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A Boating Choice Model for the Valuation of Lake Access

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This study reports results from the applications of a discrete choice method to alternative choice processes individuals go through and the factors that are considered when making boating decisions. The discrete choice or random utility model for studying outdoor recreation demand is described. Using a random household-based sample of registered boat owners living in the region surrounding the Catawba River Basin in North Carolina, we test our assumptions about the sequences of boating choice decisions that are made by individuals. We begin with a boating activity and destination lake choice problem. We conclude with a more complex choice problem that includes boating activities, an intervening choice of boat launching facilities, and destination lakes. Results indicate that the boating choice model appeared to benefit from this nesting of decisions. Estimations from discrete choice equations produce probabilistic outcomes for boating demands that are useful to managers in determining the amount of boating trips to each lake in a region and in calculating estimates of the willingness to pay per boating occasion to each lake.

KEYWORDS: *Recreation modeling, recreation choice theory, boating benefits, travel cost methods*

Most policies that bear on the management of lakes for public boating have regional use implications, with the lake attributes and individual preferences for boating activities determining the quantity of trips (Bockstael, McConnell & Strand, 1991). Managing authorities work to control boating access to lakes and to comply with a variety of internal and federal regulations compelling them to provide water-based recreation to individuals living in areas surrounding the lakes. For example, managing authorities produce operating plans on a periodic basis for the Federal Energy Regulatory Commission as evidence of their compliance with the region's boating needs. Plans incorporate present and future boating use patterns and address the impact of changes in public and private lake access for existing lake conditions and long-range lake developments. Attempts, then, to value the benefits to boaters from lake management policies should have a regional scope and be based on management's understanding of the underlying preferences of

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boaters and the availability of alternative boating sites (Peterson, Stynes, Rosenthal & Dwyer, 1985). Yet, most studies of lake boating are site specific relying on data from on-site surveys of users.

Conceptual and empirical issues associated with the development of methodologies that are applicable to water-based recreation demand and benefits are discussed by Smith (1989); Fletcher, Adamowicz and Tomasi (1990); Bockstael, McConnell and Strand (1991); and in the proceedings on recreation choice behavior (Stankey and McCool, 1985). An assumption common to the analysis of recreation demand and corresponding welfare benefits is that, when making choices, an individual is maximizing the utility (value) derived from pursuing a particular choice.[1] Unfortunately, with indirect approaches for measuring the demand for lake boating, we can never comprehend all the factors underlying choice decisions and describe comprehensively the sequence of decisions (Smith, 1989). Rather, we are organizing what we hypothesize to be the determinants and constraints of individual decisions to participate in lake boating (Smith).

This article reports results from the applications of a discrete choice method to alternative choice processes that individuals go through and the factors that are considered when making boating decisions in the context of multiple lakes. The discrete choice or random utility model for studying outdoor recreation demand is described by Bockstael, McConnell, and Strand (1991). Using a random household-based sample of registered boat owners living in the region surrounding the Catawba River Basin in North Carolina, we test our assumptions about the sequences of boating choice decisions that are made by individuals. We begin with a boating activity and destination lake choice problem, and conclude with a more complex choice problem that includes boating activities, an intervening choice of boat launching facilities, and finally destination lakes.

Estimations from discrete choice equations produce probabilistic outcomes for boating demands that are useful to managers in determining the amount of boating trips to each lake in a region and in calculating estimates of welfare benefits per boating occasion to each lake. Our welfare estimates are conditioned on a boater wanting to gain access to a lake and if, hypothetically, that boater were to be denied access to the lake per boating choice occasion (Bockstael, McConnell & Strand, 1991). Given the denial of access to a closed substitute lake, the measure of compensating variation, which is

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[1] It is assumed implicitly in the household production theory of recreation economics that the recreational decision unit is a household. Work on a theory of social interaction in a household setting shows that a household's utility function becomes identical to using a single individual's if the household head cares about the welfare of the household members and transfers income among all members (Becker, 1974). Although one member of the household may go boating, the household unit is directly affected by the trip expense and we refer to the economic decision maker as the individual or boater.

calculated from discrete choice models, is interpreted as the welfare estimate of lake access or the amount of compensation per choice occasion an individual in our sample would need if one of the lakes were not made available for a period of time.

Modeling Boating Choice

Consider a simple choice problem of lake boating and three lakes (d). Since we are considering one activity, boating, an individual's choice problem at one occasion in time is among three lakes with the following utility function: $U = U(d_1, d_2, d_3)$. We impose the following restrictions on the choice problem: $d_1 = 1$ *if lake 1 is chosen, 0 otherwise;* $d_2 = 1$ *if lake 2 is chosen, 0 otherwise;* $d_3 = 1$ *if lake 3 is chosen, 0 otherwise,* and only one alternative lake is chosen. Substituting the restrictive values into the utility function above, we obtain three possible combinations of lake values for a boating choice occasion: $U(1, 0, 0)$, $U(0,1,0)$, *and* $U(0, 0, 1)$. The extra twist that has been added to this formulation of the lake demand problem is that the utilities of alternative lake choices are not only a function of the lake chosen but also of competing lakes in the choice set. This type of conditional demand problem is McFadden's choice model (Maddala, 1983; Ben-Akiva & Learman, 1985).

Since substitution among the three lakes is an essential part of the choice problem, discrete choice methods are useful in modeling the choices among potential lakes for a boating occasion, with each occasion assumed independent of the other (Peterson, Stynes, Rosenthal, & Dwyer, 1985).[2] Influencing the boating occasion are the varying physical characteristics of the lakes and individual travel costs to them. Income and other individual-specific variables remain constant in the specification of the three lake choice problem since an individual's income does not vary with the choices of substitute lakes.

A boating occasion may be more than a single decision about substitute lakes. It may embody other decisions that include alternative boating activities, alternative boat storage options, or alternative boat launching facilities. The choice set of one activity and three lakes in our example is a structural condition, imposed by us in framing the lake choice problem and can be changed to a nested decision structure. In application, the nesting of separate decisions into some hierarchal order avoids the independence from irrelevant alternatives (IIA) property of non-nested choice problems by split-

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[2] In contrast, conventional travel cost methods treat each lake as being different, with different demand functions that consider boating demand as a function of each lake. In a preliminary demand analysis, we found it statistically difficult to accommodate the effects of lake characteristics at ten substitute lakes with the more conventional varying parameter demand model.

ting similar alternatives into like groupings (Bockstael, McConnell & Strand, 1991; Maddala, 1983).[3]

Recreation engagement theory suggests that the recreational experience is generally composed of two decisions—an activity and a place (Williams, 1985). When analyzing the sequence of decisions made by individuals in outdoor recreation, the natural partitions between alternative activities and places are not always apparent (Clark and Downing, 1985). Since the nature of choices inherent in the outdoor recreation are complex, the alternative decision sequences of a boating activity and a lake choice in nested structures are not clear cut. We refer to the separate decisions in the nested models as *stages*, and we hypothesize the different choice structures in Table 1.

We begin with a joint decision by a boater to participate in a specific activity and at a specific lake. In the three remaining frameworks in Table 1, the decision processes are analogous to the structures of nested logit models. This implies that the choice of an alternative at each stage in the decision making process is a separate decision and is not dependent on the variables that influenced the previous decision (Bockstael, McConnell & Strand, 1991).

Using the decision structure where alternative destination lakes are nested within boating activities in Table 1, we assume that the activities—boat-fishing, pleasure cruising or motor boating, and water or jet skiing—are not perfect substitutes for one another. In this decision scenario, the distinction between decisions about a boating activity and a destination lake may appear arbitrary; however, one could argue that individuals who take boating trips do plan ahead for particular boating activities, prior to choosing a lake, by assembling specialized equipment (e.g., fishing tackle, bait, water skis, etc.). By nesting the choice of alternative destination lakes within the choice of alternative boating activities, the probability P_{ij} of choosing lake j and activity choice i is equal to the *conditional* choice $P_{j|i}$ of choosing lake j given activity i times the *marginal* choice P_i or $P_{ij} = (P_{j|i})|(P_i)$. The boating choice model takes the following nested form (Greene, 1990):

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[3] In the application of discrete choice theory, we assume that a boater's preferences for lakes are transitive (Maddala, 1983). In our three lake example, the transitivity assumption means that if our boater prefers lake 1 to lake 2 and lake 2 is preferred to lake 3, then our boater prefers lake 1 to lake 3. In choice theory, the dominance of lake 1 indicates that it is the *best* alternative lake since it is better for our boater on at least one attribute, let us say travel cost, and no worse for the other site attributes (Ben-Akiva & Learman, 1985).

Transitivity requires that alternative lakes in the choice set be independent, where the probabilistic version of the order of independence is referred to independence from irrelevant alternatives (IIA) property. If lake 1 is identical to lake 2 in terms of travel cost and site characteristics, then boaters will view the two lakes as a single alternative. This general pattern of dependence among the two lake choices in discrete choice analysis will violate the implicit restriction of the IIA assumption, that is, when there are obvious patterns of potential substitution and complementarity among alternative lakes (Bockstael, McConnell & Strand, 1991). Also, see Stynes and Peterson (1984) for a review of the IIA property and discrete choice models with applications to modeling recreation choice behaviors.

TABLE 1
Alternative Boating Choice Structures

Joint Decision: [P(a) · P(d)]

$$(a_1, d_1) \ldots (a_1, d_n)(a_2, d_1) \ldots (a_2, d_n)(a_3, d_1) \ldots (a_3, d_n)$$

where a = boating activity
l = launching facility
d destination lake

Two-stage Form: [P(a) · P(d|a)]

$$\begin{array}{ccc} a_1 & a_2 & a_3 \\ (d_1 \ldots d_n) & (d_1 \ldots d_n) & (d_1 \ldots d_n) \end{array}$$

Two-stage Form: [P(d) · P(a|d)]

$$\begin{array}{cccc} d_1 & d_2 & d_3 \ldots\ldots\ldots\ldots & d_{10} \\ (a_1\ a_2\ a_3) & (a_1\ a_2\ a_3) & (a_1\ a_2\ a_3) & (a_1\ a_2\ a_3) \end{array}$$

Three-stage Form: [P(a) · P(l|a) · P(d|al)

$$\begin{array}{ccc} a_1 & a_2 & a_3 \\ (l_1 \quad l_2 \quad l_3) & (l_1 \quad l_2 \quad l_3) & (l_1 \quad l_2 \quad l_3) \\ (d_1.d_n)(d_1.d_n)(d_1.d_n) & (d_1.d_n)(d_1.d_n)(d_1.d_n) & (d_1.d_n)(d_1.d_n)(d_1.d_n) \end{array}$$

and n *1,...,10* lakes.

Notes. Boating activities are fishing, pleasure cruising, and water/jet skiing. Launching facilities are public areas, private piers, and commercial facilities. In the notation of probability theory, $P(a)$ is the marginal probability of decision maker choosing alternative a, and $P(d|a)$ is the conditional probability of choosing alternative d conditioned by the choice of alternative a.

$$P_{ij} = e^{(V_i)} \Big/ \sum_i \sum_j e^{(V_{ij})}$$

where we drop the boater's observation subscript, and the summation of i *and* j are the available choice alternatives of boating activities and destination lakes for each of the two choice decision stages.

V_{ij} is the deterministic part or the indirect utility function, and an individual will choose a boating trip that maximizes utility (U), so that $U_{ij} = V_{ij} + \epsilon_{ij}$. By inserting an observable demand function for a boating occasion into the utility function, the indirect utility function is $V_{ij} = \alpha' X_{ij} + \beta' Y_i$, where $i = 1, 2, 3$ activities; $j = 1, \ldots, n$ lakes; and α and β are vectors of unknown parameters.[4] The indirect utility is now a function of X_{ij} and Y_i;

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[4] Maddala (1983) shows that the nested logit model can be derived from the theory of stochastic utility maximization, analogous to that of the multinomial logit. Maddala (1983) reports that the nested multinomial logit model is derived from the assumption that the residuals have a generalized extreme-value distribution that allows for a general pattern of dependence among choices, and avoids the IIA assumption.

not the amount of boating trips taken. X_{ij} is the vector of such observable measures as travel costs and the varying lake characteristics. Y_i is the vector of all individual attributes that vary only with the boating activity.

Although a boater is assumed to select the destination lake with the highest utility, the utility that a boater obtains from participating in a particular activity and using a particular lake is not completely known to us. Consequently, the error part ϵ_{ij} represents the effects of random error about the boater's decision making process. The sources of random error are attributable to omitted variables, measurement error, imperfect information, and the use of a proxy variable like travel cost (Ben-Akiva & Lerman, 1985). The random error has been assumed to have an extreme-value distribution, and is given a random utility interpretation by economists to make it more in line with consumer theory (Bockstael, McConnell & Strand, 1991; Maddala, 1983).[5]

The three-stage decision structure in Table 1 predicts the probability of an individual's choice of boating activity *i*, launching facility *j*, and the destination lake *k*.[6] Conditioned by one of the three boating activity choices, the individual is viewed as choosing an alternative launching facility—public ramp, private facility, or boat slip at a commercial marina. Conditioned by the choice of launching facility, the individual then chooses a lake, where the multiple-activity uses of lakes are not independent of one another. We include the choices of different boat launching facilities for lake access as an intervening decision, and we hypothesize that the different types of launching facilities do influence whether a boater decides to visit a particular lake or not. The probability P_{ijk} that the *ijk* alternative would be chosen is

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[5] Bockstael, McConnell and Strand (1991) note that the random term can have an omitted variable interpretation, which is functionally similar to random utility. In deriving nested structures for recreation choices, discrete choice theorists require us to make assumptions about the joint probability distribution of random errors between alternative choices (Ben-Akiva & Lerman, 1985). In the context of our boating problem, we assume that a boater has $a \cdot d$ feasible *alternative choices* from the combinations of boating activities and destination lakes. For the decision structure of destination lakes nested within boating activities, we have the case where we assume that the random errors of alternative choices having the same boating activity are correlated, but the random errors of alternative choices sharing the same destination lake are not. The opposite case exists for the decision structure where boating activities are nested within destination lakes. Here, we assume that the random errors of alternative choices are correlated when sharing the same destination lake, and random errors are not correlated for alternative choices sharing the same boating activity.

[6] Maddala (1983) suggests that the probability-choice model has a generalized extreme value distribution since the error terms are correlated and the choices are made to maximize utility. From Maddala (1983), the generalized extreme value distribution for the indirect utility function is:

$$G(\cdot) = \sum_i a_i \left(\sum_j \left(\sum_k e^{V_{ijk} / 1 - \sigma_j} \right)^{1 - \sigma_j / 1 - \delta_i} \right)^{1 - \delta}$$

where a_i is a positive value greater than one, σ *and* δ are between zero and one, and *i, j, and k* are the boating activity, launching facility and lake, respectively.

estimated from the conditional lake and launching facility choices and the marginal boating activity choice.[7]

Methodology

The application of discrete choice theory to predict how individuals will choose among the different lakes requires information that we inferred from observations of boaters and from lake characteristics (Table 2). The selection of a random household sample required decisions about the participation region that included the origins from which the lakes drew boaters. Our boating participation region consisted of zip code areas within a radius of 40 to 70 miles around each of the 16 lakes that form the Catawba River Basin in North and South Carolina. From a preliminary survey of 3 of the 16 lakes under study, over 95% of the respondents traveled less than 60 miles.

During 1992, we mailed three separate waves of self-administered questionnaires to a random sample of 1,600 from 174,000 registered boat owners in our boating participation region of North and South Carolina, followed by the appropriate postcard reminders to complete and return to the agency sponsoring this research. The design of the questionnaire, questions, and format was similar to the Raystown Lake, PA, instrument (Graefe, Vaske, Moore, & Lenz, 1988). The questionnaire included items that sought infor-

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[7] From Maddala (1983) and Greene (1990) the system of equations that describe the conditional and marginal probabilities are:

$$P_{k|ij} = e^{(\alpha' X_{ijk})} \Big/ \sum_k e^{(\alpha' X_{ijk})}$$

$$J_{ij} = \log \left[\sum_k e^{(\alpha' X_{ijk})} \right]$$

$$P_{j|i} = e^{[\beta' Y_{ij} + (1-\sigma) J_{ij}]} \Big/ \sum_j e^{[\beta' Y_{ij} + (1-\sigma) J_{ij}]}$$

$$I_i = \log \left[\sum_j \sum_k e^{(\alpha' X_{ijk} + \beta' Y_{ij})} \right]$$

$$P_i = e^{[\gamma' Z_i + (1-\delta) I_i]} \Big/ \sum_i e^{[\gamma' Z_i + (1-\delta) I_i]}$$

X_{ijk} is the vector of all observed attributes that vary with boating activities, launching facilities, and lakes (e.g., travel costs, miles of shore for public use). Y_{ij} is the vector of all attributes that vary only with the boating activity and launching facility alternatives. Z_i is the vector of attributes that vary only with the boating activity. α, β, and γ are vectors of unknown parameters. The variable, J_{ij}, is the inclusive value or measure of accessibility, and it is a scalar summary of the expected worth of the set of lake alternatives to an individual at the next choice stage, in this case launching facilities (Ben-Akiva & Lerman, 1985). Similarly, the inclusive value, I_i, is the attractiveness of alternative types of launching facilities to an individual at the boating activity stage from the conditional launching facilities stage. The terms, $1 - \sigma$ *and* $1 - \delta$, are the coefficients on the inclusive values for the launching facility and activity stages, respectively.

TABLE 2
Lakes and Land-Use Characteristics

Lakes	Water surface (acres)	Private land (miles)	Public access (miles)	Wetlands (miles)
Norman	32,510	332.28	11.96	37.44
Wylie	12,455	210.60	5.53	18.53
James	6,510	6.00	4.65	6.75
Wateree	13,250	172.55	6.53	23.72
Hickory	3,905	.53	42.95	10.29
Lookout	1,150	5.624	2.85	14.80
Rhodhiss	2,758	.36	1.62	5.13
Mountain Is.	3,235	9.27	4.70	24.58
Fishing Creek	1,937	4.51	1.04	14.03
Rocky Creek	1,077	0	.17	.10

Notes. Private land consists of multi-slip, residential, common-use areas.

mation from boaters about their decisions to visit lakes and their perceptions about lakes. Specific information included:

- total trips taken to each of the 16 destination lakes
- trips taken on weekends or throughout the week
- one-way distance and time to lakes
- start trips (home, vacation home)
- preparation and boat launch time
- lake facility used (public, marina, private pier, etc.)
- composition of group (family or friends)
- boating activity done most frequently by lake
- entrance fees
- size of party
- boat storage (home, marina, commercial facilities)
- residence (city/town, zip code)
- occupation
- household income

A total of 498 questionnaires were returned and provided complete information on 857 choice occasions to the 16 lakes. Of the 857 choice occasions, 489 boating occasions were for the 10 destination lakes, managed by our client power company. The 6 remaining lakes are in South Carolina and omitted from analysis due to insufficient data on lake development measures, which were a necessary requirement in this application of discrete choice analysis.[8]

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[8] The basin is a common property resource belonging to several states. Therefore, a charge cannot be levied upon individuals to use the lakes. Shoreline development and lake operations are managed by a power company, which must provide public access ramps to the basin under Federal Energy Regulations.

Many respondents visited the same lakes on repeated trips, and we did not account for repeated trips by weighing each lake that the boater visited by the number of trips taken to that lake. Instead, we applied the consistency assumption of discrete choice theory that an individual, under the same decision making circumstances, will repeat the same choice of an alternative (Maddala, 1983). We assumed that a boater in deciding on a lake, no matter the repeated number of trips made, was considering the same set of circumstances that influenced the initial lake choice. Therefore, one visit of the many trips made by boaters to each of the 10 lakes was considered a representative choice occasion.[9]

Our analysis was limited to boating participants whose sole purpose was to visit a lake.[10] Of respondents in our sample who choose to visit one or more of the 10 lakes, 64 % of the participants used public ramps. The composition of boating groups was 55% family members, and the mean sample travel cost was $55 per trip. The sample of respondents took approximately a mean of 13 boating trips per year with a sample standard deviation of 25 trips per year. The median estimate was 9 trips per year.

Estimation

Table 3 provides a summary of demand determinants, used in our boating trip choice model.[11] Adopting the variable labeling scheme from Greene (1990), the *dummy* variables in Table 3 equaled one if a destination lake and activity choice alternative was chosen and zero's otherwise, and the *individual-specific* variables, planned expenditures and waiting costs, equaled the dollar

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[9] The quantity of lake boating trips, as reported by individuals in boating surveys, is important information and can be viewed as a repeated observation while the characteristics of alternative lake choices remain constant (Ben-Akiva & Lerman, 1985). For example, rather than observing an individual's activity choice for pleasure cruising for a single day, we might observe all his or her choices over an entire boating season, if we assume that the individual and lake characteristics remain constant. We can simply repeat the choice decisions for the number of trip occasions made during the year. However, the inclusion of repeated observations in analysis can be perceived as a potential source of error leading to a mis-specification of the model due to the inability of respondents to recall accurately the number of trips made over a period of time. Statistically, the procedure of treating each individual's trip as separate and independent sample observations, and then applying the appropriate population weights yields exactly the same results with the exception of the log-likelihood functions differing by a constant, which depends on the population weight (Ben-Akiva & Lerman, 1985).

[10] The issue of non-participation, whether an individual chooses a boating or a no-boating alternative, and its exclusion in discrete choice analysis is discussed by Morey, Shaw and Rowe (1991).

[11] We found income to be a non-significant variable in both the boating activity and launching facility choice stages of analysis. Bockstael, McConnell, and Strand (1991) note the failures of recent studies to estimate significant income coefficients, which suggests to them that incomes are more likely to distinguish participants in a recreational activity from nonparticipants. A significant income effect might have resulted if we had analyzed boating and non-boating types of recreation uses like swimming. Income was not included in the analysis of the destination lakes choice stage because a boater's income does not vary with alternative choices of destination lakes, as would travel costs and lake characteristics.

TABLE 3
Definitions of Demand Determinants

Variable name	Definitions
Dummy variables:	
Group Composition	1 if boating activity is with family; 0 otherwise.
Activity Schedule	1 if boating activity is on weekends; 0 otherwise.
Occupational Status	1 if boating activity is by retiree; 0 otherwise.
Start Boating Trip	1 if vacation home; 0 otherwise
Boat storage (home)	1 if home storage;
(marina)	1 if marina storage; 0 otherwise.
Individual-specific variables:	
Planned Expenditure	Expenditures trip per activity; 0 otherwise.
Waiting Cost	Cost of launching and retrieving boat; 0 otherwise.
Lake destination variables:	
Travel Cost	Cost of two-way travel to destination lakes
Public Access Areas	Miles of shore for public access
Wetlands	Miles of shore designated as wetlands
Private Land	Miles of shore with residential developments

Notes. If composition of the boating party is a family, then total trip expenditures are divided by number of people in the party. Planned expenditures did not include cost estimates of fuel for motor boats. Wage rates for occupation categories came from Smith (1989) and are adjusted for inflation. The opportunity cost of travel time and waiting time was derived from survey data following the estimation procedure outlined in the McConnell and Strand (1981) argument and was 60% of wage rate. Millage was $.22 per mile. Boating activities are fishing, pleasure cruising, and water/jet skiing. Boating activity variables are incorporated in discrete choice analysis using the equivalent of dummy variables (Greene, 1990).

amounts spent or zero's otherwise. Greene (1990) discusses procedures for combining dummy and individual-specific variables with lake choice effects in discrete choice models, and points out that failure to follow his procedure results in the dummy variable trap of the linear regression analysis.[12]

We estimated boating choice problems with the discrete choice command in the econometric software LIMDEP (Greene, 1990). Prior to statistical analysis, data were arranged to conform to the data specifications of

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[12] In combining the effects of individual and lake characteristics, fishing and pleasure cruising activities were normalized against the water skiing alternative to avoid the singular Hessian matrix, which is similar to the dummy variable trap in regression analysis (Greene, 1990).

this command. The number of cases tended to be large, due to the stacking of observations by the choice alternatives from one stage to the next stage in the decision process. The groupings of destination lakes by activities was unbalanced and did vary by activities due in part to missing observations of travel costs to substitute lakes. For the two-stage choice structures, a boater on each occasion choose one activity a_i and one destination lake d_j from $a \cdot d$ alternative choice combinations of boating activities and destination lakes, where $i = 1, 2, 3$ and $j = 1, \ldots, n$ lakes. The choice (dependent) variable was set to one and the remaining $(a \cdot d) - 1$ alternatives in the choice set were set to zero's. Missing data for individual-specific and dummy variables were handled internal by the LIMDEP computer program, and did affect the number of cases for analysis at each stage in the estimation process.

Maximum likelihood estimates for discrete choice models were obtained by Newton's method (Greene, 1990). For the two-stage choice model of destination lakes nested within boating activities, the estimation process began with the *conditional* destination lake decision and moved sequentially in reverse order to the initial or *marginal* boating activity stage, while the opposite procedure was done for boating activities nested within destination lakes. Here, the estimation process began with the *conditional* boating activity decision and moved sequentially in reverse order to the initial or *marginal* destination lake stage.

Inclusive values for both choice models were computed by LIMDEP, and served to capture information about the alternative choices in the conditional stage. An inclusive value is a probability-weighted average of the expected similarity of alternative choices to an individual at the next or, in this instance, the marginal choice stage (Ben-Akiva & Lerman, 1985). A coefficient $1 - \sigma$ for the inclusive variable was computed and reported in the marginal choice stage. The theorem by McFadden in Maddala (1983) specifies that the coefficient σ (sigma) of the inclusive values lie on a unit (zero to one) interval. Given the alternative two-stage models in this application, σ related to the level of correlation of random errors among choices of destination lakes that shared common boating activities or among choices of boating activities that shared common lakes.[13] The following interpretations for a statistically significant σ are:

1. If σ is outside the unit interval, this is evidence of specification error (omitted variables) in the formulation of the decision problem and

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[13] The multinomial logit (MNL) model implicitly assumes independence of irrelevant alternatives. This model allows for no specific pattern of correlation among the errors associated with the alternatives. The McFadden choice model incorporates the varying correlations among the errors associated with the alternative choices. Since the errors have a generalized extreme value distribution, McFadden proved that a pattern of dependence or correlation among alternative choices can be allowed and σ (sigma) can be interpreted as an indicator of the similarity within groups of alternatives. See Maddala (1983) for a proof of the theorem by McFadden that relates the generalized extreme value model to a utility maximization framework to be consistent with the nested logit model.

consequently, the model must be re-formulated (Ben-Akiva & Lerman, 1985; Maddala, 1983).

2. When σ equals zero, the analysis reduces to a simple multinomial logit between alternative choices at the conditional decision stage with no violation of irrelevant alternatives in the choice set (Bockstael, McConnell & Strand, 1989).
3. If σ equals one, the conditional alternative choices within each choice group at the marginal stage are perfect substitutes for one another and our two-stage problem is now only among alternative choices in the initial or marginal decision stage (Bockstael, McConnell & Strand, 1989).

The goodness-of-fit measures in discrete choice analysis is the *pseudo* R^2 or ρ^2 (rho-squared or likelihood ratio index). ρ^2 is calculated from $\rho^2 = 1 - L/L^R$, where **L** is the unrestricted log-likelihood and L^R is the restricted log-likelihood summary values (Greene, 1990). There are no guidelines for when a ρ^2 is sufficiently high and the measure is most useful when comparing alternative specifications develop on the exact same data (Ben-Akiva & Lerman, 1985).

Results

Joint and Two-stage Choice Models

Joint and two-stage models showed that the probability of choosing a lake diminished with increasing travel costs. Travel costs were clearly a determinant of lake choice and had the anticipated negative influence on the likelihood of choosing a particular lake. As expected, the miles of shoreline with public access areas and private land were positive and significant determinants, while the miles of wetlands were a significant and negative determinant of lake choice. However, the joint decision specification was better $\rho^2 = .23$ than either of the two-stage nested specifications ρ^2's $= .15$. We support the joint decision as having the better choice structure, and summarize the results in Table 4.[14]

Coefficients for the dummy variables—family, weekend, and retiree—as well as the individual-specific variable, planned boating expenditures, were normalized against the boating activity choice of water or jet skiing. We used this device so that the choice models would be estimable and avoid the dummy variable trap of the linear regression analysis (Greene, 1990). The proxy variable for occupational status, retiree, was significant having an influence on the likelihood of choosing fishing and pleasure cruising at a destination lake. The significance of remaining dummy variables for group composition and activity schedule were mixed between the joint decision

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[14] T-ratio values are asymptotic (large sample) estimates and apply to the *n* sample values in the various stages of discrete choice analysis, not the initial household sample (Ben-Akiva & Lerman, 1985).

TABLE 4
Maximum Likelihood Estimation Results for Joint Decision Model

Variable	Coefficient estimate	Standard error	*t*-value
Family (Fishing)	.30568	.262494	1.165
Family (Pleasure Cruising)	.362875	.292177	1.242
Weekend (Fishing)	.65444	.243983	2.682
Weekend (Pleasure Cruising)	.35193	.275786	1.276
Retiree (Fishing)	2.50821	.749717	3.346
Retiree (Pleasure Cruising)	1.75508	.784146	2.238
Planned Expenditure (Fishing)	.01730	.009755	1.773
Planned Expenditure (Pleasure Cruising)	−.00747	.012451	−.600
Travel Costs	−.04335	.004924	−10.099
Public Access Areas	.08864	.037402	2.370
Wetlands	−.05432	.011982	−4.533
Private Lands	.00474	.009196	5.157
Summary statistics			
Number of cases	9405		
Log-likelihood	−420.74		
Restricted (Slope = 0) Log-L	−543.81		
Chi^2 (12)	337.21		
ρ^2	.23		

Notes. Corrected standard errors from LIMDEP (Greene, 1990). Coefficients for family, weekend, retiree, and planned expenditures are normalized to the choice of water/jet skiing. The pseudo R^2, ρ^2, is the likelihood ratio index and is presented as a goodness-of-fit measure. t-statistics are asymptotic for the null hypothesis of no association.

model and two-stage nested models. Among choices of boating activities, the significance of the dummy variables and the planned expenditures for fishing would suggest that these variables adequately explained activity choices. Reported lake choice characteristics significantly influenced the likelihood of the boater choices of the destination lakes.

For the choices of destination lakes nested within boating activities decision structure, an inclusive coefficient $1 - \sigma = .29$ was calculated for the inclusive variable from the first or lake choice decision stage, implying a $\sigma = .71$. For the alternative structure of boating activity choices nested within the choices of destination lakes, we estimated a coefficient $1 - \sigma = .05$ for the inclusive variable and a $\sigma = .95$. The standard errors surrounding the inclusive coefficients were almost twice as large as the coefficients in both estimations; the coefficients were therefore not statistically different from zero. The non-significance of the inclusive coefficients indicated that we derived no benefits from nesting boating activity choices and destination lake choices. Furthermore, the lack of significant inclusive coefficients suggested that combining boating activities and destination lakes into the joint decision would violate the IIA property, and implied that an exploratory variable like alternative boat launching facilities, omitted from the joint decision analysis, might be an appropriate choice to include as a separate decision in the boating choice process.

Three-stage choice model

As was the case with the two-stage choice structures, the probability of choosing a destination lake in the three-stage model, displayed in Table 5, diminished with increasing trip costs and the miles of wetlands. Travel cost was a determinant of lake choice with the anticipated negative influence on the likelihood of a boater choosing a particular lake. The miles of shoreline with public access areas and private land were positive and significant determinants of lake choices.

Waiting costs, home storage of boats, marina storage of boats, starting a trip from second homes, and the inclusive coefficients were all significant determinants in the conditional choice of launching facilities chosen. Waiting costs had a negative influence and the storage of boats at homes and marinas were positive.

The estimated value of the inclusive coefficient was $1 - \sigma = .38$ and therefore an estimate of $\sigma = .62$. Unlike the two-stage choice structures, the σ estimate was significantly different from zero, which suggested that we gained a better understanding of the boating choice decision process by nesting destination lakes within alternative choices of launching facilities. The estimate of σ was different also from one, which indicated that the destination lakes within alternative launching facilities were not perfect substitutes for one another and that a simple model with choices limited to only substitute destination lakes would have violated the IIA assumption.

The estimated inclusive coefficient in the marginal boating activity stage was $1 - \delta = .82$ and therefore an estimate of $\delta = .18$. The δ estimate was significantly different from zero, which suggested that the alternative launching facilities were not perfect substitutes and that we benefited from nesting launching facilities. Results from the marginal activity stage showed that the probability of choosing a boating activity was not affected by planned activity expenditures. Fishing diminished significantly (*.05 level*) on weekends, and we speculate this was due to crowding at ramps or perceived conflicts between fishermen and other boaters since the probability of pleasure or motor boating increased on weekends. The remaining group composition, occupational dummy variables, and the planned expenditures for pleasure cruising were omitted from analysis because the inclusive coefficients $1 - \delta$ were outside the one unit interval during repeated maximum likelihood estimations and re-specifications of the marginal activity stage (Ben-Akiva & Lerman, 1985). Although reported, little insight into the boating activity choice process was gained from the inclusion of the dummy and individual-specific variables. The $\rho^2 = .37$ exposed the significance of the inclusive values rather than the dummy and individual-specific variables.

TABLE 5
Maximum Likelihood Estimation Results for Three-stage Boating Choice Model

Variable	Coefficient estimate	Standard error	*t* value
Travel cost	−.023337	.004080	−5.719
Recreational facilities	.137237	.038286	3.585
Wetlands	−.049060	.011744	−4.177
Private facilities	.004128	.000923	4.472
Waiting cost	−.36920	.117733	−3.136
Boat storage (home)	1.54036	.312007	4.937
Boat storage (marina)	1.85639	.387855	4.786
Start (vacation home)	1.50842	.437967	3.444
Inclusive value ($1 - \sigma$)	.38037	.125432	3.033
Planned expenditure	.036940	.046333	.797
Weekend (pleasure)	.106275	.544552	.203
Weekend (fishing)	−.808667	.480225	−1.684
Inclusive value ($1 - \delta$)	.823551	.095941	8.584

Stage 3. Summary (conditional lake choice)
Number of observation = 4,260
Log−likelihood (L) = −926.98
Restricted (L^R) = −1,044.1
$\chi^2 = 234.2$
$\rho^2 = .112$
Stage 2. Summary (conditional launching facility choice)
number of observation = 1,479
Log-likelihood (L) = −364.88
Restricted (L^R) = −541.62
$\chi^2 = 353.47$
$\rho^2 = .326$
Stage 1. Summary (marginal boating activity choice)
Number of observation = 1,479
Log-likelihood (L) = −338.97
Restricted (L^R) = −541.62
$\chi^2 = 405.3$
$\rho^2 = .374$
Combined Model Summary
Log-likelihood (L) = −1630.83
Restricted (L^R) = −2127.34
$\rho^2 = .234$

Notes. Corrected standard errors for three-stage model (Greene, 1990). Coefficients for boat storage are normalized to the choice of private storage facilities, such as piers. Coefficients for weekend schedule are normalized to the choice of water/jet skiing. *t*-values are asymptotic for the null hypothesis of no association. In the notation of probability theory, the nested form of the boating choice model is $P_{ijk} = P_{k|ij}|(P_{j|i})|(P_i)$, where *i* is a boating activity, *j* is a launching facility, and *k* is a destination lake.

On theoretical grounds, the three-stage choice structure was satisfactory because the inclusive coefficient estimates were in agreement with the requirement that they be within zero and one. The goodness of fit measures for the conditional launching facility choice of $\rho^2 = .33$ and marginal boating activity choice of $\rho^2 = .32$ were higher than the conditional lake choice of $\rho^2 = .11$. The combined summary from the three stages of the maximum likelihood estimators was a $\rho^2 = .23$.

Discussion

In our attempt to unravel the boating choice process and to derive monetary values of lake access, the application of discrete choice methods provided insights into the decision-making structure of boaters. A decision to participate in a specialized activity was dependent on an individual's decision factors and on lake characteristics. In the context of regional boating where substitution among lakes was an essential part of the problem, individuals made choices about boat launching facilities as well as the boating activities and the lakes that supported such activities.

The joint decision and the three-stage structures had comparable ρ^2's of .23. In the three-stage structure, a significant σ was obtained by hypothesizing that the utilities of destination lakes shared a common launching facility and alternatives choices sharing common destination lakes were not correlated with one another, which affirmed the importance of including choices of boat launching facilities in our understanding of the boating decision process. The inclusive values were significant and the coefficients were within the one unit interval at the conditional boating launching and marginal boating activity stages. The demand determinants of travel expenditures and waiting costs had the expected negative signs. In commenting on the sensitivity of our results to the imposed three-stage choice structure of the final boating trip choice model, our hypothesized structure of boating decisions should not be interpreted as support for our specification over other specifications. The physical characteristics of our choice set of lakes, the classification of launching facilities, and the kinds of boating activities were defined by a common management policy. The selection of lakes was set by their natural geographical pattern as part of the Catawba River Basin.

The expected conditional and marginal probabilities, produced by the three-stage structure, were interpreted as shares of an individual's total trips. For example, the marginal probability of an individual choosing to motor boat for pleasure was 21.93%, and the conditional probability of that individual choosing a public access area was 31.28%, and at Lake James was 10.26%. Although estimating probable outcomes of a boating decision were important for boating trip estimation purposes, of more importance for our purposes were the resultant welfare effects of lake access.

Lake Access Values

Welfare measurement in the context of discrete choice models and the derivation of equations that defined the appropriate welfare measures are described by Bockstael, McConnell, and Strand (1991). The computation of lake access values is derived from a measure of compensating variation (*cv*) that is interpreted as the maximum amount a boater would be willing to pay for the opportunity to gain access at current travel costs. However, our welfare estimates were conditioned on a boater wanting to gain access to a lake and if, hypothetically, that boater were to be denied access to the lake per choice occasion. For a denial of access to a substitute lake, *cv* estimates measured what must be paid to the boater to make that boater indifferent to the new choice set of substitute lakes (Bockstael, McConnell & Strand, 1991; Bockstael, Hanemann, & Kling, 1987). Therefore, we interpreted the amount of compensation per choice occasion an individual in our sample would need if one of the lakes were not made available for a period of time as the value of lake access.

We calculated the utility of each discrete boating choice with the expected maximum utility equation that measured the lose from eliminating an individual's access to a boating lake (Bockstael, McConnell, & Strand, 1989):

$$cv = -\frac{1}{\alpha_1}\left[lnG(e^{v_1^1}, \ldots, e^{v_n^1}) - lnG(e^{v_1^0}, \ldots, e^{v_n^0})\right],$$

The *cv* represents the compensation for a change in lake access from the current situation where an individual has access to lake V^1 to a hypothetical situation where the individual is denied that lake choice V^0, which requires that the individual now choose from a reduced set of substitute lakes. The parameter α_1 takes the value of the travel cost coefficient, but is interpreted as the marginal utility of income since it is assumed that an individual's income does not vary across choices of alternative destination lakes (Kaoru, 1991). Using the *cv* equation, we calculated the access values per choice occasion for the hypothetical elimination of lakes from further boating use and reported them in Table 6.

The first entry in Table 6 gives the individual per choice occasion *cv* estimate for fishing while using a public access area for boat launching at Lake Norman. A person fishing, on the average, would need to be compensated $13.33 per fishing occasion when using a public launching facility if some action precluded access to Lake Norman. The values in Table 6 were averaged over all individuals in the sample with considerable differences in compensating variations across boating activities and launching facilities found in our sample. The values of substitution possibilities for fishing ranged from $16.74 to $1.85; for pleasure or motor boating, from $22.09 to $1.90; and for water or jet skiing, from $33.82 to $4.28. An individual's *cv* was higher if there was a higher probability that the boater would chose the affected choice alternative, which meant that the absence of this boating alternative will have a greater effect on the boater's indirect utility function. Table 6 also reflects the different values of boating substitution possibilities among destination lakes. In addition, lake access values could be multiplied

TABLE 6
Lake Access Values Per Choice Occasion

	Boat launching facilities		
Lakes	Public ($)	Private ($)	Marinas ($)
	Fishing		
Norman	13.33	14.26	16.74
Wylie	7.77	7.38	8.87
James	4.60	4.99	5.90
Wateree	4.13	4.63	4.44
Hickory	3.32	3.70	4.12
Lookout	2.75	3.13	3.24
Rhodhiss	3.50	4.04	4.42
Mountain. Is.	2.22	2.46	—
Fishing Creek	1.85	2.09	—
Rocky / Cedar Cr.	2.90	—	—
	Pleasure / motor boating		
Norman	16.05	22.09	19.76
Wylie	7.95	11.75	10.24
James	4.64	5.75	5.65
Wateree	4.03	6.16	4.86
Hickory	3.53	4.41	4.61
Lookout	3.00	—	3.82
Rhodhiss	3.61	—	—
Mountain. Is.	2.44	—	—
Fishing Creek	1.90	—	—
	Water / jet skiing		
Norman	22.69	23.19	33.82
Wylie	13.09	12.78	13.91
James	6.91	4.58	8.35
Wateree	8.33	5.85	—
Hickory	—	4.28	—

Notes. For example, boaters wanting public access at Norman Lake for fishing were willing to pay $13.33 to maintain access to this lake.

by the predicted number of annual trips the household takes to obtain annual benefit estimates.

Since our primary interest is the study of outdoor recreation, a comprehensive model about the decision-making behavior of boaters allowed us to ask relevant shoreline development questions and provide lake access values, an important planning product in the analysis of the cost and benefits of alternative development strategies. Alternatively, we can calculate a similar type of welfare effect for hypothetical changes in the shoreline miles of future developments to the alternative types of boating uses. Although a simulated increase in miles of shore for recreational facilities or private development was not reported, the effect of an expansion in alternative development policies at one or more substitute lakes could be studied with the boating choice model.

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