Economic Value of Ecosystem Attributes in the Southern Appalachian Highlands

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Abstract

The hedonic travel cost method was used to make preliminary estimates of the economic value of ecosystem attributes found in the Southern Appalachian highlands. Travel costs were estimated using origin-destination data from Wilderness Area permits, and site attribute data were collected by field crews. Ecosystem attribute price frontiers were estimated and used to estimate attribute demand functions. Preliminary analysis of a data subset indicated that wilderness visitors hold relatively high consumer surplus values for viewing large trees, and lesser consumer surplus values for viewing rhododendron and the availability of camping areas. Overall, these initial results indicate that the hedonic travel cost method can be a useful tool to help land managers weigh the costs and benefits of various ecosystem management practices.

Introduction

Widespread public concern with sustainable patterns of economic development have engendered programmatic responses such as the USDA Forest Service's recent mandate for ecosystem management. The success of ecosystem management as a guiding paradigm for national forest management will depend upon the ability of proponents to articulate and operationalize basic concepts that distinguish this approach from other approaches to land management. Proposed goals for ecosystem management such as ecosystem health (Costanza and others 1992) and ecological integrity (Woodiey and others 1993) are not value-free concepts and can be evaluated only from the point of view of a value system. An understanding of human values relating to ecosystems is essential for ordering priorities and making management decisions,

Human values can be articulated from many disciplinary perspectives including ethical, cultural, esthetic, and economic. While we encourage the development of pluralistic value theories with the goal of establishing criteria with which to evaluate the success of ecosystem management, in this paper we focus attention on the application of economic theory to the articulation and measurement of value. The economic concept of value that we utilize has its foundation in neoclassical welfare economics. This concept is based on the premise that each individual is the best judge of how well off they are in any particular situation and that an individual's welfare depends on their consumption of both private goods and services provided by the market and their consumption of nonmarket goods and service flowing from the environment (Freeman 1993). This focus on the individual does not negate or necessarily omit ethical or altruistic values held by individuals.

Four basic economic methods can be used for valuing nonmarket forest resources: the contingent valuation method, the generalized travel cost method, the discrete choice random utility model, and the hedonic travel cost (HTC) method. In this study we use the hedonic travel cost method to estimate the economic value of specific forest ecosystem attributes in the Southern Appalachian mountains. Rather than valuing a particular species of animal or a particular recreational site, the HTC method is used to value a set of attributes that characterize both the biotic (e.g. vegetation type and size) and abiotic (e.g. campgrounds, roads) attributes of a forest ecosystem. The types of ecosystem attributes that are valued by the HTC method are also those attributes that are subject to management decisions. The value estimates can be directly compared with management costs to facilitate management planning and decision making.

The Hedonic Travel Cost Model

The basic theory underlying the HTC was initially elucidated by Brown and Mendelsohn (1984). Since that time few studies on the HTC method have been published and none to our knowledge have been conducted in the South. A recent study by Englin and Mendelsohn (199 1) on forest attribute values in the Pacific Northwest is germane to our study.

The overall goal of using the HTC method is to evaluate changes in net economic benefits accruing to consumers of nonmarket forest attributes when the levels of attributes change. We begin by assuming that individuals make recreational decisions by considering the attributes inherent to various forest areas and the specific costs of accessing those areas. The consumer's problem is to maximize utility subject to budget constraint:

$$Max\ U(Z,X) + \lambda(Y - C(Z) - XP) \qquad (1)$$

where U is individual utility, Z is a vector of forest characteristics, X is a vector of all other goods, P is a

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vector of market prices, C is the cost of purchasing a trip with characteristics Z, and λ is the marginal utility of income. The first order conditions for constrained utility maximization require that the individual set the marginal value of each attribute equal to the cost of enjoying it; likewise, the marginal values of consuming other goods are set equal to their marginal costs:

$$U_{z(i)}/\lambda = C_{z(i)} \text{ also } U_{x(i)}/\lambda = p(i), \qquad (2)$$

where the subscripts denote partial derivatives. Equation 2 says that the marginal value to the individual of forest characteristic z(I) is equal to the marginal cost of accessing that characteristic in the same way that the marginal value of a market good is equal to its price. Because attribute values are not directly observable (i.e. there is no market for them) marginal costs are used to estimate marginal attribute benefits.

By analyzing how far individuals travel to access forest sites with different bundles of characteristics, we can estimate the marginal cost of obtaining individual forest characteristics. Of course, the access cost to any particular bundle of attributes depends upon the individual's origin. Therefore the first step in the HTC method is to estimate the implicit marginal costs (benefits) of forest characteristics for each origin zone by regressing site attributes on travel costs:

$$C = C(Z) = c_0 + \sum_{i=1}^{m} c_i z_i \qquad (3)$$

By combining the first-order conditions with the consumer's budget constraint, a system of individual demand equations for the set of forest attributes can be derived and written as:

$$Z = G(C_z, W), \qquad (4)$$

where W is a vector of individual characteristics by origin zone. In order to estimate equation (4), sufficient variation must exist in the estimated marginal costs C,. That is, the sample must contain origin zone information for individuals with dispersed locations around forest destinations. To be consistent with a well-behaved utility function, the demand system in equation (4) should have negative own price terms and symmetric cross-price terms. The latter condition is imposed by estimating the demand system using seemingly unrelated regression with symmetry constraints.

Marginal attribute values as estimated by equation (3) are useful for estimating the value of a small change in the quality of a single site. The marginal social value of such a change is the sum of the marginal dollar costs across all visits to the site. Forest attribute demand curves, on the other hand, can be used to measure changes in values (consumer surplus) associated with changes in the systemwide level of a particular characteristic across all levels of that characteristic. Consumer surplus values associated with policy changes that influence the height but not the shape of the hedonic price gradient can be measured by the area under the demand function minus the travel cost:

$$\int_0^{z_j'} G(C_{z_j}, W)\,dq - C_{z_j}' * z_j', \qquad (5)$$

where z_j' is the typical consumption level of ecosystem attribute z,.

Data

Three types of data are generally required to implement the hedonic travel cost method. First, information on individual origins and destinations are required to compute travel costs. Second, information about the attributes of the forest system at the sites chosen by recreationists is also required. Finally, it is useful to obtain information about individual characteristics that enter the model as demand shifters.

The origin-destination data were obtained from Wilderness Permit registration cards for wilderness areas in the Southern Appalachian mountains. Cards are collected from voluntary registration boxes on various ranger districts and sent to the regional headquarters in Atlanta for processing. With the cooperation of the recreation staff in Atlanta, we were able to receive a computerized record of the coded information. The wilderness permit cards include information on zip code, entry and exit points, and length of trip. Round-trip distances were computed using the ZIPFIP software package.

Information on forest attributes along the trails identified by the wilderness permits was collected by students from the Yale School of Forestry and Environmental Studies. The decision on which forest attributes to measure was made in collaboration with district rangers and wilderness and recreation specialists for the sampled forests. Field crews hiked trails and made observations every fifth mile on a list of trail attributes including basal area, forest type, stream crossings, and views. Trail attributes were collected for the first 3 miles of each included trail. After this distance, intersections with other trails made it impossible to unambiguously assign routes to individuals. Trailhead information was also recorded for such attributes as campsites and parking spaces.

Finally, socioeconomic information on individuals by origin zone is available in the Census and other data sets provided with the ZIPFIP software. This allows us to test for the influence, if any, of variables such as income and percentage of urban population on the demand for individual forest characteristics.

Results

The results presented in this section are based on analysis of a subset of the overall data. As such they should be viewed as strictly illustrative. The entire data set consists of over 2,500 observations on trips to wilderness areas in Tennessee, North Carolina, and Georgia. The preliminary results are based on a subset of 305 observations on trips to wilderness areas in Tennessee from eight origin zones in relatively close proximity to the wilderness areas.

Table 1 provides the descriptive statistics and acronyms for the forest attributes considered in the preliminary analysis. The ecosystem components we studied were (1) the average basal area along the trail in trees greater than 1 foot in diameter, (2) the proportion of observations along the trail with rhododendron thickets, (3) the number of waterfalls viewed along the trail, (4) whether or not the trail passed through a clearcut (outside the wilderness area), and (5) the number of campsites within 5 miles of the trailhead.

One of the keys to a successful implementation of the HTC method is deciding which attributes to include in the estimation system. Table 2 shows the relationship between ecosystem variables. It is not surprising that we found correlations between the various ecosystem attributes. The implication of this result is that forest attributes may be proxies for distinct ecological types. For example, rhododendron is generally found at mesic sites at low and middle elevations. An important area for future research is to explore how groups of attributes such as elevation, aspect, vegetative cover, and basal area may be combined to represent an array of ecological types that can be included in the demand analysis.

Table 1-Descriptive statistics for forest attributes

Acronym	Variable	Mean value (std. dev.)
LARGE	Avg. basal area in trees >1' dbh	14.52 ft^2 (2.93)
RHOD	Proportion of obs. with rhododendron	0.66 (0.31)
FALLS	Number of waterfalls	1.46 (0.98)
CLEARCUT	Trail through clearcut, dummy variable	0.14 (0.35)
CAMPG	Number of campsites within 5 miles	46.65 (47.36)

Table 2–Correlation matrix for ecosystem variables

Variable	LARGE	RHOD	FALLS	CLRCUT	CAMPG
LARGE	1.00	0.35	0.06	-0.29	0.77
RHOD		1.00	0.29	-0.51	0.53
FALLS			1.00	-0.15	-0.29
CLRCUT				1.00	-0.34
CAMPG					1.00

Table 3 shows the estimated demand system relationships. As can be seen on the main diagonal, all own-price effects were negative as expected. The off-diagonal effects demonstrate substitute-complement relations. For example, these results suggest that waterfalls and rhododendron are complements in consumption.

Using the parameter estimates from the demand system, the largest estimate of consumer surplus per trip was associated with large trees, followed by the availability of campsites and presence of rhododendron vegetation. Presence of clearcuts had zero consumer surplus for the group of recreationists in our sample, although we expect that this result would not hold for other groups such as hunters. Surprisingly, we also found zero consumer surplus for waterfalls. This is probably due to the small sample size used in the preliminary analysis.

Evaluation of the estimated demand functions showed that the typical quantities consumed of the specified attributes were in the neighborhood of the estimated consumption amount if the attribute could be accessed at zero price. This implies that consumers in our sample are satiated or nearly satiated with the forest attributes we considered. This is not surprising since our subsample was drawn from origins relatively close to the wilderness areas.

Conclusions

Based on our preliminary analysis we conclude that the hedonic travel cost method is a promising method for estimating economic values associated with forest ecosystem characteristics. Because the method relies on observations of actual, versus stated or intended, behavior the method is not subject to the usual criticisms associated with surveys of stated preferences. The method is particularly useful for evaluating the economic impacts of system level changes in the level of particular attributes.

Table 3-Estimated demand system relationships

	LARGE	RHOD	FALLS	CLRCUT	CAMPG	R
LARGE		0	0	0		0.30
RHOD	0			+		0.32
FALLS	0			+		0.91
CLRCUT	0	+	+		+	0.91
CAMPG	-			+		0.50

Note: 0 indicates the relationship was not significantly different than zero at the 0.05 level.

Future research should focus on exploring methods for grouping forest attributes that may better represent specific ecological types. Quantitative information relating changes in the condition of ecological types with economic benefits and costs will help land managers make decisions in the pursuit of ecosystem management.

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United States
Department of
Agriculture

Forest Service

Southern
Research Station

General Technical
Report SRS-17

Integrating Social Science and Ecosystem Management: A National Challenge

Proceedings

September 1997

Southern Research Station
P.O. Box 2680
Asheville, NC 28802

Integrating Social Science and Ecosystem Management: A National Challenge

Proceedings of the Conference on Integrating Social Sciences and Ecosystem Management

Helen, GA
December 12-14, 1995

Editor:

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