CONJOINT ANALYSIS: A PRAGMATIC APPROACH FOR THE ACCOUNTING OF MULTIPLE BENEFITS IN SOUTHERN FOREST MANAGEMENT

By

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CONJOINT ANALYSIS: A PRAGMATIC APPROACH FOR THE ACCOUNTING OF MULTIPLE BENEFITS IN SOUTHERN FOREST MANAGEMENT[1]

ABSTRACT. With conjoint analysis as its foundation, a practical approach for measuring the utility and dollar value of non-market outputs from southern forests is described and analyzed. The approach can be used in the process of evaluating alternative silvicultural and broader natural resource management plans when non-market as well as market outputs are recognized. When applied to the case of designing a nature and recreational park within a pine forest of North Carolina, the approach accurately predicted potential visitors' first choice, from five competing options, at rates as high as 86.7%.

CONJOINT ANALYSIS: A PRAGMATIC APPROACH FOR THE ACCOUNTING OF MULTIPLE BENEFITS IN SOUTHERN FOREST MANAGEMENT

Public and private southern forests provide individuals with multiple benefits derived from outputs that are both traded and not traded in the marketplace. An accurate accounting of both pecuniary and non-pecuniary benefits, along with cost data, is needed by policymakers and forest resource managers in order to evaluate the relative attractiveness of various forms of alternative forestry-related plans and decisions.

Pearse and Holmes (1993) reviewed the theory of non-market valuation and alternative approaches for estimating the non-market values produced by southern forests. Their framework emphasized applications for managers of public forests. Our paper presents and analyzes a pragmatic approach, not reviewed by Pearse and Holmes and rarely applied in the past to forestry problems. The approach can be adapted and extended to the task of valuing non-market benefits from the perspective of either private landowners or users (or prospective users) of forests. With conjoint analysis serving as its foundation, this approach offers the following potential advantages or additional applications (vis-a-vis one or more of the alternative approaches for valuing non-market benefits):

- It does not require the respondent to participate in the oft-confounding task of estimating a willingness-to-pay (WTP) level for some incremental level of a non-market benefit.
- It does not require the respondent to participate in a simulated referendum, which is often a poor reflection of conditions faced by decision makers.
- It can simultaneously capture the relative importance and value of a number of non-market benefits.
- It provides a means of estimating the values of resource attributes at varying levels, thereby allowing resource benefit estimates to be transferred from test sites to alternative sites.
- It allows a direct evaluation of use- and passive- (or non-use) values of natural resources to be made.
- As a mechanism for estimating preference functions, conjoint analysis has been extensively tested and evaluated (see Green and Srinivasan 1990 for an overview).
- User-friendly commercial software packages are available for implementing conjoint analysis studies (e.g., Bretton-Clark's Conjoint Analyzer and Sawtooth Software's ACA, or Adaptive Conjoint Analysis).

After reviewing the technique of conjoint analysis and presenting related valuation models in the next section, we outline and characterize potential southern forest management applications. Then, we apply conjoint analysis to estimating implied WTP levels for potential visitors to a hypothetical private nature and recreational park within the longleaf pine (Pinus palustris Mill) forests of North Carolina. Preliminary validity testing of this approach is also undertaken. Finally, we present our conclusions.

<u>An Overview of Conjoint Analysis and its Application to Estimating Implied WTP Levels</u>

Conjoint analysis is one of the most popular commercial marketing research tools (Wittink and Cattin 1989). The most common commercial application is providing information for designing and pricing products. Specifically, market researchers use conjoint analysis to estimate the impacts of alternative product designs and pricing levels on consumer utility.

Consider the example of designing a new nature park within a southern forest. To apply conjoint analysis to this problem, a form of new product design, potential visitors would be presented with a balanced array of alternative combinations of park features. Each combination would represent a unique mix of a given set of attributes such as non-motorized boating and entrance fee, two attributes to be considered in a later section of the paper. As for non-motorized boating, the levels under investigation might be "allowed" and "not allowed." With regard to entrance fee, the levels might be \$10, \$20, and \$30. Respondents would be directed to rate (or rank) different combinations of these two attributes. With dummy variables denoting the presence of a given level of a given attribute and ratings serving as the independent and dependent variables, respectively, ordinary least squares regression (followed by a form of scaling) is used to estimate the marginal utility (or part worth in conjoint analysis terminology) associated with each attribute level.[2] If the presence of a given attribute level tends to be associated with much higher ratings than other levels of the same attribute, then a relatively high part worth is estimated for that level. By summing the part worths associated with a given prospective park design, an alternative's total utility level can be compared with the other alternatives. Given the decision rule of maximizing user satisfaction, the design with the highest total utility level will be selected, assuming no other constraints exist.

In addition to its use as a tool for estimating consumer utility, conjoint analysis can be adopted as a form of a Multiattribute Utility Model (MAUM).[3] That is, multiattribute alternatives can be compared using conjoint-analysis-supplied total utility levels, estimated from the perspective of owners/managers. As noted by Boucher and MacStrovic (1991, p. 3), the "robustness [of MAUMs] in dealing with judgment has made them a natural substitute for the limitations of the financial calculation." For those managers desiring to integrate utility and financial considerations, a financial criterion such as net present value may serve as one of several attributes within the MAUM.

Whether used to account for user- or manager/owner-level utility, if at least one of the attributes, say attribute a, being considered is dollar denominated (e.g., an entrance fee, production cost, or net present value), then the following formula estimates the dollar per part-worth level (\$PERPW) for a given individual or group of users or managers:

$$\$PERPW_a \;\; (\$_{amax} \;\; \$_{amin})/(PW_{amax} \;\; PW_{amin}) \qquad \textbf{(1)}$$

where:

$\$_{amax}$, $\$_{amin}$ = maximum and minimum dollar levels, respectively, associated with attribute a.

PW_{amax}, PW_{amin} = maximum and minimum part-worth levels, respectively, associated with attribute a.

Assuming a constant \$PERPW across the range of levels for attribute a for a given individual or group, an incremental implied WTP for non-market attribute b can be estimated. As the level of b changes from *l - 1 to l*, equation (2) converts part-worth output to dollar-based units to estimate the incremental WTP for bl:

$$WTP_{b1}\ \ (PW_{b1}\ \ PW_{b1\ \ 1})\$PERPW_{a} \qquad \textbf{(2)}$$

The economic value of natural resource plan alternative x relative to alternative y (EVx-y) can then be estimated by summing the differences between them with respect to the market-based and the now converted (i.e., dollar-denominated), non-market attributes using equation (3):

$$EV_{x\ y} \quad \sum_{a\ 1}^{A} (\$_{xa}\ \ \$_{ya})\ \sum_{b\ 1}^{B} (WTP_{xb}\ \ WTP_{yb}) \qquad \textbf{(3)}$$

where:

A, B = the number of market- and non-market-based attributes, respectively.

$\$_{xa}$, $\$_{ya}$ = the dollar levels associated with market-based attribute a for alternatives x and y, respectively.

WTP_{xb}, WTP_{yb} = the dollar levels associated with non-market attribute b for alternatives x and y, respectively.

Potential Southern Forest Management Applications

Conjoint analysis holds potential for use in at least two basic categories of southern forest management problems:

(1) MAUM applications; that is, evaluating two or more competing forest management plans from the perspective of one or more managers (or landowners or planners) with respect to multiple attributes, at least one of which is a non-market benefit.

(2) Estimating users' (or citizens') utility and WTP for one or more non-market benefits produced by a forest management plan.

Table 1 defines the different dimensions for categorizing alternative MAUM and users' utility applications to southern forestry. Besides the MAUM (I) versus users' utility (II) dimension, other key nodes in Table 1 include public-sector (A) versus private-sector (B) applications, individual-specific (1) versus aggregated (2) output, and output units (i.e., total utility (a) versus dollars (b)). Note that at least one of the attributes must be a market-traded benefit in order to convert part-worth data into dollar units using equations (1) - (3).

MAUM Applications. There have been numerous applications of MAUM to forest management problems. Some of these have been private-sector oriented (e.g., Hyberg's (1987) comparison of forest management alternatives relative to the utility function of an NIPF couple) and some public-sector oriented (e.g., Teeter and Dyer's (1986) adaptation to the comparison of strategies of forest fire management planners). Apparently, only one previous study--an analysis of southern agroforestry alternatives by Zinkhan and Zinkhan (1994)--adopted conjoint analysis as the mechanism for eliciting manager (or owner or planner) preference functions.

Hyberg's application suggests several important southern forest management problems to which conjoint analysis can be applied. Shelterwood, seedtree, and clearcut systems were evaluated for a loblolly pine (Pinus taeda) plantation in North Carolina. A "lottery" methodology, as opposed to conjoint analysis, was adopted in order to measure the couple's utility as a function of timber income and aesthetics, where aesthetics was defined as a function of residual basal area. For example, one question presented by Hyberg (p. 841) to participants was: "Given a lottery between an uncut stand with $200,000 vs. a clearcut stand with no income, what probability of success would you need to make you indifferent between participating in the lottery and accepting the clearcut stand with $200,000?" Whether adopting Hyberg's or our approach, the professional forester would need to accomplish two separate tasks:

(1) Estimate the owner's utility function relative to a set of relevant attributes, in this case timber income and aesthetics.

(2) Assess each forest management alternative relative to the set of attributes.

Implementation of our conjoint analysis-based approach would differ from Hyberg's application with respect to task #1. Instead of risking landowners' resistance by forcing them to engage in an artificial lottery scenario, a conjoint analysis-based approach simply requires some form of rating or ranking of various arrays of alternatives.

Estimating Users' Utility for Non-market Benefits. As emphasized by Pearse and Holmes, utilization of a benefit/cost criterion on a public forest with multiple outputs is not feasible without value estimates for the non-market benefits. Private forestland investors interested in capturing income from typically non-market forest outputs also have a need for these valuation data. Such data can be incorporated into the decision framework for both evaluating natural resource plan alternatives from the perspective of potential users and establishing pricing levels for a property's outputs. A related case is presented in the next section.

An Application

For the purpose of developing a clear case for applying our approach and methods for testing it, a convenience sample of 30 students in a graduate business administration class[4] in Rocky Mount, North

Carolina was directed to consider a prospective (and hypothetical) 5,000-acre private nature and recreational park near Pinehurst/Southern Pines, North Carolina. Using the classification system in Table 1, this case would be characterized as users' utility-private sector-aggregated output-total utility and dollars, or II(B)(2)(a & b). The park was described to the students as follows:

> This site, located in the sandhill region, is largely forested with natural stands of longleaf pine--including some that are over 120 years of age. A number of colonies of the endangered red-cockaded woodpecker, or RCW (Picoides borealis), are located on isolated portions of the tract. The prospective park includes a 300-acre, man-made lake stocked with bass. A small fishing pier, accessible to visitors, runs into the lake. A sandy beach surrounds the lake; part of the lake will be designated as a swimming area and will be patrolled by a lifeguard. Hiking trails permit individuals to reach most parts of the park.
>
> A nature center in the park will serve as the site for displays of local nature-oriented photographs, art, and literature. A video that describes and depicts the local ecology will be shown at the center. Also, the center will serve as the base for evening lectures.

Students, directed to assume the perspective of a prospective visitor, were informed that five park designs were under investigation. Each alternative park design represents a unique mix of the four attributes described in Table 2.

Part worths, associated with each level of the four attributes, were estimated for the group using a customized exercise prepared with ACA software. The results are reported in Table 2. Notice that the part worths sum to 400 utils (i.e., 100 x # attributes). As expected, these data suggest the following with respect to each of the four attributes:

- A preference for the right to launch their non-motorized boats (versus a prohibition).

- A preference for the availability of small rustic cabins in addition to an area for tents.

- A preference for the provision of the opportunity to visit an RCW colony site with a park ranger.

- A preference for a relatively low entrance fee (per adult visitor) to a relatively high entrance fee.

Based upon the group's part-worth matrix in Table 2, the attribute-specific implied WTPs were estimated using equations (1) - (2), and are reported in column 1 of Table 3. With respect to the opportunity to visit an RCW colony site, for example, the part-worth matrix implies that each adult visitor would be willing to pay $6.18 more to visit the park when the opportunity to visit the RCW colony is included.

Using the part-worth matrix in Table 2 in conjunction with the descriptions of the five park designs in Table 4, the sums (i.e., the total utility levels) were tallied (and are also reported in Table 4). For this sample of respondents, park design B provided the greatest utility. Incorporating the data from column 1 of Table 3 into equation (3), the incremental economic values of each alternative design relative to the least preferred alternative were estimated and are included in Table 4. Each respondent, for example, would have apparently been willing to pay, on average, an additional $3.64 ($44.91 -$41.27) to visit a park with design B rather than design C.

For the purpose of evaluating the degree of difference between conventionally estimated (contingent valuation) and conjoint-analysis-generated attribute-specific WTPs, the following steps were undertaken. Each respondent was requested to directly estimate an incremental WTP (beyond an entrance fee) for each of the three non-market attributes. The resulting mean values are depicted in column 3 of Table 3. Using each respondent's part-worth matrix, three implied attribute-specific WTPs were also estimated for the 30 respondents. The means are reported in column 2 of Table 3. Since each of the non-market attributes was characterized as an optional activity, not an obligation, any negative implied WTPs for a given respondent were truncated at zero. This adjustment explains why the mean implied estimates shown in column 2 of Table 3 are greater than the estimates implied from the aggregated part-worth matrix (see column 1). After pairing, for each respondent, these two forms of WTPs (reported in columns 2 and 3 of Table 3) associated with the three attributes, the results in columns 4, 5, and 6 were generated. All three mean differences are statistically different from zero.

At least two factors may account for the lower WTPs obtained through use of the direct estimation method. First, previous studies have hypothesized that low directly reported WTPs may represent a form of protest against placing a dollar value on non-market resources (see discussion in Mitchell and Carson 1989). The usual technique for identifying protest bids from those who prefer to forgo the good in question rather than pay for it is simply to ask those giving zero bids why they did so and remove protest responses from the data set. In the current study, this was infeasible, and all $0 bids were included. Second, the differences can be partially accounted for by the upward bias resulting from the necessity to truncate the negative, individual-specific implied WTPs estimated with conjoint analysis. Further empirical testing of the differences between estimated WTPs of conjoint analysis and more conventional, contingent valuation methods is needed.

<u>A Preliminary Investigation of the Approach's Internal Validity and User Satisfaction</u>. Prior to beginning the ACA exercise, the respondents were directed to rank order the five park design alternatives, from most preferred to least preferred. Rankings of the resulting mean ranks are shown in Table 5. Notice that the Kendall tau correlation (Snedecor and Cochran 1978) of 0.80 between the directly ranked and the utility-ranked (or incremental economic-value-ranked) park designs is positive and significantly different from zero. A Kendall tau correlation, between direct rankings and utility-based rankings, was also estimated for each respondent. The mean Kendall tau correlation, 0.69, is also positive and significantly different from zero (see Table 6). These results, representing basic tests of the approach's internal validity (see, e.g., Green, Goldberg, and Montemayor 1981), imply that the part-worth data reflect much of the same preference structure as the directly ranked alternatives.

As also exhibited in Table 6, use of the part-worth data to predict each respondent's initial first choice was significantly better--with a 56.7% hit rate--than the 20% rate of a random model. Furthermore, the last row in Table 6 shows that many of the respondents were influenced by their personal conjoint analysis and WTP output when provided a second opportunity to select a first choice. After observing their personal output, the predictive ability of the conjoint-analysis- based data increased from 56.7% to 86.7%.

This implies that the users of the model perceived its output to represent incremental information relative to the raw data provided in the case.

Finally, provided with a seven-point (strongly disagree-strongly agree) semantic differential scale, the students responded with better-than-neutral, albeit not overwhelming, satisfactory-related ratings of the approach (see Table 7). Of the five items, the respondents agreed most strongly with the potential of the approach to help in the park design process (item #5).

Conclusions

Rarely do forest management scenarios permit total reliance on directly assessed financial criteria. For those forest resource managers unwilling to abandon systematic evaluation approaches, the conjoint-analysis-based approach represents a tractable option. However, as noted by Pearse and Holmes, given the less-than-absolute nature of non-market value estimates, managers need to complement such systematic estimates with professional judgment when evaluating forest management alternatives.

Applications of conjoint analysis to forestry and other natural resource management and policy problems is still in its infancy. In addition to the Zinkhan and Zinkhan (1994) study, the only natural resource applications known to the authors are two studies on deer hunting by Mackenzie (1990 and 1993) and one study on recreational site choice by Adamowicz, Louviere, and Williams (1994). Obviously, empirical testing of conjoint analysis in a wide range of forestry/natural resource applications is required.

Given the importance of nonindustrial private forest owners (NIPFs) in the South, two lines of empirical inquiry regarding the utilization of conjoint-analysis-generated measures of non-market benefits should prove especially fruitful. First, sensitivity of implied WTP estimates for attributes like aesthetics and recreational opportunities to such study design factors as the magnitude of the range of the pecuniary benefit (see Cooper and Loomis 1992) needs to be examined in conjunction with NIPFs' forest management plans. Second, an understanding of the influence of landowner and property characteristics--such as demographic variables (see Christensen, Stewart, and King 1993)--on implied WTP estimates should be helpful to foresters involved in implementing the approach.

In addition, methodological research in applying conjoint analysis to forestry/natural resource problems is warranted. In particular, research examining the potential for combining conjoint analysis with traditional non-market valuation tools such as contingent valuation and travel cost analysis may prove especially beneficial (see Adamowicz, Louviere, and Williams). The traditional methods do a relatively good job of measuring an individual's total WTP for natural resource and environmental goods and services (Smith 1990), however they become problematic when attempts are made to disaggregate the total value into its component values such as use and passive-use values or by attributes of the resource involved. Traditional methods may improve upon the measurement of total values estimated from conjoint analysis, while conjoint analysis may provide a means to extend traditional analyses to the disaggregation of total values into their component parts. With the rise of ecosystem approaches to forest management, understanding how the public and particular stakeholders value different components and combinations of use and non-use goods and services provided by southern forest ecosystems is crucial.

In contingent valuation, total resource values are typically decomposed by asking survey respondents to partition their total value for a resource into use and non-use categories. This method is subject to misplaced precision (Mitchell and Carson 1989). A second method is to estimate separate resource values for users and non-users of a resource (Holmes and Kramer 1994). Conjoint analysis may make a significant contribution to understanding component resource values because value components can be directly estimated. For example, by representing a resource attribute as the degree of use permitted in the protection of that resource, the marginal value of different levels of use (perhaps ranging from no use to allowing unlimited use) can be evaluated.

Finally, research is needed to test the potential for using conjoint analysis to remedy the problems associated with using "benefit transfer" techniques (i.e., inferring benefits and costs of management actions from the results of existing research studies on different sites) for cost-benefit analysis (see Desvousges, Naughton, and Parsons(1992) for a discussion of problems with benefit transfer methods). Although transfer of resource benefit information can improve research efficiency, its use has been limited because replication of an experimental design across many different sites rarely occurs. Consequently, economists sometimes use meta-analysis, a statistical tool for synthesizing results from different studies, to evaluate resource values collected for a variety of sites that may vary by site characteristics and research method (Smith and Kaoru 1990). The major limitation of meta-analysis is that many studies must be available before an evaluation can be performed (i.e., the research study is the observational unit). Conjoint analysis could make a significant contribution to benefit transfer because, in essence, it replicates a valuation experiment by iterating similar packages of resource attributes at varying levels. Estimated attribute values can then be recombined to simulate resource conditions at different sites that are of managerial or policy interest.

Endnotes

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2. See Urban and Hauser (1980) for a description of the conjoint analysis estimation equation.

3. Our categorization system presumes the MAUMs are limited to managerial--as opposed to consumer--applications.

4. Graduate business students are frequently used as subjects for presenting and testing conjoint analysis approaches (e.g., Safizadeh 1989; Srinivasan 1988).

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Table 1. Conjoint analysis and southern forest management applications: a classification system.

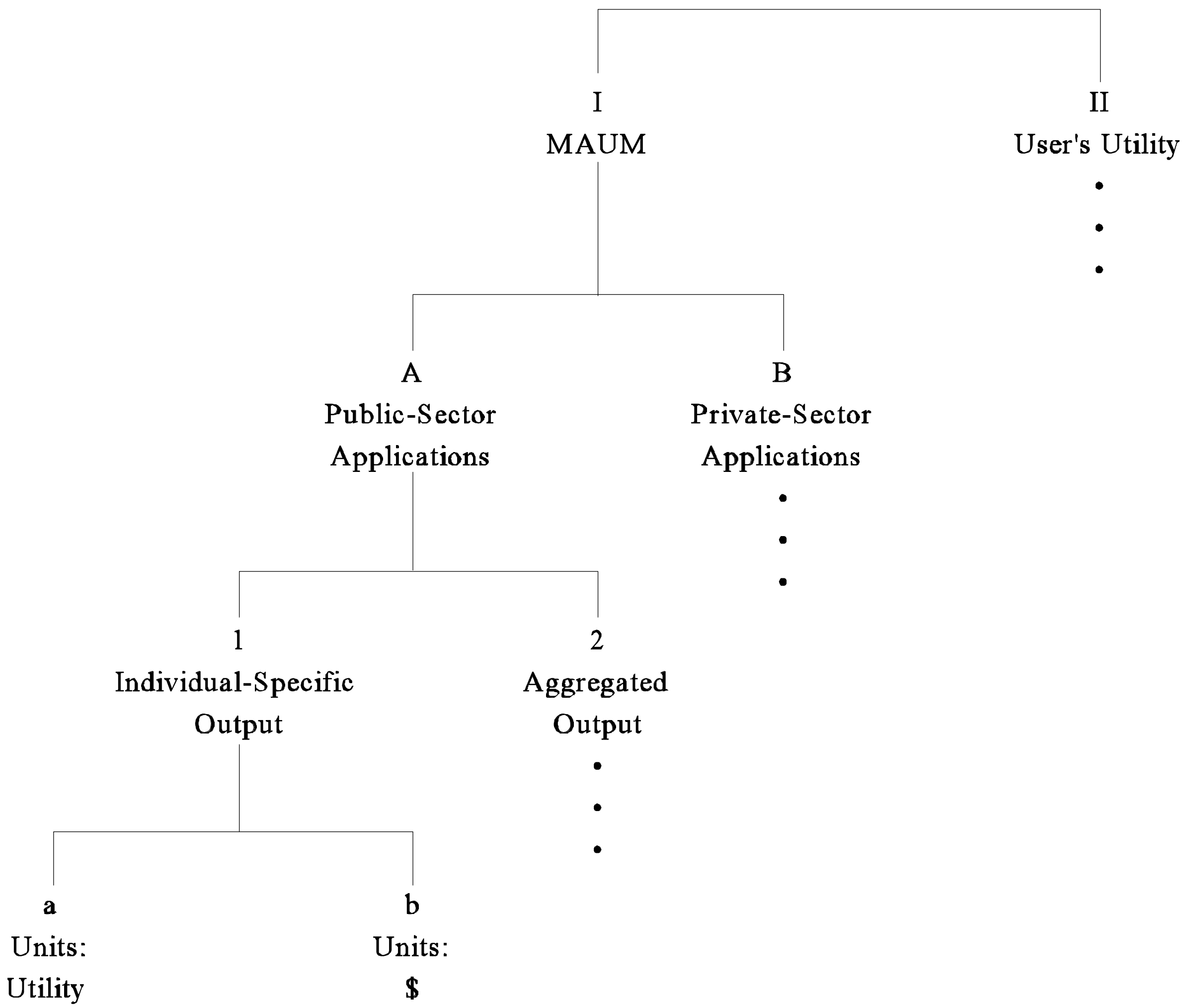

Table 2. Part-worths associated with different levels of the four attributes (N=30).

Attribute	Level	Part-Worth
BOAT LAUNCH (for non-motorized watercraft)	No	6
	Yes	81
OVERNIGHT ACCOMMODATIONS	Tent	3
	Tent & Cabin	86
RCW COLONY VISIT	No	11
	Yes	45
ENTRANCE FEE	$10	110
	$20	58
	$30	0
		Sum 400

Table 3. Three alternative estimates of attribute-specific WTPs (N=30).

Attribute	(1) WTP: Aggregate Function	(2) Mean WTP: Individual Functions[a]	(3) Mean WTP: Directly Reported	(4) Mean Differences (2-3)	(5) s_D	(6) t
Boat Launch	$13.64	$18.06	$6.25	$11.18	$3.25	3.63[b]
Overnight Accommodations-Cabin	$15.09	18.58	12.18	6.40	2.87	2.23[c]
RCW colony visit	6.18	8.83	6.10	2.73	1.34	2.05[c]

[a]Individual negative implied values were set equal to zero.
[b]Greater than $t_{.01}$, two-tailed test.
[c]Greater than $t_{.05}$, two-tailed test.

Table 4. Estimated utility and incremental economic values associated with five alternative park designs (N=30).

Designs	Boat Launch	Overnight Accommodations	RCW Colony Visit	Entrance Fee	Total Utility Level	Incremental Economic Value[a]
A	No	Tent only	No	$30	20	-
B	Yes	Tent & cabin	Yes	$20	270	44.91
C	No	Tent & cabin	Yes	$10	247	41.27
D	Yes	Tent only	Yes	$30	129	19.82
E	Yes	Tent & cabin	No	$20	236	38.73

[a]Relative to design A.

Table 5. Rankings: Total utility level (or incremental economic value) versus mean direct rankings (N=30).

Combination	Rankings-Aggregate Utility	Rankings-Direct
A	5	5
B	1	1
C	2	3
D	4	4
E	3	2
	Kendall tau = 0.80[a]	

[a]Significantly different from zero at the 0.05 level.

Table 6. Summary of other validation tests (N=30).

Mean Kendall tau between each respondent's direct and utility-based rankings	0.69[a]
Percent of correct first-choice predictions (using utility data to predict initial preferred combination)	56.7[b]
Percent of correct first-choice predictions (using utility data to predict final preferred combination)[c]	86.7[b]

[a]Significantly different from zero at the 0.05 level (with testing applied to normalized data, zero mean and unit standard deviation).

[b]Significantly greater than a random choice model at the 0.01 level.

[c]After being provided with their personal conjoint analysis and implied WTP results, respondents were given a second opportunity to select a preferred park design.

Table 7. Summary of user feedback (N=30).

Item	Statement	Mean Rating[a]
(1)	The conjoint analysis output helped me make a better decision regarding my preferred combination for Longleaf Nature Park.	4.6
(2)	My personal conjoint analysis output well expressed my beliefs about the Longleaf Nature Park alternatives.	5.2
(3)	I have a lot of confidence in the conjoint analysis results.	5.0
(4)	I am very satisfied with the conjoint analysis procedure.	5.2
(5)	If I were a planner for the Longleaf Nature Park, conjoint analysis results for individuals representing our target market would help us in the park design process.	5.5

[a]Based on a 1 (strongly disagree) to 7 (strongly agree) semantic differential scale.