Measuring Environmental Quality in the Southern Appalachian Mountains

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ABSTRACT: This study presents a method for valuing recreational environmental quality in the forests of the southeastern United States. The paper offers a method for choosing, measuring, and valuing forest attributes. Surveys and popular recreation literature are used to identify forest attributes that contribute to recreational quality. Standard ecological techniques are employed to measure levels of these attributes along trails in Tennessee, North Carolina, and Georgia. Finally, the paper demonstrates how hedonic methods can be used to assign values to forest attributes. We show that values for recreational quality vary across users and sites. Furthermore, we demonstrate the existence of negative marginal values for certain forest attributes and provide evidence that suggests these negative values are not the result of mis-specification, but are consistent with oversatiation. For. Sci. 44(4):603–609.

Additional Key Words: Hedonic, recreation, valuation, nonmarket.

For the last several decades, there has been an increasing call throughout the United States for forestry to become more environmentally sensitive. Nonetheless, it remains unclear precisely how foresters are expected to translate this message into action. Specifically, it is not yet clear what society wants foresters to manage for, if not timber. Should foresters manage for bigger trees, more big game, more song birds, paved roads, easier hiking trails, no clearcuts? If some of these goals are mutually exclusive, which ones are more important? What environmental values should be applied? Traditional forest management has properly come to rely on natural science as a guiding tool in forest management but often has failed to recognize the importance of the wide variety of nontimber human values as well. This study explores the values of wilderness users in the Southeast United States for different forest attributes. By engaging in studies of this type, forest managers can learn how important specific forest characteristics are to society so that management plans can be designed to take these environmental values into account.

This study relies on revealed preference to estimate the economic value of environmental qualities. That is, the technique estimates values by observing what people actually do, not what they say. Specifically, by observing where people choose to recreate, it is possible to determine the importance of alternative forest attributes in the destination decision. For example, if they are willing to drive to a site which is an extra 50 miles farther away to see bigger trees than they can see at a nearby trail, these larger trees are worth at least the travel cost of driving 100 round trip miles. On the other hand, if they are not willing to drive an extra 5 round trip miles to get to trails that are wider, then wider trails are not worth very much. To determine these marginal values, we use the hedonic travel cost method (Brown and Mendelsohn 1984). The hedonic travel cost method has been applied to value a number of outdoor characteristics including steelhead populations (Brown and Mendelsohn 1984), deer populations (Mendelsohn 1984), forest attributes in the Pacific Northwest (Englin and Mendelsohn 1991) and fishing populations in the Northeast (Englin et al., 1991, Pendleton 1996, Pendleton and Mendelsohn 1998).

In this study, we extend the hedonic travel cost method to study the values of forest attributes in the Southeast. Whereas previous nonmarket forest studies have relied on general measures of attributes, this study focuses on careful measurement of a host of forest attributes for improved accuracy and relevance. Attributes are chosen based on their relevance to forest managers and hikers and our

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Acknowledgments: The authors wish to acknowledge the USDA Forest Service for their financial and logistical support. The authors would also like to thank several anonymous reviewers for their suggestions.

Manuscript receivedApril 30, 1998. Accepted June 10, 1998.

ability to measure them accurately. To ensure both accuracy and objectiveness, we employ ecological transect methods to measure forest attributes.

Methods

Englin and Mendelsohn (1991) develop a precise theoretical foundation for the HTC method. The HTC assumes that visitors choose a site that maximizes a utility function conditional on the visitor having decided to take a trip. The utility function contains arguments that include a vector of attributes for the site chosen, Z_i, and a vector of all other goods, W, available at prices, P. The visitor is also assumed to face a budget constraint in which the sum of the costs of traveling to a site, $C(i)$, and expenditures on all other goods, WP, are equal to the visitor's income, Y. The term i refers to the site chosen.

When utility is assumed to have a quadratic functional form:

$$U = \frac{1}{2}(Z_i - A)B^{-1}(Z_i - A) + W \tag{1}$$

(A is a vector of constants)

utility maximization results in a system of linear demand functions:

$$Z = A + BC_z \tag{2}$$

where C_z is a vector of marginal prices for attributes Z. If the utility function is well behaved, the individual's per trip demand for an attribute is downward-sloping in its own price, B_{ii} (see Englin and Mendelsohn 1991 or La France 1985), and the coefficients on cross-price terms (B_{ij}) are symmetric.

The hedonic method is a two-step procedure where the marginal values, C_z, are estimated in the first stage for each origin, and the demand function is estimated in the second stage across all origins. Whereas the demand functions are important for estimating nonmarginal changes, the first stage price regressions are sufficient for valuing marginal changes in attributes. We focus, in this paper, on the first stage regressions because most land management decisions involve making small changes on the land. Having some clear values for the environmental benefits of these changes should be an invaluable tool for forest managers.

The marginal value for a site characteristic is estimated for each origin. All the households who reside in this origin and visit a site are asked where they chose to visit in the last year. The characteristics of each destination are then measured. For each origin, the marginal values are determined by regressing the travel cost, TC, to each destination on the vector of forest characteristics for that site, **Z**. For origin j, we estimate

$$TC^j = f^j(\mathbf{Z}) \tag{3}$$

The value of a marginal increase in a site attribute at a particular destination site is the sum of the marginal value for that attribute, say z_k, across all the n^j users of the site from origin j, summed across all origins:

$$MV(z_k) = \sum_j n^j \frac{df^j(\mathbf{Z})}{dz_k} \tag{4}$$

The marginal values for each trail are the same for everyone from a specific origin, but they tend to be different for each origin. The values are summed across users because forest attributes are public goods that are shared by all users. Sites which have many users tend to have larger total marginal values.

In this analysis, we assume that (3) is linear:

$$TC = \sum a_i z_i \tag{5}$$

The marginal value for attribute z_k is therefore:

$$MV(z_k) = \sum_j n^j a_k \tag{6}$$

The marginal value of attribute z_k is the sum of the coefficient a_k across all users who visit the site.

We do not estimate a participation function in this paper. In response to changing a site attribute, it is possible that a manager would affect not only the site quality but also the number of visitors to the site. This would change social marginal values because it makes the number of visitors a function of site attributes as well, instead of a constant as in Equation (4). Because it omits this effect, Equation (4) underestimates the value of site quality changes. Including visitation rates in site valuation is investigated further in Pendleton (1996) and Pendleton and Mendelsohn (1997).

Study Area and Data Collection

This study examines wilderness recreation in the southern Appalachian Mountains of North Carolina, Tennessee, and Georgia. Data were collected on 4778 visitors to 46 trails in 20 different forest areas. The total data set includes information on visitors to this region from across the country, but we limit our study to people within 300 miles of the North Carolina and Tennessee border. All visitor data came from one of two sources, the USDA Forest Service (USFS) and our independent survey efforts.

Visitor data were collected during 1992 and 1994. The USFS collects information voluntarily from individuals visiting its wilderness areas in the region. Registration boxes at trailheads or wilderness borders have permit cards that are to be filled out by visitors. One permit card is required per party.[1] These cards report hikers' zipcodes, and the trail to be hiked. If the trail was not identified, the permit was not used for analysis. It is not possible to know whether any permits represent repeat visits by any party.

Table 1. Descriptive statistics for selected forest ecosystem attributes.

Attribute	Description	Mean (SD)
Basal area	Square meters/ha	14.96 (4.83)
Big trees	No. of trees greater than 30cm dbh in prism plot	3.24 (1.13)
Boulders	% of trail through boulders	32 (35)
Riparian	% of trail along creek	31 (25)
Hardwood	% of trail through predominantly hardwoods	55 (32)
Hillside	% of trail along mountainside	49 (35)
Elevation	Maximum elevation of trail (m)	310.27 (100.98)
Mixed wood	% of trail through mixed woods	30 (23)
Rhododendron	% of trail through rhododendron	67 (27)
Ridge top	% of trail along ridges	24 (30)
Softwood	% of trail through predominantly softwood	15 (20)
Valley	% of trail in valleys	27 (28)
Woody debris	% of trail with "blowdowns" nearby	83 (18)
Isolation	Kilometers from paved road to trailhead	11.53 (12.04)

Hiker information from several nearby popular trails in North Carolina and Georgia were collected to augment the permit information data. Surveys were conducted in nonwilderness area trails, trails in the State Park system, and a trail in the Great Smoky Mountain National Park. The inclusion of these other sites provides additional variation in forest attributes. The data were aggregated by the visitors' origin of travel.

The HTC method requires detailed data on the level of site attributes experienced by each visitor to a particular destination in the study. We relied on trail guides to identify which trail attributes are likely to be important to visitors. While written trail guides can provide a wealth of knowledge and information, they do not provide the same information for each trail. No single guide provides data on the entire study area, and there are large differences between the quality of the data in each guide. Trail guides also tend to make qualitative observations about areas rather than actually measuring the attributes in question. Because the HTC requires quantification of the environmental attributes of each site, we used the trail guides solely as a means of identifying important site attributes.

We combined basic ecological measurement techniques with coarse subjective measurements to create measures of trail attributes. First, we identified a unit of measure that could serve as an index for the level of a given attribute. For example, we used *big trees* (the number of trees greater than 30 cm dbh that fall within a forester's prism) as a general measure of the number of big trees along a trail, and we used a simple presence (1) or absence (0) measure to indicate if the trail was in a valley (*valley*). Each attribute was measured at fixed intervals along the trail (every 0.3 km) using pedometers to mark distance. In this study, we calculated average values for the first 5 km of each trail.[2] Thus, *valley* captures the proportion of a trail that is in a valley and *big trees* measures the average number of big trees along the trail. *Elevation change* is the number of meters of vertical gain or loss from the trailhead to the highest point along the first 5 kilometers of the trail. Descriptive statistics for selected forest ecosystem attributes along trails in the southern Appalachian Mountains are shown in Table 1.

We test how familiar hikers are with the trails they choose. Revealed preference methods assume that hikers make well-informed decisions about the quality of potential recreation sites. Individual survey data were collected using intercept surveys at different trailheads for 213 people on 10 different trails in North Carolina. (Because surveys were initiated only for willing participants, it is not possible to calculate an exact response rate.) Table 2 presents summary statistics explaining how people found out about the sites. Almost all respondents had some prior knowledge of the site visited. Over four-fifths of the sites had been recommended to hikers by friends, guidebooks, or USFS personnel.

Table 3 reveals which forest attributes were important to visitors. Each particular reason was scored on a scale of 1 (least) to 5 (most) important. The top rated reasons are given in the table. Based on the results from Table 3 and information from the trail guides, we identified forest attributes that were relevant to hikers and amenable to a standard metric. Sometimes, however, we were forced to use a proxy for the desired attribute. For instance, the availability of views was captured by the proxy variable "*elevation*"; proximity to water was measured as the percentage of trail along a creek or body of water (*riparian*), and *isolation* was measured by the distance from the nearest paved road to the trailhead.

Table 2. Source of information concerning trail.

Source	Proportion
Friend	0.40
Guidebook	0.36
Map	0.09
Forest Service personnel	0.05
Live in area	0.04
Club	0.02
Other	0.04
Observations	213

1 Watson et al. (1992) found that the mean party size for wilderness areas in the Southeast was 3.7 people.

2 Original distances were measured in English units and converted to metric. Distances in the text are rounded.

Table 3. Average importance of characteristic in choosing trail on a scale of 1 (least) to 5 (most).

Reason	Average response
Views	2.92
Water	2.89
Isolation	2.76
Close to home	2.67
Wildlife	2.20
Flowers	2.06
Observations	213

Basal area was used to capture a suite of ecosystem attributes related to the biomass of trees along a trail.[3] Forests with more basal area are more closed and likely to have different wildlife than forests with less basal area.

Many forest attributes are spatially collinear, albeit not perfectly, because ecosystem attributes are not entirely independent (see Table 4). For example, *basal* area is positively correlated with *hillsides* and negatively correlated with *riparian* areas; maximum trail *elevation* is positively correlated with the proportion of observations along *ridges*. The high degree of collinearity among forest attributes led to the selection of a parsimonious representation of attributes to include in the study. This selection procedure increases econometric performance, but many attributes reflect the value of correlated but omitted variables. One consequently must be cautious not to interpret the results for each attribute too literally.

Results

The first stage of the hedonic travel cost analysis estimates the hedonic prices for site attributes. We estimated the marginal price of trail attributes by regressing total travel costs of sites visited, *C(Z)*, on levels of environmental attributes at these sites. Because the geographic configuration of sites differs for every origin, a different hedonic price function is estimated for each origin. We include only those sites actually visited by residents of a given origin. It is assumed that sites that are not visited are not on the hedonic price frontier (i.e., these sites are inferior). We assume that the hedonic price function is linear:

$$C(Z) = c_0 + c_1(basal) + c_2(elevation) + c_3(riparian) + c_4(isolation) \quad (7)$$

[3] Our measure of basal area is slightly lower than estimates from McClure and Knight (1984) for fully stocked 40- to 80-yr-old stands in the Southeastern Mountains. Two explanations for lower basal area are that stands are not fully stocked in many wilderness areas and that our measurement plots were centered on the trails themselves. Measurements from trails are likely to reduce basal area because trees do not grow in the trails themselves. Because we are interested in variation in basal area among different trails, the average differences between our measurements and those of McClure and Knight are irrelevant. Furthermore, our measurements are a more accurate indication of the basal area that hikers are experiencing than general measurements from plots off the trail in the same forest.

Table 4. Simple correlation coefficients between selected forest ecosystem attributes along trails in the southern Appalachian Mountains.

Attribute	Basal	Riparian	Elevation	Isolation
Basal	1.00	–0.37	–0.07	–0.14
Big trees	0.38	–0.02	–0.19	–0.40
Boulders	–0.44	–0.01	0.20	0.44
Riparian	–0.37	1.000	–0.48	0.02
Hardwood	0.02	–0.02	–0.01	0.44
Hillside	0.47	–0.535	0.20	–0.41
Elevation	–0.07	–0.48	1.00	0.02
Mixed wood	0.00	0.14	–0.18	–0.42
Rhododendron	–0.09	0.12	–0.22	–0.17
Ridge top	–0.26	–0.43	0.33	0.34
Softwood	–0.03	–0.13	0.22	–0.20
Valley	–0.29	0.69	–0.61	0.15
Woody debris	–0.29	–0.05	0.07	0.27
Isolation	–0.14	0.02	0.02	1.000

The coefficients, c_i, represent the marginal cost or marginal price the user (in our case the party)[4] from an origin must pay in order to get one more unit of attribute z_i. Because we run a different regression for each origin, a different vector of hedonic (marginal) prices, C_Z, exists for each origin.

For this study, we use average *basal* area, proportion of trail along creeks (*riparian*), maximum *elevation* along trail, and *isolation* (kilometers from paved road to the trailhead) as our primary forest attributes. (Other specifications, using different attributes, were also estimated, but none performed as well in terms of the significance of coefficients and goodness of fit.) The levels of the attributes can be managed by rerouting trails or by managing forests. For instance, the level of *basal* area could be controlled by changing harvesting in a forest. The fact that *basal* area is shown to be a good in this study signals that forest managers can improve the recreation value of their forest by managing tree density. Such management may include longer rotations, selective harvesting to favor faster growing trees, planting particular species, or rerouting trails.

As with all travel cost studies, there is some controversy concerning how to measure the travel cost per kilometer. We present the results of this study assuming that travel costs per kilometer traveled are \$0.15. We assume that visitors are engaged in single site trips, and that the costs include out-of-pocket expenses (such as gas and oil), depreciation, and travel time (we assume that travel time is a linear function of distance). The reported environmental values are proportional to the cost per kilometer so that readers can readily adjust the estimates to alternative travel cost assumptions.

Hedonic prices represent the value, per party, of a marginal change in any particular attribute. Table 5 gives the summary statistics for the hedonic price estimation. Some marginal value (price) estimates are negative. Nega-

[4] Since our data are aggregated by party, our values and costs are per party.

Table 5. Summary statistics for the full set of hedonic regressions. (All prices are per party.)

	Price (basal)	Price (elev)	Price (riparian)	Price (isolation)
Positive prices				
No. of positive prices	22	19	20	11
Mean attribute level (SD)	16.48 (1.52)	256.40 (35.86)	0.32 (0.12)	6.73 (6.09)
Negative prices				
No. of negative prices	6	9	8	17
Mean attribute level (SD)	20.36 (1.89)	314.93 (10.78)	0.30 (0.14)	20.38 (8.52)
Mean price (weighted by visitors/origin) US$[2]	1.57	0.012	21.02	–0.91

tive prices may indicate that the equation is mis-specified. To test for mis-specification, we ran 13 alternative specifications for the hedonic model. Each alternative specification included the 4 original forest attributes plus 1 of the following forest attributes: the maximum number of big trees along a trail; the mean number of big trees along a trail; the percentage of a trail with boulders; percentage of a trail within hardwood forest; percentage of a trail within softwood forest; the percentage of a trail with briars; the elevation change over the first three miles of a trail; the percentage of a trail along a hillside; the percentage of a trail within a rhododendron thicket; the percentage of a trail along a ridge; the percentage of a trail within a valley; and the percentage of a trail with significant woody debris. Combining the 13 alternative specifications and 28 origins, the maximum number of instances in which the sign of a parameter could differ from the original is 364. In fact, the parameter signs differed from the original specification in 18, 26, 17, and 12 cases for the estimated hedonic prices of *basal* area, maximum *elevation*, *riparian*, and *isolation* respectively. The infrequency with which the coefficients change sign under alternative specifications demonstrates the stability of these price estimates and indicates it is not likely that negative prices are due to omitted variables.

Negative prices may indicate that the attribute in question is undesirable or that visitors from an origin with negative prices actually are oversatiated with a particular attribute (Englin 1986, Englin and Mendelsohn 1991). In markets, attributes that decrease welfare can be easily disposed, but in wilderness recreation it is difficult to dispose of quality attributes that decrease welfare at the margin (i.e., there is no "free disposal"). This leads to the possibility that hikers who live in an area where the closest trails contain more of an attribute than is desired will be observed to travel further to obtain less of that attribute. For example, if a person lives in an area of very high mountains, there may be an abundance of nearby high-elevation hikes. Although elevation may generally be considered to be a good, such a person may be willing to drive further to enjoy a hike at a slightly lower elevation. Because the person is observed to drive further to get lower trails, this behavior implies a negative price for elevation. As shown in Figure 1, it is possible to observe negative prices for attributes which are generally desirable if the consumer is oversatiated. Even though the consumer is observed to avoid the attribute on the margin, it is possible the consumer still has a positive consumer surplus for the attribute.

If oversatiation is causing negative prices to appear, we should observe negative prices when there is more of the attribute. Table 5 indicates that negative prices are associated with higher attribute levels compared to positive prices (all differences are significant at the 0.05 level using a Wald test except for *riparian*, where there is no significant difference). This implies that negative prices reveal important information about how visitors value forest attributes.

The social marginal value for each trail is equal to the sum of prices across all visitors. The social marginal values are of immediate importance to land managers, because they measure the value of changing the characteristics of each trail. Table 6 presents the aggregate social marginal value of each attribute for trails in each of the three states in the study. Our aggregation is based on the annual mean total number of permits completed at each trail during 1992 and 1994. This aggregation should be considered a lower bound because it does not include hikers who fail to complete the trail permits. The results indicate that the sites in Georgia have higher aggregate social values than the other two states. There are more visitors to the sites in Georgia because of the close proximity of Atlanta, the largest metropolitan area in the region.

Even controlling for visitation, however, there are some other important patterns in the data. Data in Tables 5 and 6 show that the per visitor marginal values for attributes are negatively correlated with the quantity of each attribute

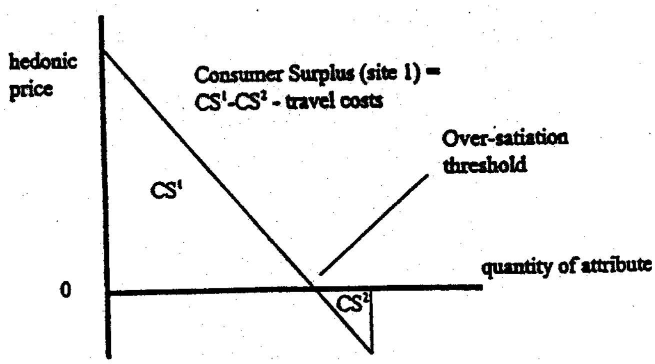

Figure 1. Negative prices and attribute oversatiation.

Table 6. Marginal social values for trails.

	Aggregate social marginal value ($)				Quantities			
	Basal	Elevation	Riparian	Isolation	Basal (m^2/ha)	Elevation (m)	Riparian (%)	Isolation (km)
GA	372	3.40	5,418	–372	14.2	1007	0.35	18.5
NC	8.50	–0.07	3.50	4.00	12.2	1141	0.35	4.13
TN	30.5	–0.09	340	36.5	17.8	911	0.34	5.4
	Mean social marginal value per party ($)							
GA	2.01	0.019	30.05	–2.25				
NC	1.22	–0.006	4.06	0.53				
TN	1.11	–0.003	9.58	0.65				

Simple correlation coefficients for mean social value per party and quantity of attribute chosen (by origin)

Quantities chosen	Mean social value per party: Basal	Elevation	Riparian	Isolation
Basal	–0.356			
Elevation		–0.395		
Riparian			0.011	
Isolation				–0.673

chosen by hikers (except for riparian). These results support the idea that there is a demand function for site quality. Lower marginal values prevail at sites that have an abundance of particular attributes. The results also indicate that if a site attribute becomes too abundant, its price becomes negative. That is, with oversatiation, site qualities that are positively valued when scarce tend to become undesirable when there is too much of them. These results apply to *basal* area, maximum *elevation*, and *isolation*.

The results in Table 6 also demonstrate how important environmental services might be. The values in Georgia for *basal* area and *riparian* of $372 and $5,418 are large and could well justify some adjustment in forest management or trail placement. Isolation, on the other hand, is fairly large and negative, suggesting that visitors to trails in Georgia would prefer less isolation. The values of these variables in Tennessee and North Carolina tend to be more modest in comparison. This, however, does not mean that trails in Tennessee and North Carolina are not valued. It simply means that changes in trail attributes from the current levels would not be highly valued.

Conclusion

This study offers insights on how to identify and collect data to value environmental quality for forest management. Ecological transect methods are shown to be a practical way of measuring environmental attributes in forest wilderness areas. We show how information about ecosystem functions, hiker preferences, and management options can lead to the selection of a parsimonious set of environmental attributes. This study also demonstrates that the hedonic travel cost method is a useful method to value these environmental attributes.

The study estimates a hedonic travel cost model for forest attributes in the southern Appalachian Mountains. The study demonstrates that the marginal social value of attributes depends on the proximity of urban areas and the abundance of the characteristic. The proximity of cities increases visitation which enhances aggregate forest values. The more abundant each attribute, the lower its marginal value. In the extreme, we offer evidence that environmental attributes take on negative values when they are overabundant.

Perhaps the most important result is that we demonstrate that forest attribute values can be large in certain circumstances. Scarce resources near urban areas lead to high environmental values for certain forest attributes. The benefits of providing more environmental services in such cases warrant significant spending. However, care should be applied in not generalizing values from one area to another. We demonstrate that the values placed on forest attributes vary over regions and the origins of visitors. Furthermore, sites with abundant quantities of forest attributes and sites in remote locations away from all population centers often have low marginal values.

Finally, our study demonstrates that travel cost data and the careful measurement of forest attributes can provide important information for forest managers—information not available from standard travel cost analyses.

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