. Harrington (1987) noted that "[resources] per capita might be a rough indicator of crowdedness at recreation facilities. An increase in population in a county leads to an increase in users competing for the recreation resources, increased congestion, and reduced availability of recreation opportunities. The first step in the EROS calculation is to divide county-level resource amounts by the county population, resulting in a series of resource per population (RPP) variables.

Step 2

Recreation opportunities for any activity can seldom be fully measured by one resource. Backpacking opportunities, for example, depend on acres of forest land, miles of trails or primitive roads, and numbers of trailheads providing access to the trails. Additionally, numbers of guide, outfitter and rental enterprises enhance resource accessibility by providing knowledge, organization, and equipment. The problem is one of combii several different inputs measured in different units into a single metric of effective opportunities for one type of recreation. No guidance exists as to the "correct" proportions of inputs needed to produce or measure recreation opportunities.

Our solution was to transform RPP's into resource availability indices to make units comparable. Index values ranged from 0 to 100. Such indices allow comparisons of relative abundance of opportunities across counties. The methods could be duplicated in subsequent years using the 1989 index base to measure trends in effective recreation opportunities. Maximum county RPP values were truncated at the 95th percentile to account for highly skewed values, and RPP's were indexed to that maximum.

Step 3

An expert panel of 20 recreation researchers and managers was surveyed to assign weights to each RPP index as a recreation opportunity measure for each of the 12 recreation environments. Resources central to a recreation environment, such as wilderness acres for remote land opportunities, were given a weight of 3. Resources that provided access to the central resources, such as boat ramps, trailheads, or guide services, were assigned a weight of 1. For each county, 12 recreation opportunity indices (ROI) were calculated as:

$$ROI_i = \sum [RPP_j * W_{ij}] / \sum W_{ij} \qquad (6)$$

where

ROI_i = recreation opportunity index for category i (i= 1,2...12)

RPP_j = resource per population index for resource j

W_{ij} = expert opinion weight for RPP_j in category i

The 12 ROI values for each county were themselves indexed across all counties, where the highest ROI value for each recreation environment was assigned an index value of 100. This recreation environment index was the Weighted Opportunity Set Index (WOSI) for the county. WOSI values describe the relative availability of recreation opportunities within a county and allow comparison of recreation opportunities across counties.

Step 4

WOSI values do not account for all recreation opportunities available to households. Intercounty travel implies use of resources in nearby counties. Harrington (1987) felt that households would distribute their use across all sites to even out congestion costs. We incorporated that idea, allowing an osmotic flow of trips from counties with different resource availabilities. For example, households in counties with low resource availability (low WOSI values) will go to nearby counties with higher availabiity because sites there should be less congested. Overall, effective recreation opportunity for households in one county will be increased (decreased) if nearby counties have relatively greater (lesser) opportunities.

The magnitude of the effect of a nearby county on recreation opportunities is determined by the distance separating the counties and the type of opportunity. Empirical research (Cordell and English 1985) has shown that there are differences in household travel patterns for different activities. It was assumed that each WOSI could have a unique threshold (maximum) distance, and that any counties within the threshold distance could affect the recreation opportunities available to a household.

The threshold distance for each recreation opportunity type was estimated in the following manner. An expert panel of recreation researchers estimated the proportion of recreation trips for 50 activities occurring in each of the 12 recreation environments. Trip data from the 1985-1987 Public Area Recreation Visitor Study were weighted by these proportions and classified by primary trip activity. Weighted trip data provided a distribution of visitor travel distances. It was assumed that the highest 15 percent of travel distances represented vacation travel. Clawson (1984) deleted vacation travel from his effectiveness calculations because one of the unique characteristics of vacations is the desirability of long travel. Vacation trips were deleted here as well. Travel distance at the 85th percentile of each recreation environment was assumed to be the threshold distance for that environment. Threshold distances ranged from 40 miles for developed water resources to 250 miles for developed snow activities (primarily skiing).

The magnitude of the opportunity effect of counties within the threshold declines with distance. More distant resources are less important to effective recreation opportunity supply because they require higher travel costs. Travel cost models assume that travel costs rise linearly with distance (Clawson and Knetsch 1966; Walsh 1986). Effectiveness of resources was assumed to decline linearly with distance, and to vanish at the threshold distance. Distances between counties were measured from county centers. The effectiveness decay weight (EW_i) for each opportunity set i between any two counties x and y was dcfined as:

$$EW_{ixy} = 1 - (D_{xy} / TD_i) \qquad \text{if } D_{xy} \le TD_i$$
$$EW_{ixy} = 0 \qquad \text{if } D_{xy} > TD_i$$

where
D_{xy} = distance between counties x and y
TD_i = threshold distance for opportunity set i.

Step 5

The Effective Recreation Opportunity Set (EROS) index for a county is based on WOSI values, threshold distances for recreation environments, and effectiveness decay weights between counties. For any county **x,** EROS values were calculated as:

$$EROS_{ix} = \frac{\sum_{y} (WOSI_{iy} * EW_{ixy})}{\sum_{Y} EW_{ixy}} \qquad i=1,2,.. \qquad (7)$$

where
EROS, = EROS value of recreation environment i for county x
$WOSI_{iy}$ = WOSI value of recreation environment i for county y
EW_{ixy} = effectiveness decay weights between counties y and x for recreation **environment** i.

For any county, the most important determinants of EROS values are the resources available in that county. Proximity to a county with a large resource mass may greatly augment effective supply. Similarly, proximity to other counties with large population concentrations and few resources will reduce effective opportunities when these competing populations are taken into account. Small counties have larger adjustments from surrounding counties because of greater effectiveness weights associated with the surrounding counties.

EROS values have been used to compare the relative abundance of effective supply of different types of recreation opportunities across regions and to track the anticipated future changes in recreation supply availability (Cordell and others 1990). EROS values have also been used as regressors representing substitute recreation opportunities in modeling **annual** recreation trip demand and consumption and the value of outdoor recreation trips (Bergstrom and **Cordell 1991;** Cordell and Bergstrom 1991).

Empirical Example

Consider an area comprised of nine square counties, numbered 1 through 9 (fig. 1). County numbers appear in the bottom left corner of each county and centers are marked by asterisks. Let each county be **900** square miles in area. We will develop an EROS measure for each county for water-based recreation. Let each county contain three relevant recreation resources: (1) acres of lakes, (2) numbers of boat launch ramps, and (3) miles of lakeshore. The amounts of resources aud population in each county are shown in table 1. It is assumed that county 6 is devoid of lakes, and hence of both boat ramps and lakeshore miles.

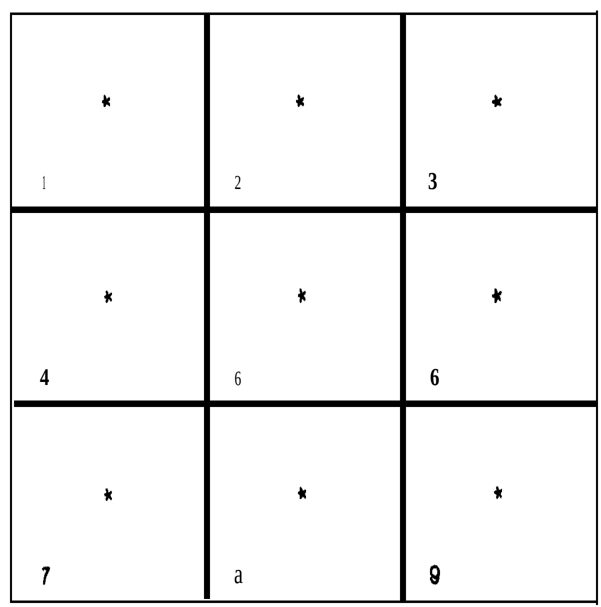

Figure 1 . Layout of hypothetical counties.

Table l--Resource and population amounts for empirical example counties

County	Acres of lakes (1000s)	Number of boat ramps	Miles of lakeshore	Population (1000s)
1	15	5	60	75
2	20	10	40	75
3	10	15	100	150
4	50	25	254	25
5	40	20	160	40
6	0	0	0	20
7	120	80	440	20
8	70	35	230	10
9	50	50	225	25

Step 1

Resource per population **values** for lake acres **(RPP1),** boat ramps **(RPP2),** and lakeshore miles (RPP3) are shown in table 2. County 8 has the greatest **availability** of both lake acres and lakeshore miles per capita. County 7 has the greatest per capita **availability** of boat ramps.

Table **2--Resource** per population (RPP) values and indices, example data

County	Values			Indices		
	RPP1	RPP2	RPP3	RPP1	RPP2	RPP3
1	0.20	0.07	0.80	2.9	1.8	3.5
2	0.27	0.13	0.53	3.9	3.3	2.3
3	0.07	0.10	0.67	1.0	2.5	2.9
4	2.00	1.00	10.00	28.6	25.0	43.5
5	1.00	0.50	4.00	14.2	12.5	17.4
6	0.00	0.00	0.00	0.0	0.0	0.0
7	6.00	4.00	22.00	85.7	100.0	95.7
8	7.00	3.50	23.00	100.0	87.5	100.0
9	2.00	2.00	9.00	28.6	50.0	39.1

Step 2

Due to the **small** number of counties in the example, RPP **values** were not truncated. Index **values** were **calculated** based on the absolute maximum RPP values. Indices for each resource are **also** shown in table 2.

Step 3

The central resource for this recreation opportunity is acres of lakes. It was assigned a weight of 3. Both boat ramps and lakeshore miles provide access to the water, and each was given a weight of 1. The sum of **all** weights equals 5. Recreation opportunity indices (ROI) for counties range from zero for county 6 to 97.5 for county 8 (table 3). In general, the RPP index of the central resource determines the ROI values. For eight of the nine counties, ROI values are within 5 points of the RPP index level of the central resource. The relative abundance of lakeshore miles and boat ramps in county 9 increases the **overall** ROI **value almost** 7 points above the RPP index for lake acres. WOSI values for each county are created by indexing ROI **values** to the largest ROI **value** for **all** counties (table 4). **Values** range from zero to 100.

Step 4

Distances between county centers are presented in table 5. Distances range from 30 miles to 84.8 miles. For this example, let the threshold distance for water recreation be 45 miles. This implies that the EROS **value** for any county **will** depend on its own WOSI **value** and the values of **only** those counties that adjoin it. Effectiveness decay weights between pairs of counties have been calculated according to the formula given previously and are shown in table 6.

Table **3--Resource** Opportunity Index (ROI) calculation, example data

County	RPP1 •	Wt1 t	RPP2 *	Wt2 t	RPP3 •	Wt3/5 =	ROI
1	2.9	3	1.8	1	3.5	1	2.8
2	3.9	3	3.3	1	2.3	1	3.5
3	1.0	3	2.5	1	2.9	1	1.7
4	28.6	3	25.0	1	43.5	1	30.9
5	14.2	3	12.5	1	17.4	1	14.5
6	0.0	3	0.0	1	0.0	1	0.0
7	85.7	3	100.0	1	95.7	1	90.6
8	100.0	3	87.5	1	100.0	1	97.5
9	28.6	3	50.0	1	39.1	1	35.0

Table C-Weighted Opportunity Set Index (WOSI) calculation, example data

County	(ROI	/ MAXROI)	* 100 =	WOSI
1	2.8	97.5		2.9
2	3.5	97.5		3.6
3	1.7	97.5		1.7
4	30.9	97.5		31.7
5	14.5	97.5		14.9
6	0.0	97.5		0.0
7	90.6	97.5		92.9
8	97.5	97.5		100.0
9	35.0	97.5		35.9

Table 5--Mileage between county centers, example data

County	1	2	3	4	5	6	7	8	9
1	0.0								
2	30.0	0.0							
3	60.0	30.0	0.0						
4	30.0	42.4	67.1	0.0					
5	42.4	30.0	42.4	30.0	0.0				
6	67.1	42.4	30.0	60.0	30.0	0.0			
7	60.0	67.1	84.8	30.0	42.4	67.1	0.0		
8	67.1	60.0	67.1	42.4	30.0	42.4	30.0	0.0	
9	84.8	67.1	60.0	67.1	42.4	30.0	60.0	30.0	0.0

Table 6--Effectiveness decay weights between county pairs, example data

County	1	2	3	4	5	6	7	8	9
1	1.00								
2	0.33	1.00							
3	0.00	0.33	1.00						
4	0.33	0.06	0.00	1.00					
5	0.06	0.33	0.06	0.33	1.00				
6	0.00	0.06	0.33	0.00	0.33	1.00			
7	0.00	0.00	0.00	0.33	0.06	0.00	1.00		
8	0.00	0.00	0.00	0.06	0.33	0.06	0.33	1.00	
9	0.00	0.00	0.00	0.00	0.06	0.33	0.00	0.33	1.00

Step 5

EROS values for each county are presented below.

County	EROS
1	9.0
2	5.6
3	2.2
4	35.2
5	26.4
6	11.1
7	79.9
8	70.8
9	40.7

EROS values were calculated by:

$$EROS_x = \frac{\sum_{y=1}^{9} (WOSI_y * EW_{xy})}{\sum_{y=1}^{9} EW_{xy}} \qquad (8)$$

where

$EROS_x$ = EROS water recreation value for county x

$WOSI_y$ = WOSI value for county y

EW_{xy} = effectiveness decay weight between counties y and x.

EROS values range from about 2 to almost SO. The effect of the EROS calculation is to even out disparities across counties in the within-county availability, the WOSI values. The seven counties with the lowest WOSI values show increases in recreation availability when opportunities in nearby counties are included. Similarly, the two counties with the highest within-county availability show reduced availability when use pressures from nearby counties are taken into account. The greatest adjustment to within-county resource availability comes for counties whose neighbors have the greatest difference in resource availability. County 8 ranked highest in its within-county availability but dropped to second in EROS value because of its proximity to counties 5 and 6, which are relatively much worse off.

Conclusion

The EROS supply measures developed in this Paper are based on and incorporate existing theory and empirical research related to outdoor recreation supply. EROS describes the supply of recreation opportunities specific to recreation environments. By using weighted combinations of indices, EROS can account for the variety of resources that make up a particular type of recreation environment. Analysis could be extended to include quality and additional capacity measures, as the available data permit. EROS accounts for effectiveness of resources, as proposed by Clawson (1984), by including both distance measures between counties and estimation of threshold distances for recreation trips. Harrington's (1987) congestion costs are incorporated by population density weights. EROS measures also could be extended to include differential congestion effects of population subgroups on resources. For example, changes in elderly population may have less effect on wilderness congestion than would changes in younger populations.

Further research is needed to define and assess the role of quality measures for each recreation environment and the component resources. At present, quality measures are only marginally included. In addition, research is needed to validate the resources that describe each recreation environment and to assess their relative importance. Fiiy, research should be undertaken to further develop the estimates of threshold distances and to test the assumption of a linear decay function for resource effectiveness.

The primary advantage to EROS over effective price is that EROS can be calculated from existing resource, travel, and population data. These two measures are important advances in economic analysis of recreation opportunity supply. Combii these with demand-side developments, especially household production functions for recreation, provides a sounder base for economic assessments of outdoor recreation and wilderness.

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APPENDIX

Flowchart for calculating EROS values.

STEP 1	Calculate resources per population (RPP)	
STEP 2	Index RPP values to 95th percentile value	
STEP 3	Calculate recreation opportunity index (ROI)	**Resource importance weights (W)**
	Index ROI values to get weighted opportunity set index **(WOSI)** values	
STEP 4	Calculate effectiveness weights **(EW)**	
STEP **5**	Sum weighted WOSI values = effective recreation opportunity set (EROS) index	

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The EROS Set index is an economic measure of the availability of recreational opportunities to households and was developed for use in the 1989 Renewable Resources Planning Act Assessment. EROS indices are location specific, and can be calculated for any desired recreational environment or opportunity set using existing resource, population, and recreational travel behavior data.

Keywords: Supply, outdoor recreation, household production theory, effectiveness.

English, Donald B.K.; Cordell, H. Ken. 1993. Effective recreation opportunity set (EROS) index: a computable measure of recreation supply. Res. Pap. SE-286. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 11 pp.

The EROS Set index is an economic measure of the availability of recreational opportunities to households and was developed for use in the 1989 Renewable Resources Planning Act Assessment. EROS indices are location specific, and can be calculated for any desired recreational environment or opportunity set using existing resource, population, and recreational travel behavior data.

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The Forest **Service,** U.S. Department of Agriculture, is **dedicated** to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives-as directed by Congress-to provide increasingly greater service to a growing Nation.