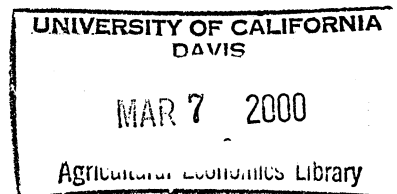# Multi-Purpose Trip Valuation in Recreation Demand Models: Some Methodological Approaches

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One unresolved issue in recreation demand modeling is how to treat multi-purpose trips. When multiple sites or activities are consumed in a single trip, it is usually not clear what portion of the total trip cost (viewed as a proxy for price) is attributable to consumption of which site or activity (Hanley, Shogren, and White). To avoid this cost-allocation problem, researchers typically assume recreation trips are single purpose trips—individuals are presumed to participate in only one activity at one site (Durden and Shogren). Consequently, the travel or trip cost can be interpreted as a proxy for the price of the single recreation experience or site. In many cases estimates of the value of individual recreation activities or sites are desired.[1] Therefore, it becomes important to be able to estimate the value of individual activities when multiple activities are consumed each trip. Surprisingly, this problem has received little attention by empirical researchers (Smith).

This paper explores ways to relax the restrictive single-purpose assumption and estimate the value of recreational activities when multiple activities are consumed at the same site within behavior-based recreation demand models. As such, we focus our attention on the case where individuals are purposeful in visiting a single site, but participate in multiple activities once at the site. In what follows, several approaches that treat multiple activities as characteristics of sites chosen or as choice variables in utility-theoretic frameworks in order to estimate the value of specific activities within a multiple-activity setting will be discussed.

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[1] This is particularly true in light of the increased use of benefit transfer, which relies in part on accurate activity-specific benefit-estimates, as a cost-effective tool in policy analyses by resource agencies such as the U.S. Forest Service, U.S. Fish and Wildlife Service, and the California Department of Transportation

I.   Learning from the Multiple-Destination Trips Literature

In general, little work has been done to address multi-activity trip phenomena in recreation demand models.[2] A notable exception is a study by Creel and Loomis. In this study, separate activity-trip frequency functions for combinations of three recreation activities were estimated by Poisson regression as the second stage of a linked discrete-choice travel cost demand model. Activity quantities are treated as homogeneous across trips—the quantity of an activity per trip is 0 if the individual did not participate in the activity on the trip or 1 if they did. The end result of this procedure is separate estimation of demand functions within subsets of the sample with common activity portfolios. This eludes the cost-allocation problem by treating each observed combination of activities as a distinct recreation activity. In effect, this approach is an application of a suggestion made by Mendelsohn, *et al*. for multiple-destination trips applied to the multiple-activity problem. To avoid the cost-allocation problem, Mendelsohn, *et al*. suggested treating each combination of visited sites as a separate "site" and estimating separate demand functions for each.[3]

When estimating the value of recreation activities using the approach suggested by Mendelsohn, *et al*. and by Creel and Loomis, a quantity dimension is ignored. Individuals consume one unit of a recreation activity for each trip that they take in which they participate in

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[2] Other studies dealing with multiple-destination trips contain ideas applicable to the multiple-activity setting as well. Hanley, Shogren, and White, and Haspel and Johnson discuss ways to allocate costs based on importance, marginal distance between sites, and by giving each site equal weight. Once the prices of destinations (activities) are identified, they can be used in standard constrained utility maximization to yield estimable site (activity) demand functions. The fundamental problem with applying cost-allocation schemes such as these to model either multiple-destination or multiple-activity trips is that they are ultimately arbitrary. A priori, researchers have no way to know what fraction of travel costs to assign to each site or to each activity. Thus, the approaches suggested by Hanley, Shogren, and White and Haspel and Johnson effectively represent *ad hoc* methods used to circumvent the cost-allocation problem

[3] The approach assumes an individual maximizes a common utility function with respect to each combination of observed recreation activities (which are primitive to the individual's utility) subject to a budget constraint with trip costs representing prices, thus retaining consistency with a utility-theoretic framework. Therefore, if $\mathbf{a} = (a_1, \ldots, a_n, a_{n+1}, \ldots, a_m)$ represents the vector of n activity levels and m-n combinations of activity levels, the utility function can be written as $U = U(\mathbf{a}, y)$, where y is all other goods.

the activity, no matter how long they spend in the recreation activity. However, defining activity quantities in this manner does not capture differences in either time spent in the activity or the intensity of the experience.

The remainder of the paper is focused on developing methodological approaches to value activities in a multiple-activity setting where we assume that a_{ij} can be defined as a dummy variable indicating availability of the jth recreation activity or as the amount of time spent in activity j for all $i = 1,\ldots,n$ sites. We begin by considering whether activity demand functions can be derived within a utility-theoretic framework by treating activities as choice variables or whether activities are more appropriately modeled as characteristics of trips. To this end, the multiple-activity valuation problem is discussed in terms of a household production function (HPF) model. Using the HPF model, it is shown that activity demand functions cannot be obtained in the model due to joint production of recreation activities. As a consequence, several approaches that treat activities as characteristics are discussed and methodological approaches to value these activities are pursued.

II.   A Household Production Function Approach

Initially suggested by Becker and Lancaster, the household production function model postulates that goods bought by individuals do not yield utility in and of themselves. Instead, market goods are combined with time and other non-market goods, such as environmental quality and time, to produce utility-bearing commodities. These commodities enter directly into the individual's utility function.

Smith and Desvousges provide a version of the HPF model for describing individual's recreation-decision making in a multiple-activity setting for a specified time horizon (generally a season or year). Their model treats recreation activities as commodities and recreation trips as

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the market goods which, when combined with other goods, quality, and time, produce recreation activities. However, in order for commodity prices to be independent of household preferences (a prerequisite for commodity demand functions), the individual's household production technology must exhibit constant returns to scale and no joint production (Pollak and Wachter). This precludes multiple-activity trips, which inherently exhibit jointness in production.[4] Therefore, well-behaved activity demand functions cannot be derived in this framework.

An alternative approach treats the $j = 1,...,m$ recreation activities at each of the $i=1,...,n$ sites (a_{ij}) as characteristics of trips, like environmental quality.[5] Instead of treating recreation activities as primitive to the individual's utility function, consider activities as exogenous characteristics of trips that enter the production function. Then, when combined with trips, $\mathbf{x} = x_1,...,x_n$, to n sites, time spent on each trip to each of the n sites, $\mathbf{t} = t_1,...,t_n$, a scalar x_r representing all recreation goods, and a quality characteristic $\mathbf{q} = q_1,...,q_n$ associated with each recreation site, recreation activities produce some recreation experience commodity (ϕ_r), assumed to be a scalar. Likewise, x_{nr} is a scalar representing non-recreation goods purchased which is combined with non-recreation time (T_{nr}) to yield a single non-recreation commodity (ϕ_{nr}). Therefore, we have

(1) $$U = U(\phi_r, \phi_{nr}).$$

Given convex production sets for the recreation and non-recreation commodities,

(2) $$F_r(\phi_r, \mathbf{A}, \mathbf{x}, x_r, \mathbf{t}, \mathbf{q}) = 0, \text{ and}$$

(3) $$F_{nr}(\phi_{nr}, x_{nr}, T_{nr}) = 0,$$

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[4] Nonjoint production does not permit visits to multiple sites to contribute to the production of the same commodity or recreation activity, nor does it allow multiple activities to be produced from trips to the same site.
[5] It is reasonable to view recreation activities as characteristics of sites for individuals who are familiar with recreation sites in their choice set, and thus have a more or less set pattern of activities they participate in at specific recreation sites.

and quasi-concave utility, (1) can be transformed into a direct utility function that embodies both tastes and technology,

(4) $$u = u(\mathbf{A}, \mathbf{x}, x_r, \mathbf{t}, \mathbf{q}, x_{nr}, T_{nr}),$$

which is also quasi-concave (Pollak and Wachter). By maximizing (1) subject to a money budget, we obtain derived demand functions for trips that reflect both preferences and technology of the form

(5) $$\mathbf{x} = \mathbf{x}(p_r, p_{nr}, t, \rho, \mathbf{A}, \mathbf{q}, T_{nr}, M),[6]$$

where p_r and p_{nr} are the market prices associated with recreation and non-recreation goods, respectively, ρ is the opportunity cost of time, and M is income. Assuming that weak complementarity between trips and activities hold, this derived demand for trips can be used to estimate welfare changes from changes in exogenous activity levels (Bockstael and McConnell).[7] Since we are treating activity levels as characteristics of individual sites, weak complementarity holds trivially.

The HPF model described above motivates the inclusion of the availability of recreation activities as characteristics that enter the consumer's utility function. With this as a starting point, the following two sections propose two alternative methods for valuing individual recreation activities in a multiple-activity setting. In the first approach, availability of recreation activities at each site ($\mathbf{a_i}$) enter as dummy variables in a RUM model. Thus, a_{ij} represents the technological capacity of the ith site to accommodate the jth activity. Although this does not capture quantity differences in recreation activity consumption, it avoids difficulties with

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[6] If production is linear and quality and activity characteristics are exogenous, these demand functions can be interpreted as traditional travel cost recreation demand equations.

[7] Formally, weak complementarity implies the marginal utility of the weak complement (activity at a site in this case) is 0 if the nonessential good (trips to a site) is 0, $\partial U(0, a)/\partial a = 0$. Alternatively, it can be expressed in terms of changes to the expenditure function evaluated at the choke price (p^*) of the nonessential good, $\partial e(p^*, a, U)/\partial a = 0$.

measurement and interpretation experienced when $\mathbf{a}_i$ represents the amount of time spent in each activity, which is discussed using the second approach.

III. Discrete-Choice Random Utility Models of Recreation Demand

Discrete-choice random utility models have become increasingly popular approaches to value environmental quality in the recreation demand literature (Bockstael, Hanemann, and Kling; Caulkins, Bishop, and Bouwes; Feenberg and Mills). Inclusion of recreation activity characteristics within these models is straightforward. Instead of making decisions over a season or year, these models analyze individual recreation decisions on a specific choice occasion. This discrete-choice model of recreation posits that individuals will choose the recreation site that yields the greatest per-trip conditional indirect utility from among the available choices. The weak complementarity that exists between trips, activities, and quality imply the indirect utility function, which is *conditional* on the individual choosing a given site i, can be defined as

$$(6) \qquad U_i = V_i(\mathbf{a_i}, q_i, M_k^f - p_i^f, v_i^f) + \varepsilon_i$$

where V_i is the systematic portion of the indirect utility function arising from a two-constraint joint recreational choice model similar to McConnell (1992). This function depends on the available full income in period k (M_k^f), the travel cost to site i expressed as a full price (p_i^f), the full price of on-site time (v_i^f), site quality attributes assumed to be water quality (q_i),[8] and m dummy variables for availability of recreation activities to the individual at the site ($\mathbf{a_i}$). It is important to note that since per-occasion income does not differ across choices yet is critical for determining the marginal utility of income, researchers employ the specification in (6) for the income term.[9] Also, inclusion of the full price of on-site time follows directly from a consumer

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[8] Although only one quality variable is assumed here, the basic model can easily accommodate multiple quality measures.
[9] This means the coefficient on the income term is the negative of the estimated coefficient on the travel price variable, which must hold due to Roy's Identity.

choice problem where individuals maximize utility by choosing number of trips and the duration of on-site time at each site subject to time and money constraints.

Following the random utility hypothesis, ε_i is known to the individual, but not from the perspective of the researcher. Alternative distributional assumptions about ε_i lead to different estimation models. Given (6), the probability of choosing site i out of n recreation sites can be written as

(7) $\Pr(\text{individual chooses site i}) = \pi_i = \Pr(V_i - V_j \geq \varepsilon_j - \varepsilon_i, \forall j \neq i, j = 1,\ldots,n).$

If all ε_i are i.i.d. type I extreme value random variables, the multinomial logit (MNL) results,[10] thus implying (7) can be written as

(8) $\pi_i = \exp(V_i)/\sum_k[\exp(V_k]$ $\forall k = 1,\ldots,n$ sites

implying the likelihood function is

(9) $$\mathcal{L} = \prod_l \prod_i \pi_i^{d_{il}},$$

for $l = 1,\ldots,L$ individuals in sample and d_{il} is 1 if the individual l chooses site i and 0 if they do not. Equation (9) can be estimated using maximum likelihood (ML) procedures once a functional form is chosen for V_i. Suppose V_i takes a linear form such that

(10) $V_i = \alpha v_i^f + \beta(M_k^f - p_i^f) + \gamma q_i + \delta' \mathbf{a_i}.$

Once the parameters of (10) have been estimated, the per-trip value of the jth recreational activity can be determined by the per-choice occasion compensating variation (Small and Rosen, 1981). If we assume initially the individual participates in the jth activity, we have

(11) $CV_{kj}(a_{ij}^0 = 1 \rightarrow a_{ij}^1 = 0) = \beta^{-1}[I(v_i^f, M_k^f - p_i^f, q_i^0, a_{i1}^0, \ldots, a_{ij}^0, \ldots, a_{im}^0) -$

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[10] The MNL formulation assumes independence of irrelevant alternatives (IIA). In practice, this is often violated because of natural substitution relationships between sites. A potential fix for this problem would be to use a nested multinomial logit (NMNL) approach, which groups alternatives in nests and thus relaxes the IIA assumption between nests.

$$I(v_i^f, M_k^f - p_i^f, q_i^0, a_{i1}^0, \ldots, a_{ij}^1, \ldots, a_{im}^0)],$$

where $I(v_i^f, M_k^f - p_i^f, q_i, a_{i1}, \ldots a_{ij}, \ldots, a_{in}) = \ln[\sum_i \exp(\alpha v_i^f + \beta(M_k^f - p_i^f) + \gamma q_i + \delta'\mathbf{a}_i)], \forall i = 1, \ldots n.$

$I(\cdot)$ is the "inclusive value" and is a measure of the expected maximum utility from site characteristics. The compensating variation (CV_{kj}) in (11) can be interpreted as the per-occasion value of the recreation activity.[11] Equation (11) can be easily generalized to represent the per-occasion value of multiple recreation activities. For instance, the compensating variation associated with a policy or event that precludes the first c activities from being supplied (and thus consumed) is

$$(12) \qquad CV_{event} = \alpha_2^{-1}[I(v_i^f, M_k^f - p_i^f, q_i^0, a_{i1}^0, \ldots, a_{ic}^0, a_{i(c+1)}^0, \ldots, a_{im}^0) -$$

$$I(v_i^f, M_k^f - p_i^f, q_i^1, a_{i1}^1, \ldots, a_{ic}^1, a_{i(c+1)}^0 \ldots, a_{im}^0)],$$

where the first c recreation activities are assumed to be precluded from being consumed when the event occurs ($a_{ij}^1 = 0$) and the environmental quality measure, q_i, changes to q_i^1. The statistical significance of the above welfare measures can be determined using Monte Carlo methods (see Krinsky and Robb, 1986).

Since welfare estimates are based on the estimated coefficients on recreation activity availability and income, it is important to get the most efficient estimates possible. A major benefit of deriving a theoretically-consistent conditional indirect utility function specification that accounts for on-site time is the added information it provides. On-site time is highly dependent on the availability (and choices) of recreation activities. Therefore, it represents a way in which recreation activity quantities can be implicitly included in the welfare estimates. By applying Roy's Identity to (6), we can obtain the conditional Marshallian average on-site

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[11] To obtain the value of a recreational activity per-season, there are two general approaches used in the literature. In the repeated approach, the season is divided into T choice occasions and the site-choice decision can be re-estimated for each choice occasion (Feenberg and Mills; Morey, Rowe, and Watson; Morey, Shaw, and Rowe). The

time demand function, s_i. To illustrate this, we use a Generalized Leontief functional form with quality (q_i) and the superscripts denoting full prices and income suppressed. Therefore, the deterministic part of the conditional indirect utility is

$$(13) \quad V_i(\mathbf{a_i}, M_k - p_i, v_i) = \beta_{10}(M_k - p_i)^{.5} + \beta_{20}(v_i)^{.5} + \Sigma_j\beta_{j0}(a_{ij})^{.5} +$$

$$\beta_{11}(M_k - p_i) + \beta_{22}(v_i) + \Sigma_j\beta_{jj}(a_{ij}) + \beta_{12}(M_k - p_i)^{.5}(v_i)^{.5} +$$

$$\Sigma_j\beta_{2j}(v_i)^{.5}(a_{ij})^{.5} + \Sigma_j\beta_{2j}(M_k - p_i)^{.5}(a_{ij})^{.5}.$$

The Marshallian demand for average on-site time at site i can be recovered using Roy's Identity to yield:

$$(14) \quad s_i(\mathbf{a_i}, M_k^f - p_i^f, v_i^f) = \frac{2{\cdot}\beta_{22} + \left(v_i\right)^{-.5}{\cdot}\left[\beta_{20} + \beta_{12}{\cdot}\left(M_k - p_i\right)^{.5} + \sum_j \beta_{j2}{\cdot}\left(a_{ij}\right)^{.5}\right]}{2{\cdot}\beta_{11} + \left(M_k - p_i\right)^{-.5}{\cdot}\left[\beta_{10} + \beta_{12}{\cdot}\left(v_i\right)^{.5} + \sum_j \beta_{j1}{\cdot}\left(a_{ij}\right)^{.5}\right]},$$

which is observed. The additional information provided by (14) can be used to get more efficient estimates of the parameters by jointly estimating (13) and (14) following specification of an error structure for (14). This joint estimation approach combines two complementary sources of information to obtain more precise parameter estimates and is similar to approaches used by Cameron (1992) and Larson (1990) to combine contingent valuation and travel cost data.[12] A potential problem with this approach is the welfare estimates based on (13) due to the use of non-linear function form specifications for (6) (Herriges and Kling, 1999).

One other issue regarding this method should be mentioned. The use of dummy variables in this approach is necessary to avoid endogeneity of time spent in activities chosen by the individual. If the elements of the vector $\mathbf{a_i}$ are defined as the amounts of time spent in each

second approach links the site-choice decision to a trip frequency function in two stages (Bockstael, Hanemann, and Kling).

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activity at site i, either a discrete-continuous model which predicts both site choice and levels of activities participated in, or a model like the one discussed in the next section is necessary. Bear in mind that empirical difficulties arise with any method that treats a_i as a vector of time spent in activities due to the need for accurate of measurement of time quantities, which may be difficult for respondents in surveys to provide with any level of certainty for past trips.

IV.   The Hedonic Travel Cost Method

First proposed by Brown and Mendelsohn, the hedonic travel cost (HTC) method combines individual travel cost models with hedonic price theory to derive demand functions for recreation site characteristics. Englin and Mendelsohn built on the model proposed by Brown and Mendelsohn by motivating it within a conditional utility framework analogous to the one underlying the RUM approach. Incorporation of activity levels in the model to obtain activity-demand functions proceeds as follows: Conditional upon an individual's choice to take a trip to any site on a given choice occasion, the individual is assumed to choose the activity levels of the $j = 1,...,m$ activities at the site (a_j) and a numeraire good (z) that will maximize his conditional utility (assumed to be well-behaved), which is also a function of quality characteristics of the site, which are assumed to be a scalar for simplicity (q). Thus, the objective is to maximize U(q, $\mathbf{a}$, z), subject to a budget constraint, $p(\mathbf{a}) + z = M_k$, which is assumed to be binding. Here, the price or trip cost ($p(\mathbf{a})$) is a function of the recreation activity level characteristics of the trip, M_k is the income available for the choice occasion, and the price of the numeraire good is unity. Solving the first-order conditions associated with the numeraire good and the m first-order conditions associated with the activities levels (measured in time units) yields the activity demand:

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[12] See Kling (1997) for a discussion of gains in precision and bias from combining contingent valuation and travel cost data.

(15) $$a_j = a_j(\mathbf{p_j}, q, W), \forall j = 1,\dots,m$$

where $\mathbf{p_j}$ is the vector of first partial derivatives of the travel cost equation with respect to the activity levels, and W is an exogenous demand shifter.

Implementation of the model involves two steps: First, the trip cost equation is postulated to be a function of the recreation activity characteristics of the site. Hence, by regressing trip costs on the activity characteristics of the trip, we obtain a hedonic price function,

(16) $$p(\mathbf{a}) = f(a_1,\dots, a_m).$$

This regression is done for subgroups of the sample so that price varies across the sample. These subgroups are determined by the researcher and frequently have been based on residential origin. Typically, $f(\cdot)$ is postulated as linear. This functional form has the convenient property that the implicit prices of characteristics, obtained by differentiating $p(\mathbf{a})$ with respect to the characteristics, are constant. That is, $p_j(\mathbf{a}) = \partial p(\mathbf{a})/\partial a_j, \forall j = 1,\dots,m$, does not depend on the characteristics bundle. In the second step, these hedonic prices are used to estimate (15), from which welfare values of each activity can be obtained by standard consumer surplus calculations using the activity-characteristic demand function (Smith and Kaoru).

This method is ostensibly appealing as a means of estimating the value of recreation activities. However, as noted by numerous authors, the method suffers from several serious empirical and conceptual drawbacks when applied to *site quality*.[13] These difficulties must be confronted before using the method for estimating the value of recreation activities. In a number of applications attempting to estimate the demand for quality, negative implicit prices were estimated for quality characteristics (Bockstael, Hanemann, and Kling; Smith and Kaoru). Bockstael, McConnell, and Strand suggest that this result may be a consequence of a missing

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[13] Pendleton presents a number of counter-arguments to many of these criticisms with respect to site quality.

relationship between quality characteristics and travel costs. This points to a more fundamental difficulty—no market intervenes between buyers and sellers of quality characteristics of recreation sites. In reality, a site's quality characteristics are determined by nature, not by the laws of supply and demand.

A point made by Bockstael, Hanemann, and Kling and by Smith and Kaoru is that the hedonic travel cost approach does not account for total trips taken by the individual in the demand for characteristics. Since welfare estimates calculated from (15) represent per-occasion values of recreation activities, the same difficulties experienced using the RUM in calculating per-season welfare values arises. Moreover, they argue that the two-step estimation procedure requires the researcher to make two key decisions that may affect the results. The first decision regards how to divide the sample for purposes of estimating (16), and the second decision is whether or not to include negative implicit prices should they arise in estimation.

To a limited extent, the concerns expressed by these authors can be ameliorated in an activity-based framework. If travel costs are replaced by total trip costs or on-site costs, a relationship between activity levels and costs is plausible. This interpretation of the appropriate costs to consider in p(**a**) would imply that more recreation equipment purchases and on-site goods and services (e.g. rental equipment) purchases imply more time spent in activities. Thus, in terms of a HPF framework, a "market" for activities may in fact exist. Moreover, per-season welfare estimates based on (15) can potentially be resolved by appealing to methods used to deal with aggregate seasonal values in RUM models discussed above. Unfortunately, an appeal to the nature of activities does not resolve concerns over biases resulting from decisions made in implementation.

V.   Discussion and Further Work

As we have seen, there is no theoretically-sound way to evade the problem of cost-allocation when attempting to estimate *conventional* demand functions for individual recreation activities in the presence of multiple-activity trips. The alternative to *ad hoc* cost-allocation schemes generally advocated is to estimate separate demand functions for combinations of recreation activities. Still, there are reasons this alternative may not be desirable. The HPF model provides justification for treating recreation activity availability as a characteristic of recreationists' trips. This way of thinking about recreation activities seems reasonable. By treating recreation activities as site characteristics, valuation becomes possible within several models. In the two models that we did examine, the HTC and MNL random utility travel cost models, proceeding with valuation of recreation activities was straightforward. This is not to say valuation of recreation activity characteristics in the two models is not without faults. In fact, both models admit several significant problem areas that should be further studied. Furthermore, the discussion primarily centered on conceptual issues, thereby ignoring a fair number of econometric difficulties associated with each approach.

It is also critical to recognize that our discussion of approaches used to value recreation activities as site-specific characteristics within multiple-activity settings has not been exhaustive. The hedonic travel cost demand model and discrete-choice recreation demand model are only two of several potentially plausible approaches that can be used. Other methods that are employed to value exogenous quality changes are candidates as well.

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