ANALYZING MULTIPLE OBJECTIVE DECISIONS ON PUBLIC LANDS

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ABSTRACT.—Public land managers and policy makers need a means to solicit and analyze public preferences and values. A conjoint ranking survey was used to solicit preferences for various levels of timber harvesting, wildlife habitats, hiking trails, snowmobile use, and off-road-vehicle access on the Green Mountain National Forest. The survey was completed by 76 respondents during public involvement meetings. Linear and quadratic main effect components were estimated using an ordered probit model. Respondents preferred moderate levels of timber harvesting and snowmobile access, and lower levels of off-road-vehicle access. They favored a mixture of mature closed canopy and younger, more open forests over either extreme, and were somewhat indifferent toward extending the network of hiking trails.

INTRODUCTION

Those who manage public lands or design policy that affects natural resources must make difficult choices that frequently involve conflicting uses. The public has articulated clearly that their values and preferences must be considered, and that biophysical information and technical expertise alone are an insufficient basis for decisions about resource allocation. Because desires vary widely among individuals and groups, conflict and expensive litigation frequently arise over the choice of management strategies and resulting mix of benefits to be provided on public lands.

Caught between the vocal and unyielding demands of stakeholders, managers seek a systematic and rational means to evaluate alternatives. Externalities, particularly those surrounding common property, often make market-based decisions on allocation inefficient and even inappropriate. Nonpriced costs and benefits are important and must be considered. Differences in units of measure and the nonmarket nature of many natural resource management objectives pose severe problems for traditional modes of analysis.

This research explores the use of conjoint techniques to solicit and analyze public preferences associated with multiple objective decisions involving extramarket values. The empirical portion of this study addresses the solicitation and assessment of public preferences for various levels of timber harvesting, wildlife habitats, and recreational opportunities on the Green Mountain National Forest (GMNF) in Vermont.

METHODS

Conjoint techniques are used by marketing researchers to measure consumer preferences (Green et al. 1988). The objective is to decompose a set of factorially designed stimuli or attributes so that the utility of each attribute can be inferred from the respondent's overall evaluations. In conjoint studies, respondents choose between alternate products or scenarios that display varying levels of selected attributes. These comparative evaluations, which outline a respondent's preferences or the tradeoffs he or she is willing to make, can be used to solve for the partial utilities for each attribute that are imputed from the overall tradeoffs. These partial utilities can be combined to

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estimate relative preference for any combination of attribute levels. Thus, the analyst obtains high leverage between the options actually evaluated by respondents and those that can be evaluated after the analyses.

Conjoint techniques are well suited for soliciting and analyzing the preferences of stakeholders in environmental decisions that frequently involve tradeoffs between costs and benefits that are not efficiently represented in market transactions. Asking respondents to make choices between alternatives mimics the real choices that managers must make, and can provide feedback to stakeholders with respect to the consequences of their choices. For example, Opaluch et al. (1993) described an approach that used paired comparisons to rank potential noxious facility sites in terms of social impacts.

Conjoint experiments can be designed and analyzed in many ways. Respondents may be asked to reveal their preferences by choosing one of two or more options, ranking several options, or assigning numerical ratings to each option. Numerical ratings provide the most information but may place the greatest cognitive demands on respondents. Green (1974), Green and Srinivasan (1978), Louviere and Woodworth (1983), and Louviere (1988) provide information on experimental design within the context of conjoint analysis.

THE GREEN MOUNTAIN NATIONAL FOREST

The 360,000-acre GMNF accounts for approximately 5 percent of the total land area and half of all public forest land in Vermont (USDA Forest Service 1992). Because of its remoteness and relatively large size, the GMNF provides unique opportunities for backcountry recreation and wildlife habitats in a region characterized by nonindustrial private forests and high population density. Public desires for forest related benefits are intense and cannot always be met simultaneously, so a means of assessing preferences and values must be incorporated into the planning process.

National forest planning occurs on three broad levels: national, regional, and forest. The Forest Plan for the GMNF (USDA Forest Service 1992) sets goals, objectives, standards, and guidelines that fit within broader direction specified at the national and regional levels. Forest goals are accomplished through management actions on Ranger Districts and subunits of these districts. Although public input and assessment of human values are important throughout the planning process, this study addresses public preferences for actions below the district level. Techniques and experience developed during this study will be useful in developing broader goals for the next Forest Plan.

The 18,600-acre study area located on the Manchester Ranger District includes two adjacent units known as Greendale and Utley. The area contains a developed campground (14 sites) and land classified in the Forest Plan as Management Area's (MA's) 2.1, 3.1, 4.1, 6.2, and 8.1. The first three listed MA's include opportunities for roaded natural recreation and emphasize uneven-age silviculture (2.1), even-age silviculture (3.1), and winter habitat for deer (4.1). MA 6.2 emphasizes opportunities for semiprimitive recreation while producing high-quality sawtimber by growing trees to an old age. MA 8.1 is the White Rocks National Recreation Area where the emphasis is on protecting wild values. Timber harvesting and roaded recreation are permitted but restricted. Broad management prescriptions, standards, and guidelines are contained in the Forest Plan. Specific management actions are needed for the Greendale and Utley units. The goal is to develop a procedure for assessing and analyzing public preferences and acceptable tradeoffs for various levels of timber harvesting, wildlife habitats, and three recreational opportunities: hiking trails, snowmobile use, and off-road-vehicle (ORV) access.

Timber harvesting on the GMNF is controversial. Some publics argue against the environmental disturbance that accompanies the harvesting of wood products. Proponents argue that harvesting timber generates revenue for local and regional economies by creating jobs and cash payments for wood products exported from the area. It also is used to meet objectives related to wildlife habitat, silviculture, and recreation.

The Greendale/Utley area supports a high species richness with a diverse late successional community of northern hardwoods, hemlock, and spruce. There are opportunities to enhance habitats for a variety of wildlife species

through harvesting practices and the creation and maintenance of permanent openings, but it is not clear which species the public would like to see favored. If species associated with early succession habitats are favored, management can be tailored to satisfy this preference. Similarly, management can be structured to favor species associated with mature, contiguous habitats.

Recreational concerns center around opportunities for and potential conflicts between motorized and nonmotorized trail uses. There are opportunities to feature cultural resources (e.g., old roads, bridges, and farm sites) and to view wildlife (sightings of bear, moose, beaver, and birds are common). There are several opportunities to expand the system of hiking trails. Currently, 16 miles of travelway are available for snowmobile use, and there is public interest in expanding the available travelway. However, some users are concerned that increased snowmobile access will disrupt other recreational activities and disturb wildlife. At present, ORVs are not permitted on travelways but there is public interest in obtaining ORV access to the area, and several potential opportunities have been identified. Those in opposition cite ecological damage and disturbances to wildlife or other recreationists as reasons to deny ORV access.

ANALYTICAL MODEL

When presented with a set of alternatives, individuals are assumed to make choices that maximize their utility or satisfaction. The utility that the ith individual derives from the choice of the jth alternative (U_{ij}) can be represented as:

[1] $U_{ij} = _{ij} + e_{ij} = X'_{ij}b^* + e_{ij}$

where X_{ij} is a vector of variables representing values for each of M factors or attributes of the jth alternative to the ith individual, b* is a vector of unknown parameters, and e_{ij} is a random disturbance, which may reflect unobserved attributes of the alternatives, random choice behavior, or measurement error. In the empirical study under consideration, a respondent's utility level (U_{ij}) for each of the J alternatives is not observed but an ordinal ranking (Y_{ij}) is observed that corresponds to the order of his or her underlying utilities. The probability of alternative 1 being ranked above other alternatives is:

[2] $P_{i1} = Pr(U_{i1} > U_{i2} \text{ and } U_{i1} > U_{i3} \ldots \text{ and } U_{i1} > U_{iJ})$
$= Pr(e_{i2} - e_{i1} < _{i1} - _{i2} \ldots \text{ and } e_{iJ} - e_{i1} < _{i1} - _{iJ})$

Similar expressions hold for each of the remaining alternatives being chosen next in the choice set, and the P_{ij}'s become well-defined probabilities once a joint density function is chosen for the e_{ij} (Judge et al. 1985).

McKelvey and Zavoina (1975) developed a polychotomous probit model to analyze ordinal level dependent variables. They assume that the e_{ij}'s are distributed normally and that the observed variable (Y_{ij}, the ranks for the J alternatives) is related to the true unobserved utilities (U_{ij}) in the following way:

[3] $Y_{ij} = 0 \text{ if } U_{ij} \text{ £ } m_{i1}, Y_{ij} = 1 \text{ if } m_{i1} < U_{ij} \text{ £ } m_{i2}, \ldots Y_{ij} = J\text{-}1 \text{ if } U_{ij} > m_{iJ\text{-}1}$

The m_{ik}'s define the boundaries of the intervals for the unobserved utilities that correspond to the observed ordinal response. Since the m's are free parameters, there is no significance to the unit distance between the set of observed values of Y; they merely provide the ranking.

Estimates are obtained by maximum likelihood and the probabilities entering the log-likelihood function are the probabilities that the observed ranks (Y_{ij}'s) fall within the J ranges defined by J+1 m's. The parameters to be estimated are J-2 m's plus the b vector; m_0 and m_J are assumed to be negative and positive infinity, respectively, and m_1 is normalized to 0.

The estimated parameters may be used to calculate the probability that a particular alternative will fall within each response category or rank in the case under consideration:

[4] $Pr(Y_j = k\text{-}1) = Pr(U_j \text{ is in the kth range}) = F(m_k - X'_j b) - F(m_{k-1} - X'_j b)$

where k indexes the rankings and $F(\cdot)$ is the cumulative distribution function, assumed normal for the probit specification. Thus, the effect of a discrete change in the level of the nth independent variable (x_{nj}) on the estimated probability that a response will fall within each of the categories (ranks) can be calculated by substituting the estimated parameters (b and m's) into Equation 4. The magnitude of that change will depend on the values for all the estimated parameters and associated variables, as indicated by Equation 4.

SURVEY DESIGN

A conjoint ranking survey was designed to solicit preferences for five forest-related attributes: timber, wildlife habitat, hiking trails, snowmobile use, and ORV access. Three levels covering the range of reasonable alternatives for the Greendale and Utley units were selected for each attribute (Table 1). Eighteen alternatives, each depicting a unique bundle of attribute levels, were chosen using an orthogonal design that allows estimation of all linear and quadratic main effect components as well as the interactive effect of the timber and wildlife attributes over the entire range of possible attribute combinations, with the least number of trials.

Table 1.—Choice attributes and levels

Timber

1. Do not harvest timber
2. Harvest timber on 5-10 % of the planning area
3. Harvest timber on 15-20 % of the planning area

Wildlife

4. Favor wildlife preferring contiguous unbroken forests
5. Favor wildlife preferring a mix of young forests and contiguous unbroken forests
6. Favor wildlife preferring open lands and young forests

Hiking Trails

1. Maintain existing hiking opportunities
2. Extend the hiking trail system to include 2 additional miles
3. Extend the hiking trail system to include 6 additional miles

Winter Motorized

1. Do not permit snowmobile use
2. Maintain the existing 16 miles of travelway for snowmobile use
3. Extend the travelway available for snowmobile use to 23 miles

Summer Motorized (e.g., 3-and 4-wheel ORVs, motorized trail bikes)

1. Do not permit ORVs on travelways
2. Provide approximately 5 miles of travelway for ORV use
3. Provide approximately 8 miles of travelway for ORV use

Although in some cases the attribute levels coincide with on-the-ground alternatives, they also are indicators for broad forest related values. For example, changes in miles of travelway available for snowmobile use also may represent perceived changes in the overall snowmobile experience, congestion in parking areas, noise levels, chances for sighting wildlife, tourism revenues for the region, use conflict on trails, and other values perceived by respondents. Similarly, differences in the number and size of openings in the landscape referenced within the wildlife attribute carry aesthetic meaning as well.

Respondents were given an explanation describing concerns and alternatives for the Greendale/Utley area as well as an overview of the nature and purpose of the conjoint study. A brief verbal explanation of the attributes and levels (Table 1) was provided and respondents were given the opportunity to ask questions or discuss their concerns. Additional information, such as expected volume of timber harvests for each level of the timber attribute and lists of species favored for each level of the wildlife attribute, was provided. Large overlay maps were used to illustrate locations of forest types, prospective harvests, travelways, and other pertinent information. Respondents then ranked 18 sample cards, each representing a unique alternative depicted by a bundle of forest-related attribute or factor levels for the Greendale/Utley area. Respondents also completed a series of attitudinal and demographic questions.

The survey was administered by USDA Forest Service personnel during public meetings. Those who were unable to attend one of the scheduled meetings were given the opportunity to complete the survey at the local District office. Although efforts were made to attain a broad group of respondents, we did not attempt to achieve representation from every interested group or to select a random sample of respondents to represent the general public. The goal for this portion of the GMNF's outreach effort was to solicit and analyze the preferences of people who were interested in and willing to participate in the management decisions for the Greendale/Utley area. The results discussed in the next section apply to the population of interested and concerned citizens that is characterized by this sample of respondents.

An ordered probit model was used to analyze data obtained from 76 respondents. Each respondent ranked 18 alternatives providing 1,368 observed preferences. The dependent variable is the ordinal ranking of the alternatives, which was coded from 0 to 17; higher scores were associated with greater utility. The attribute levels (1, 2, 3 in Table 1) for the independent variables were coded, respectively, -1, 0, 1 for the linear form and 1, -2, 1 for the quadratic form. This coding scheme maintains the ordinal relationship for the linear term and provides for an orthogonal contrast with the quadratic term and constant.

RESPONDENT PREFERENCES

In general, respondents were fairly affluent. The average level of education was 16 years, indicating completion of college, and the average total family income was within the range of $50,000 to $75,000 per year. Sixty-two percent of the respondents were men and the average age was 48 for all respondents. Nearly all of the respondents were Vermont residents; on average they lived in the state for 23 years.

General inferences about respondent preferences concerning each attribute can be made from the summary of results in Table 2. Results and analyses are presented in significantly greater detail in Dennis[2]. The coefficients relate to the orthogonal contrasts and coding of the dependent variable outlined in the previous section. The nature of the overall relationship depends on the signs and relative magnitudes of the estimated coefficients for both the linear and quadratic contrasts. Inferences will be discussed, first with respect to individual attributes and then overall preference for the bundles of attribute levels that comprise alternatives.

Table 2.—Ordered probit results (N=1368)

Variable	Linear effect	Quadratic effect
Constant	+***	
Timber	+***	-***
Wildlife	+	-**
Hiking trails	+*	-
Snowmobile	-	-***
ORV access	-***	-

*** Significant at 1 % level.

** Significant at 5 % level.

* Significant at 10 % level.

The significance of both the linear and quadratic terms for the timber attribute indicates that respondents supported timber harvesting but were indifferent to increases beyond level 2. Complimenting their support for moderate timber harvesting, respondents preferred a mixture of young open and contiguous unbroken forest over either extreme. Although nearly all of the respondents hiked, they generally weighted other attributes more heavily in their rankings and seemed more concerned about alternate trail uses. Although few of those surveyed used snowmobiles, they recognized this activity as a valid use of the area. However, respondents were not tolerant of opening the area to ORVs and registered this sentiment clearly in their rankings.

The optimal mix of attribute levels estimated by the model was: the midlevel for timber harvesting, a mix of open and contiguous unbroken forest, extending hiking trails, maintaining the existing snowmobile network, and not permitting ORV use in the area. The preferred mix was least sensitive to changes in the level of maintained hiking trails. Changes in overall preference resulting from adjustments to any of the other attribute levels as well as the marginal rates of substitution or acceptable tradeoffs among attributes can be readily assessed using the results and analytical techniques discussed here and in greater detail in Dennis[2].

Generally, respondents supported multiple objective management for this area. These results differ significantly from the relatively extreme demands that often are articulated by special interest groups and some individuals. Calls to ban timber harvesting or snowmobiling from an area set the stage for opposite demands from those that benefit from these activities. Managers often are trapped in a lose-lose situation--they are caught between the vocal and seemingly unyielding demands of opposing stakeholders. Conjoint surveys and the ensuing analyses offer a means to sift through the relative values placed on various benefits as well as assess preferences for entire bundles of attributes.

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