DISSERTATION

TESTING THE CONJOINT ANALYSIS TECHNIQUE FOR THE MEASUREMENT OF PASSIVE USE VALUES OF FOREST HEALTH

Submitted by

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WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER OUR SUPERVISION BY MICHELLE HAEFELE, ENTITLED TESTING THE CONJOINT ANALYSIS TECHNIQUE FOR THE MEASUREMENT OF PASSIVE USE VALUES OF FOREST HEALTH, BE ACCEPTED AS FULFILLING IN PART THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

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ABSTRACT OF DISSERTATION

TESTING THE CONJOINT ANALYSIS TECHNIQUE FOR THE MEASUREMENT OF PASSIVE USE VALUES OF FOREST HEALTH

This dissertation is composed of three papers each examining issues associated with the use of the conjoint technique to estimate passive use values of forest health. The first paper will test the equivalence of conjoint question formats to estimate the use and non-use values associated with programs to prevent forest pest infestations. Two response formats, ranking and rating, were applied to two independent samples. As has been done in the past, ratings were converted into implied rankings which were then compared with actual rankings. Further a ratings difference model was constructed with the dependent variable being the difference in rating between a "status quo" situation and a management change. This model was then compared with the actual and constructed rankings models. It was found that the constructed rankings were not statistically different than the actual rankings. This has implications for survey design as it is felt that the ratings task is less difficult for respondents.

The second paper examines the use of panel estimators for conjoint analysis. Most conjoint studies require respondents to rate multiple product profiles, thereby generating a panel data set. To date, published conjoint analyses have not employed panel estimators. A comparison of random effects panel ordered probit and ordered probit finds improvement in significance levels on individual forest health attribute coefficients and gains in precision of confidence intervals on the marginal values of the attributes as well as gains in overall model goodness-of-fit with a random effects specification.

The final paper uses conjoint analysis to explore the difference between resident and non-resident preferences for the attributes of forest management programs directed at western spruce budworm infestations in Oregon. Estimating national values for passive use attributes of forest health presents a challenge since it may be the case that residents' and non-residents' values will be different. It was found that non-residents do have different preferences for such programs than residents. Especially interesting is the fact that Oregon residents are more likely to favor management programs which enhance or protect commercial timber, while non-residents are not. Residents and non-residents are more likely to oppose a program which involves a risk of contamination from spraying if they are members of an environmental organization.

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1: INTRODUCTION

The Conjoint Technique

The measurement of non-market values, such as those associated with forest health, has been pursued by environmental and natural resource economists for decades using the set of techniques broadly categorized into intended behavior (e.g. contingent valuation) and actual behavior (e.g. travel cost, hedonics). Market researchers have used a technique called conjoint analysis, or stated preference to analyze market choices, and this technique is recently being applied to the estimation of preferences for non-market goods.

Conjoint analysis is based on methods for analyzing complex decision making. These methods are based on a body of research called information integration theory (or IIT) (Louvier, 1988). Consumers will seek out information about their options and form a set of determinant attributes. The levels of these attributes, and a consumer's beliefs about them will form the basis for the utility a consumer expects from a particular choice. This utility is unobservable, but one assumption that is made in IIT is that it is linearly related to a consumer's responses on a preference rating scale:

$$U_j = a + bR_j + e_j \tag{1.1}$$

where U_j is the unknown utility of choice j, a and b are regression coefficients, R_j is the rating applied to choice j and e_j is the random error associated with the regression. The second assumption that must be made is that the consumer uses the rating scale as an approximate interval measure. Finally one must assume that the rating strategy of the consumer reveals his decision strategy.

The rating applied to each choice is based on a consumer's expected overall utility for that choice, which is in turn based on the part-worth utility associated with the level of each attribute of the choice. If a choice has three attributes, equation 1.1 can be rewritten as:

$$U_{pqr} = C + u(A_{1p}) + u(A_{2q}) + u(A_{3r}) \qquad 1.2$$

where U_{pqr} is the overall utility associated with choice *pqr*, and $u(A_{1p})$, $u(A_{2q})$ and $u(A_{3r})$ are the part worth utilities associated with attributes 1, 2, and 3 at levels p, q, and r, respectively. Equation 1.2 assumes an additive form for the consumer's utility, other forms can also be used to model the utility for choice *pqr*, and these will be discussed briefly later.

In a conjoint experiment, each choice presented to the respondent will have different levels of the attributes which are chosen by the researcher. The attributes used in an experiment must be chosen carefully in order to encompass the set of determinant attributes most likely to influence a consumer's preference.

Attribute values can be estimated by asking an individual to compare two bundles, each with a set of attributes. Two attributes in each bundle could (holding all other attributes constant) be varied in opposing directions to reach a point where the two bundles will be equivalent (that is, the individual will be indifferent between them). If a person is indifferent between two choices, the utility derived from each is assumed to be equivalent. The marginal rate of substitution between attributes can be derived from the ratio of the marginal utilities of each bundle. Using the price of each bundle, an indirect utility function can be derived. Again varying price and another attribute to achieve equality between the two bundles, the marginal rate of substitution can be used to represent the marginal willingness to pay for the attribute. In this manner, a value can be estimated for each attribute by varying the level of the attribute and the cost of the option (Mackenzie, 1992). Using regression results, one can calculate a marginal value (or willingness to pay) for each attribute using the negative ratio of the coefficient on the attribute over the coefficient on cost.

Since one cannot observe U_{pqr}, one can use a respondents rating for choice *pqr* and rewrite equation 1.2 as:

$$R_{pqr} = D + u(A_{1p}) + u(A_{2q}) + u(A_{3r}) + e_{pqr} \qquad 1.3$$

where R_{pqr} is the rating given to choice *pqr*, $u(A_{1p})$, $u(A_{2q})$, and $u(A_{3r})$ are as defined above, and e_{pqr} is the random component of the respondent's rating. Ratings are often used to assess consumer preferences in a conjoint experiment, but rankings and binary choice are also used. The use of rankings allows the researcher to relax the assumption that the ratings approximate an interval scale.

The above example uses an additive model of utility, that is, it assumes that the attributes contribute to the overall utility of the choice in an additive manner. This means that responses to levels of one attribute are independent of responses to the levels of other attributes. If this is the true form of the utility there will be no significant interaction terms.

Other forms for the relationship can also exist. The most general form is the multilinear model:

$$\begin{aligned} R_{pqr} &= C_0 + C_1u(A_{1p}) + C_2u(A_{2q}) + C_3u(A_{3r}) \\ &+ C_4u(A_{1p})u(A_{2q}) + C_5u(A_{1p})u(A_{3r}) \\ &+ C_6u(A_{2q})u(A_{3r}) + C_7u(A_{1p})u(A_{2q})u(A_{3r}) \end{aligned} \tag{1.4}$$

This form allows for all possible interactions among the attributes. Less general forms are all subsets of the multilinear form. These include the multiplicative model where all attributes are complements, the distributive model where one attribute complements the other two, which are independent of each other and the dual distributive model where one attribute is independent of the other two which are complements. The appropriate form of utility can be tested econometrically by examining the sign and significance of the regression coefficients on the attributes and the interactions.

When the number of attributes and/or levels is large, the number of possible combinations (or options) to be evaluated by the consumer becomes unwieldy quickly, especially if interactions are expected to be significant. According to Louvier (1988), the majority of variation in ratings can be explained using main effects only. Thus it may be appropriate to use a main effects experimental design which uses a subset of the possible combinations (Adamowicz, et. al, 1998).

The Studies

This series of papers will examine various issues associated with the application of conjoint analysis to the measurement of passive use values of forest health. All three are based upon data collected using a mail survey conducted in the Fall of 1997. The survey instrument consisted of a series of Likert-scale questions on the appropriateness of various forest health management techniques, three conjoint questions, and a section of demographic questions. Residents of the Northeast, the Southeast and Oregon were sampled, with each region receiving the same questionnaire. Three forest pest management situations were presented in the form of conjoint questions. The first was the gypsy moth, the second the western spruce budworm and the third the southern pine beetle.

Question Formats

The first issue to be examined, in Chapter 2, is the influence of the question format on the coefficients and attribute marginal values for the forest pest management options. It has been found that respondents find the task of rating to be less difficult than the task of ranking, especially if there are a large number of options to be evaluated (Alwin and Krosnick, 1985; Feather, 1973). Previous studies have used the same respondents to compare ratings and constructed rankings. The first paper uses independent samples to examine the differences in these two question formats.

Half of the respondents were asked to *rank* three management options for each of the three scenarios, while half were asked to provide a *rating* on a scale of one to ten (where one is least desirable, ten is most desirable). The ratings were then converted into implied rankings and the two samples were compared. Additionally, ratings differences were calculated and compared with both actual and constructed rankings.

Coefficient equality between the constructed and actual rankings was tested using a likelihood ratio test, and marginal values were compared by constructing confidence interval around coefficient ratios. It was found that the rankings and constructed rankings produced the same coefficient estimates. Marginal values were the same for constructed rankings and rankings, however these differed from marginal values for ratings differences.

Panel Estimators

Most published conjoint studies have respondents evaluate several choices, producing several conjoint responses per individual, or a panel data set. Models which do not account for the panel nature of the data assume that the error process of each individual is the same. This is unlikely to be the case, and when examining each response from an individual as a separate case, one must account for the heteroskedasticity of the error processes.

The issue of the panel nature of the data is addressed in Chapter 3 by comparing regression coefficients and marginal values from a random effects panel ordered probit model with those from a non-panel ordered probit model. It was found that the random effects model did indeed perform statistically better than the non-panel model.

Resident versus Non-Resident Preferences

An issue of concern in many non-market valuation applications is the difference between values held by residents and those held by non-residents for the same good. If conjoint analysis is to be applied to further non-market valuation studies, this issue must be addressed. Chapter 4 looks at the differences in preferences for western spruce budworm control programs between Oregon residents and non-residents.

It was found that there are statistically significant differences between these groups. The attribute coefficients were mostly not significant for non-residents, while they were all significant for residents. This indicates that for forest pest management programs, marginal values will most likely experience the distance decay found in many contingent valuation and travel cost studies.

Conclusion

If conjoint analysis is to be applied appropriately one must be aware of issues associated with the implementation and analysis of such a study and the applicability of the results to various publics. The three tests performed here will contribute to the future use of conjoint for non-market valuation. If conjoint analysis is procedurally invariant to question format, a researcher can use a format that is less difficult for respondents or more appropriate to the application with some degree of confidence that the results will not be affected. Multiple responses from each individual are most appropriately analyzed by using panel estimators which account for heteroskedasticity. Further, results from one region must be applied with care in another region.

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CHAPTER 2: A COMPARISON OF CONJOINT RATINGS AND RANKINGS: APPLICATIONS FOR PASSIVE USE VALUES OF FOREST HEALTH

Introduction

Forest health is one of the most important resource issues facing land management agencies today. Disagreement exists as to the exact definition of forest health, but it can be said to include protection from catastrophic insect and disease outbreaks, as well as the re-establishment of natural regulation systems. Both healthy forests, and the management of forest health have multiple attributes and the characteristics of public goods. They provide habitat for endangered species, protect water quality, provide recreation settings, and deliver a host of non-use values. While no formal market exists for trading these amenities, estimating these non-market values is an important component of multiple use land management performed by Federal agencies. This paper represents one of the first applications of conjoint analysis as a tool for estimating passive use values associated with protecting forest health.

Conjoint Analysis

Conjoint analysis has been used most often in marketing research, and is only recently being applied to natural resource valuation. Conjoint analysis uses a survey method in which a respondent is presented with a set of products or options. Each option is characterized by a bundle of attributes. Differences between attribute bundles represent trade-offs between the corresponding choices. Typically, one of the attributes will be a price for each option. The respondent is asked to express his or her preferences for the options, usually by rating or ranking them or by selecting the most preferred. Conjoint analysis most closely resembles discrete choice contingent valuation where a respondent is asked to choose between paying a price specified by the researcher for some non-market good or not purchasing the good.

Marketing researchers have discovered that when consumers make complex decisions (such as purchase decisions for certain items) they define a set of criteria or attributes which they feel are most important in making the decision about which item to choose or whether to make the purchase at all. These have been called determinant attributes (Louviere, 1988). These determinant attributes will in turn define the final "choice set" from which the consumer will select the most preferred option. In a conjoint experiment the choice set and determinant attributes are chosen by the researcher and presented to the respondent to rate or rank. In general, the researcher seeks to determine the probability that a respondent will choose one member of the choice set, and to examine the role of the specified determinant attributes in that choice.

Conjoint Analysis to Estimate the Value of Non-market Goods

Traditional non-market valuation has been conducted for several decades using several techniques (Mitchell and Carson, 1989). These include indirect methods which rely on a consumer's actual behavior, such as travel cost analysis and hedonic price analysis, and direct methods which ask respondents to directly reveal behavior they expect or intend to perform. Experimental conjoint analysis most closely resembles this direct or contingent valuation method. Within the contingent valuation method, there exist several formats. Much debate has been carried on in the literature as to which of these formats best achieves the researcher's objective of inducing the respondent to reveal his or her true willingness to pay (or willingness to accept compensation) for a non-market good.

It has been hypothesized that the more closely a researcher can come to emulating "real world" scenarios the more likely it is that a respondent will give a meaningful reply to a contingent valuation question. Consumers are most familiar with paying a pre-determined price for private goods, so a question which asks a respondent to "name your price" (such as open ended and, to some extent, payment card contingent valuation formats) may be so unfamiliar that respondents are unable to give meaningful answers. A format such as dichotomous choice, which gives a respondent a "take it or leave it" choice, offering the public good for some specified price is more familiar, and may be easier for the respondent to grasp and answer.

Taking this emulation of the real world even further, a consumer who is considering making a purchase will usually have several "brands" to choose from. These different brands will have different attributes and/or levels of attributes. Among these attributes is the price of the good. A consumer will weigh each brand and its set of attributes to determine which most fully meets his or her needs and budget constraint. If a public good is being offered to a consumer for "purchase" he or she may feel most comfortable if the choice involves trade-offs among different levels of attributes and prices. For example, a 200 acre park may cost each household ten dollars per year, a 100 acre park six dollars per year, and a 50 acre park only four dollars per year. A survey respondent will be able to determine what level of this good (the park) he wants or will use, and how much he can afford to pay for such an amenity and will make some appropriate selection from among the options.

Conjoint analysis has been extensively applied to predict consumer (market) behavior. It has recently begun to be used to estimate values for non-market goods. Lareau and Rae (1989) used the technique to estimate willingness to pay to reduce diesel odors. Gan and Luzar (1993) applied conjoint methods to the problem of valuing waterfowl hunting. Revealed preferences and stated preferences (via conjoint analysis) for water based recreation were compared by Adamowicz et al. (1994). Stevens, et al. (1997) examined the value of various groundwater protection programs using a conjoint technique. Finally, Zinkhan et al. (1994) offered an example of the use of conjoint analysis to estimate the multiple values associated with forest management and Garrod and Willis (1997) estimated non-use benefits associated with forest biodiversity. Two recent studies (Mackenzie, 1992 and Roe et. al 1996) apply the conjoint technique and conduct methodological tests similar to that which will be performed here. These studies will be examined in more detail below.

Mackenzie (1992) used conjoint analysis to estimate the value of six attributes associated with waterfowl hunting trips. The attributes were varied in different combinations, which were described to the respondent as possible hunting trips. The respondent was asked to rate each trip on a scale of 1 to 10. The dependent variable in this experiment was the rating assigned to each trip and the levels of trip attributes are the explanatory variables. Using the negative ratio of the coefficient obtained via an ordered logit regression on each non-cost attribute over the coefficient on the cost a marginal value or willingness to pay was estimated.

$$MV_i = -\frac{\beta_i}{\beta_{cost}} \qquad 2.1$$

Using that same data set, Mackenzie (1993) examined four different models constructed from the ratings given for each of the trips: 1) the original ratings as indicated by the respondents, 2) ratings transformed into implied rankings, 3) pairwise comparisons constructed from the ratings, and 4) binary preferences. Coefficients on the attributes in all of the models had the expected signs, and most were found to be significant. The model using the ratings for the alternative trips was found to perform the best of the four.

Mackenzie concluded from these studies that the conjoint analysis technique can be a useful tool for estimating the value of individual attributes of a public good. This can be important when researchers attempt to value such things as whole ecosystems or land management options which have multiple attributes. Further, the author concluded that this result indicates that the rating scale approach can account for preference intensities, which would not be accounted for in a discrete choice contingent valuation study. The rating scale model format can also account for respondent indifference or ambivalence. Mackenzie speculated that this ambivalence or indifference manifests itself in the form of non-response to more traditional non-market valuation surveys, leading to bias.

In all the applications above, marginal attribute values were calculated using Equation 2.1. While they are implicit prices, these marginal values may not reflect respondents' maximum willingness to pay for the change in each attribute holding utility constant (compensating variation). Roe et al. (1996) showed that by including an option that represents the status quo and examining the difference in ratings between the status quo and an alternative state conjoint analysis can yield estimates of compensating variation. They applied this method to a study where respondents rate salmon fishing trips.

Roe et. al examined various functional forms and constructions of the dependent variable (similar to Mackenzie's 1993 paper) and compared them in order to explore which performed the best. Respondent preferences were analyzed three ways: 1) conjoint ratings were treated as cardinal preferences and analyzed using tobit models; 2) assuming transitivity of preferences, ratings were converted to implied rankings and ordinal preferences were analyzed using ordered logit models; and 3) binary logit models were estimated where the dependent variable was simply whether the respondent gave an alternative scenario a higher or lower rating than the status quo.

The researchers used four specifications to examine preferences based on the rating of salmon fishing trips: 1) a linear model with ratings as the dependent variable and the attributes, including price, and respondent characteristics as explanatory variables, 2) a similar linear model, but with the income and price variables combined (income minus price), 3) another linear model, with the difference between the rating of the status quo and the rating of the alternative scenario used as the dependent variable and the difference between the levels of the attributes as independent variables, and 4) a non-linear model using ratings differences as the dependent variable.

Rankings for the trips were constructed from each respondent's ratings. This ranking is based on an assumption of transitivity of preferences, with the highest rated trip being ranked first, the lowest rated trip ranked last. Three ordered logit models were estimated using constructed rankings. As a final examination of the data, Roe, et al. constructed two binary logit models using the binary dependent variable.

The alternate models were then compared on the basis of significance of coefficients and consistency with economic theory. The ratings difference models and the binary models had significant coefficients on price and/or income variables, with signs that agree with theoretical expectations. The ratings and rankings models had insignificant coefficients that in some cases disagreed with expectations. It was found that the tobit ratings difference models had the most significant coefficients on management attributes, and the binary logit models had the fewest. The authors concluded that from a theoretical perspective, models based on ordinal rankings of preference are most consistent, and that statistical tests indicated that the logit ranking model performs better than the tobit ratings difference model. The following study will further examine the issue of whether ratings or rankings are the appropriate response format using independent samples.

Hypotheses

The comparisons of ratings and rankings by Mackenzie and by Roe et al. discussed above both used rankings *constructed* from the ratings given by respondents, rather that *actual* rankings from independent samples. This paper compares similarly constructed rankings with actual rankings from two independent samples of respondents Both are also compared to ratings differences. The ratings difference is constructed by subtracting the rating given to the "no action" option from the ratings given to each of the action options. The attribute levels are also "differenced" in the same way to use as independent variables. Ratings differences allow us to examine a conceptually correct change in utility (marginal value) from the status quo.

It has been argued that the task complexity increases as one moves from asking a respondent to choose the best among the alternatives, to giving each alternative a rating, to rank ordering a set of alternatives (Alwin and Krosnick, 1985; Feather, 1973). If the results obtained from a relatively easier task (that is rankings derived from ratings) are determined to be the same as those obtained by asking for rankings directly, one could safely recommend that researchers use the rating technique in order to allow respondents to perform more comparisons or perhaps increase response rate for the same number of comparisons.

The first hypothesis states that the different question formats produce the same coefficients. Formally the hypotheses are:

$$H_O:\beta_{rank}=\beta_{constructed\ rank} \qquad 2.2.1$$

$$H_A:\beta_{rank}\neq\beta_{constructed\ rank} \qquad 2.2.2$$

where β_{rank} is a vector of coefficients obtained using the actual rank sample and

$\beta_{constructed\ rank}$ is a vector of coefficients obtained using the ranks constructed from the ratings sample.

One issue which must be addressed when one undertakes to construct rankings from ratings is the occurrence of ties. When asked to give independent ratings to a set of alternatives it is entirely conceivable that a respondent may give two or more alternatives the same rating. These ties may be viewed as true indifference on the part of the respondent, or as an indication that the two alternatives are so close that the true rating for each falls within the same interval on the discrete rating scale. For this study, rankings were constructed based on the assumption that the tied ratings indicate true indifference. In the case of a tie the alternatives were given the same rank, with the next lowest rank skipped.

In order to examine the influence these ties may have on the results, the model was also run with ties eliminated. Two ways of eliminating ties were compared. First, any respondent giving a tie to any two alternatives within a scenario was completely eliminated from the analysis. This was done based on the assumption that the respondent may not have given the survey enough consideration to give meaningful answers. Second, only those scenarios with tied ratings were eliminated (retaining the same respondent's responses to other scenarios if no ties exist).

The next hypothesis tested is the issue of how question format affects the marginal values of forest health attributes. Using Equation 2.1, marginal values are constructed and compared for the ratings difference model, three constructed rankings models and the actual rankings model. The following hypothesis of the equality of marginal values was tested:

$$H_O: -\frac{\beta_{i_{ratings\ diff}}}{\beta_{cost_{ratings\ diff}}} = -\frac{\beta_{i_{constructed\ rank}}}{\beta_{cost_{constructed\ rank}}} = -\frac{\beta_{i_{rank}}}{\beta_{cost_{rank}}} \qquad 2.3.1$$

$$H_A: -\frac{\beta_{i_{ratings\ diff}}}{\beta_{cost_{ratings\ diff}}} \neq -\frac{\beta_{i_{constructed\ rank}}}{\beta_{cost_{constructed\ rank}}} \neq -\frac{\beta_{i_{rank}}}{\beta_{cost_{rank}}} \qquad 2.3.2$$

where $\beta_{i\ ratings\ diff.}$, $\beta_{i\ constructed\ rank}$ and $\beta_{i\ rank}$ are coefficients for attribute i for the ratings difference, constructed rank and actual rank models respectively, and $\beta_{cost\ ratings\ diff.}$ $\beta_{cost\ constructed\ ran}$ and $\beta_{cost\ rank}$ are coefficients on cost for each of the models.

Application of Conjoint Analysis to the Valuation of Forest Health

Forest health has aspects of a pure public good and is composed of multiple attributes. One aspect of forest health is the prevention or eradication of insect and disease infestations. Pest management involves a wide variety of activities each with different levels of success and different external consequences, or attributes. Management to maximize one or more of these attributes may lead to losses or changes in the levels of other attributes. Public preferences for the various amenities and services of healthy forests and forest pest management activities can be expected to be quite diverse. Given this set of circumstances, conjoint analysis may be the most appropriate tool to estimate the values of various attributes of management activities to protect or restore forest health, since it allows us to examine the decomposed attributes of a public good.

It can be expccted that different members of society may place different weights on the various attributes of a pest management system. Also, the nature of the infestation can be expected to influence the valuation of pest management activities. For example, the value of a control program directed at an introduced pest may be different than that for a native species. Forest insects or diseases affect a variety of resources in different ways. An infestation of insects may reduce timber values, while at the same time increasing insect-eating bird populations and habitat for some wildlife. Pest management actions will obviously have different effects on these resources, and different levels of management will have different levels of impacts and different costs.

This paper examines the results of a conjoint study examining alternative management programs for three different forest pest situations in the United States. The gypsy moth is an introduced pest, which has little effect on commercial timber, but does have a high impact on ornamental trees and trees in popular recreation areas (Doane & McManus, 1981; USDA Forest Service, 1995). The second scenario is the western spruce budworm. This insect is native to most fir stands in the western US, and has a large impact on commercial timber in the Pacific Northwest (Brookes et al., 1987; USDA Forest Service, 1989). The final scenario is the southern pine beetle, another native insect. This insect has impacts on commercial timber in the Southeast, and the problem is exacerbated by infestations in Wilderness areas where regulations make some control actions illegal (Thatcher, et al., 1981; USDA Forest Service, 1987).

Survey Design

The three insect infestation scenarios were presented in a questionnaire mailed to 2400 households. The sample was concentrated equally in the three geographic regions most affected by the pests (the Northeast, the Southeast and Oregon). The same questionnaire (with all three scenarios) was sent to each region.

The first part of the questionnaire consisted of a series of Likert-scale questions dealing with the appropriateness of various forest health management techniques currently practiced by foresters on both private and public lands. The techniques are presented as measures to protect forest health in general, not as harvest techniques. Respondents were asked to mark the box which most closely reflected their feelings about each technique. The response options were on a four-point scale from "always appropriate" to "never appropriate," with a "don't know" option included. Following these questions was a page containing information about "Trade-offs in Forest Health Management." This page discussed forest pest management actions in general and explained that any actions taken will have a variety of consequences, both positive and negative. The next section of the questionnaire contained the three forest pest scenarios.

Each scenario contained a brief description of the insect, including its area of impact, and the effects of an uncontrolled infestation. Next was a description of three management options, the first of which was "no action." The next option was a moderate level of pest management and the third was intensive management. The three management options were then compared in a table showing the expected effects over the next 15 years. These effects are: the area infested, changes in non-target insect populations, changes in insect-eating bird populations, water resource effects, changes in recreation use and changes in commercial timber. Finally the respondent was asked to either rate (on a scale of 1 - 10) or rank the three options. Each regional sample was divided into halves, one receiving the rank version, the other the rate version.

The final section asked the usual demographic questions, including a question on membership in environmental organizations. Respondents were also asked whether they lived in a rural or urban area, and about their occupation. It was hypothesized that some members of the sample might work in the forest industry (especially in Oregon) and that this might have some impact on their answers.

This questionnaire was developed using the assistance of professionals in the forest health field, including foresters and entomologists. These experts participated in devising the forest pest scenarios and the Likert-scale questions in order to ensure their realism and accuracy. Further, professionals working in the public land management sector were questioned about their information needs regarding public values for forest health management. Next the survey instrument was refined using the input of a focus group of residents of Fort Collins, Colorado. A pre-test was then conducted in the three survey regions to finalize the questionnaire. Participants for the pre-test were recruited via telephone. They were asked to look over the questionnaire, then researchers called back at a pre-scheduled time for a de-briefing. Any questions which were unclear or difficult were refined and a final version was created.

Sample Design and Survey Response Rate

The final survey was mailed to a random sample of 800 households in each of the three regions (with 400 receiving the rank version and 400 the rate version). A variation of the Dillman total design method was used. After the initial mailing a reminder postcard was sent to all participants. A second mailing was sent about six weeks after the first mailing. Response rates were lower than usual, with an overall response of 32%. Breaking down the responses by version, there was a 32% response for the rating versions and a 33% response for the ranking versions. The similarity of response rates is the key for the methodological comparison to be carried out. While the sample may not be fully representative of the population, the equivalent response rates suggest they should be equivalent to each other. It is speculated that the complexity of the questionnaire, and the lack of a third mailing (due to budget constraints) contributed to the less than desirable response rate. Comparisons of the demographic characteristics of the two samples also indicate they are equivalent. Sex, age, education and income were not significantly different between the two groups.

In addition to the low response rate, there was some incidence of respondents misinterpreting the instructions on the rate/rank questions. These individuals (18% of the returned surveys) simply made an "X" or check mark in what we presume to be their preferred option. The incidence of this is higher for the rank versions (22%) than for the rate versions (14%) supporting the assumption that the task of ranking a set of alternatives is more difficult for respondents. A sample of these (67 total) were sent a third mailing, with a more careful explanation of the response we were looking for.

Sixty-one percent of these (41 out of 67) were returned with corrected responses. These were included with the main data set.

Results

This study compares actual rankings with rankings constructed from ratings and ratings differences. The models were analyzed using the ordered probit functional form.

$$P_i = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\alpha + \beta X_i} e^{-t^2/2} dt \qquad 2.4$$

Where P_i is the probability that a particular option receives a rating or ranking of "I", α is a regression constant, β_i is a vector of coefficients, X_i is a vector of independent variables and t is the standardized normal variable.

Several models were examined, with different combinations of attributes included. Correlations among some of the attributes (deliberate in some cases, such as streamflow and erosion) precluded the use of all of the attributes in one model. Models in which the crucial variables (cost of the program and extent of control) were found to be insignificant were rejected. The final model used the following attributes as independent variables: the number of forest acres expected to be infested by the pest within 15 years of implementation of the management program, the cost per household of the management program, expected changes in commercial timber harvests (expressed as a percentage change) and finally a dummy variable indicating whether the pest was introduced or native to the region.

$$Rank = \beta_1 + \beta_2 cost + \beta_3 acres + \beta_4 timber + \beta_5 native \tag{2.5.1}$$

$$Ratings\ Difference = \beta_1 + \beta_2 cost + \beta_3 acres + \beta_4 timber + \beta_5 native \tag{2.5.2}$$

$$Constructed\ Rankings = \beta_1 + \beta_2 cost + \beta_3 acres + \beta_4 timber + \beta_5 native \tag{2.5.3}$$

Table 2.1 contains the coefficients, t-statistics and log likelihood function for each of the models.

Table 2.2 displays the results of the likelihood ratio tests of equivalence of coefficients between the actual rankings and constructed rankings. The null hypothesis that the coefficients are equal cannot be rejected for any of the models. It should be noted that although the strength of this conclusion increases when ties are eliminated, the inclusion of ties does not support the inequality of the coefficients. This result shows that the rating and ranking formats reveal similar behavior (similar coefficients), and thus implicitly lead to similar marginal values for the attributes. This is important because it suggests one can choose the response format which is easiest for the respondent without changing the outcome.

Marginal values were calculated for the various forest health management attributes using Equation 2.1. These marginal values were estimated for the ratings difference model, the three constructed ranking models and the actual ranking model.

Because the marginal values are the ratio of random variables, we constructed confidence intervals around the marginal values via the method derived by Fieller (1932) and used by Mackenzie (1992, 1993). Using Equation 2.1, the marginal value for attribute *i* is - β_i /β_{cost}, we can express this as $\beta_i + \beta_{cost}MV_i = 0$. The confidence interval can then be estimated from the quadratic roots of:

$$\frac{(\beta_i+\beta_{cost}MV_i)}{(\sigma_i^2+2\sigma_i\sigma_{cost}MV_i+\sigma_{cost}^2MV_i^2)^{0.5}}>t \qquad 2.6$$

The results of this estimation are shown in Table 2.3. For acres infested and for timber values the 90% confidence intervals overlap for all five models indicating that the marginal values are equal. As the number of acres infested increases, preference (and thus the marginal value) for the management option decreases. This is reflected clearly in the negative marginal value. The confidence intervals for these marginal values do not include zero. However, the confidence intervals for timber include zero, indicating that the marginal values are not significantly different from zero.

The marginal values for "native," a dummy variable indicating whether or not a pest is native to the region are somewhat confounding. For the ratings difference model the marginal value is positive, while it is negative for the three constructed rankings models (which use the same sample as the ratings difference model) and for the actual rankings. A positive marginal value indicates that the fact that a pest is native *increases* respondents' preference for programs to control it.

The confidence intervals for all three forest health management attributes overlap (with the exception of "native" for the ratings difference model) indicating that the response formats do indeed produce similar marginal values for most of the attributes. Once again, this has implications for research implementation, as a researcher may choose to use a format which is most appropriate and easiest for respondents.

Conclusions

Conjoint analysis has been used widely in market research, but less work has been done using conjoint analysis to estimate values for non-market goods. Further, most non-market research using conjoint analysis has been in the valuation of recreation amenities. There are very few applications of conjoint analysis to the valuation of non-use/passive use values which are pure public goods. It was found that rankings constructed from respondents' ratings are not statistically different from actual rankings for an application where respondents had three options to rate/rank. This result indicates the conjoint technique's robustness with respect to procedural variance and implies that researchers may select either response format as appropriate. Further research using separate samples and a larger number of options should be conducted to confirm or disprove this result. Use of this technique to value multi-attribute land management choices will be beneficial in two ways. First, examining the separate attributes of land management actions may offer greater insight into the values held by people for public lands, and help determine the appropriate set of management alternatives to be implemented. And second, further examination of the conjoint analysis technique to estimate the values of more diverse non-market goods will help to refine this method for future applications in policy decision-making.

Resource economists have had only one tool (contingent valuation) to measure passive use values, and it has always been somewhat controversial. This study suggests that conjoint analysis can be added to the "toolbox" as a valid method for measuring passive use values. It was found that households valued a reduction in the number of forest acres infested, even in regions far enough from home to make recreation use unlikely. It was also found that the value of protecting commercial timber may not be significantly different from zero. Examining separate attributes of land management actions may offer greater insight into the values held by people for public lands, and help determine appropriate management alternatives.

Table 2.1. Results of Ordered Probit Regressions

	ratings difference	constr. rank with ties	constr. rank - resp. with ties eliminated	constr. rank - scenarios with ties eliminated	actual rank
constant	1.781***	-.50083[b]**	-.54302**	-.56187***	-.42438**
	(13.530)[a]	(-2.567)	(-2.417)	(-2.714)	(-2.101)
acres	-.001344***	.00113***	.00123***	.00132***	.000979***
	(-4.221)	(3.168)	(2.937)	(3.429)	(2.643)
cost	-.002481***	.00313***	.00326***	.00326***	.002172**
	(-2.782)	(3.061)	(2.759)	(2.997)	(2.011)
timber	.01193***	-.00443	-.00490	-.00489	-.006191
	(3.441)	(-1.045)	(-.965)	(-1.047)	(-1.467)
native	.20063*	.36690**	.40801**	.45107***	.32536**
	(1.680)	(2.395)	(2.301)	(2.760)	(2.022)
log likelihood	-4168.404	-1493.981	-1133.922	-1331.465	-1403.467
Chi-squared	29.52811	16.60686	14.24937	17.90860	9.718999
N	1488	1488	1128	1312	1362

***, **, * significant at $\alpha = 0.01, 0.05$, and 0.10 respectively

[a] $z = \beta/\text{s.e.}$

[b] Since rankings are such that a lower number indicates a more preferred option, it should be noted that the signs on the coefficients are reversed relative to what we usually expect. (For example, the sign we expect on cost is *positive* when we are examining *ranking* of preferences.)

Table 2.2. Results of test equality of constructed ranks and actual ranks

	Likelihood Ratio[a]
actual rank versus constructed rank - with ties	7.742
actual rank versus constructed rank - respondents with ties eliminated	6.938
actual rank versus constructed rank - scenarios with ties eliminated	6.286

[a] distributed ~ χ^2
[b] critical value at $\alpha = .05$ is 11.0705, at $\alpha = .10$ is 9.236

Table 2.3. Marginal values and confidence intervals

	ratings difference	constr. rank with ties	constr. rank no ties 1	constr. rank no ties 2	actual rank
acres	-0.5417	-0.3604	-0.3791	-0.4057	-0.4507
	[-1.226, -0.312][a]	[-0.730, -0.183]	[-0.868, -0.176]	[-0.838, -0.216]	[-2.089, -0.180]
timber	4.8098	1.4124	1.5041	1.5031	2.8227
	[2.550, 10.761]	[-1.071, 3.871]	[-1.456, 4.588]	[-1.115, 4.250]	[-0.576, 11.764]
native	80.868	-117.0239	-125.3487	-138.5350	-149.7983
	[1.752, 239.8]	[-267.4, -38.0]	[-318.9, -37.4]	[-314.7, -56.3]	[-771.8, -29.8]

[a] 90% confidence interval

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CHAPTER 3: STATISTICAL EFFICIENCY GAINS USING PANEL ESTIMATORS FOR CONJOINT ANALYSIS

Introduction

Market researchers have used the conjoint analysis technique to predict consumer preferences for many types of market goods. Recent applications of the conjoint technique have extended its use to non-market goods. This technique involves using a survey method which asks respondents to indicate preferences for multi-attribute goods from among a set of options. The level of the goods' attributes vary across the options (Louviere, 1988). These researchers examine the influence of individual attributes on the overall preferences for options and, when the price of each option is included, derive estimates of dollar values for individual attributes.

The flexibility of conjoint analysis has led to a wide variety of applications. For example, food safety issues (Baker and Crosbie, 1993; Halbrendt et al., 1995; and Holland and Wessells, 1998), preferences for crop plants (Baidu-Forsun et al., 1997), and demand for food products (Harrison et al., 1998) are examined using conjoint analysis. Beilock et. al (1986) apply conjoint analysis to examine pricing in the truck transport industry. Conjoint analysis has been applied to estimate values for the attributes of recreation experiences such as waterfowl hunting (Gan and Luzar, 1993; Mackenzie, 1992, 1993), salmon fishing (Roe, et al., 1996), and waterbased recreation (Adamowicz et al., 1994). Some conjoint studies have also examined non-market values other than recreation, such as groundwater protection (Stevens, et al., 1997), reduction in diesel odors (Lareau and Rae, 1989), forest management (Zinkhan et al., 1994) and forest biodiversity (Garrod and Willis, 1997).

In all but one of the above studies (Holland and Wessells being the exception) respondents evaluated at least two (usually more) options. Yet none of these studies incorporated panel estimators to analyze respondents' multiple choices. Panel estimators can account for the potential interrelationship between each respondents evaluations for several options in a conjoint survey and for the heteroskedasticity of the disturbance terms across respondents (Greene, 1997). This has the potential to improve the statistical efficiency of estimation in the presence of correlated responses and heteroskedasticity. For example, consider the standard regression equation:

$$Y_i = \alpha + \beta' X_i + \varepsilon_i \qquad 3.1$$

where Y_i is the dependent variable, X_i is a vector of explanatory variables (such as the attributes of a good), β is a vector of coefficients and ε_i is an error term with mean zero and constant variance σ_r^2. The *i* subscript indicates the individual respondent. This model assumes the error terms are independent and identically distributed, and therefore does not take into account the unique disturbance associated with each respondent. In a random effects panel model the respondent specific disturbance is included in addition to the disturbance associated with the model. The random effects panel model is:

$$Y_{ip} = \alpha + \beta' X_{ip} + u_i + \varepsilon_{ip} \qquad 3.2$$

where Y_{ip}, X_{ip}, β, and ε_{ip} defined as above and u_i represents the disturbance which is specific to each respondent. The p subscript indicates the options which are rated by individual i The respondent specific disturbance (u_i) has mean zero and variance σ_u^2. As in the basic regression model, the model error (ε_{ip}) has mean zero and variance σ_ε^2. Certain assumptions are normally made about the error terms: 1) that u_i and ε_{ip} are uncorrelated for all I, p and j, and ε_{ip} is uncorrelated with ε_{jq} for all $p \neq q$ and all $i \neq j$. Further, u_i is uncorrelated with X_{ip}. The random effects model formulation in effect explicitly acknowledges the respondent specific disturbance which creates a heteroskedastic error term, $u_i + \varepsilon_{it}$. Non-panel estimators commonly used in conjoint analysis, such as ordinary least squares regression, ordered probit and tobit models, will produce inefficient and inconsistent estimates of the standard errors in the presence of heteroskedasticity, calling into question any conclusions made about the significance of coefficients and goodness of fit. A generalized least squares procedure can be used to estimate a random effects panel model that accounts for the heteroskedasticity and produces efficient and consistent estimates of the standard errors. The procedure weights the coefficient estimates by the respondent specific error, thus introducing a possible bias in the coefficients. The trade off is between the efficient, consistent standard errors and unbaised coefficients.

The estimated coefficients are used in conjoint analysis to calculate marginal values. Using the negative ratio of the coefficient on each non-cost attribute (β_a) over the coefficient on cost (β_{cost}), a marginal value (MV_a) can be calculated for each attribute:

$$MV_a = -\frac{\beta_a}{\beta_{cost}}. \qquad 3.3$$

This calculation is valid only if both coefficients are statistically significant. If the coefficient on cost is not significant, any conclusions about the marginal value are suspect since, clearly, cost did not play a significant role in the rating of the choice. By the same logic, an insignificant coefficient on the non-cost attribute would indicate that the attribute was not a contributor to the rating of the choice.

Even if both coefficients are statistically significant, the confidence intervals for the marginal values are needed to test whether these values are significantly different from zero. Since the marginal values are the ratios of random variables, we can construct confidence intervals via the method derived by Fieller (1932) and used by Mackenzie (1992, 1993) and Roe et al. (1996). If we express the marginal value of attribute *a*, calculated using equation 3.3 as $\beta_a + \beta_{cost} MV_a = 0$, the confidence interval can then be estimated from the quadratic roots of:

$$\frac{(\beta_a + \beta_{cost} MV_a)}{(\sigma_a^2 + 2\sigma_a \sigma_{cost} MV_a + \sigma_{cost}^2 MV_a^2)^{0.5}} > t, \qquad 3.4$$

where σ_a^2 and σ_{cost}^2 are coefficient variances , $\sigma_a \sigma_{cost}$ is the covariance, and t is the critical value. Thus one can see that the correct standard errors are crucial to making any conclusions about the marginal values of attributes.

Equation 3.4 shows that the confidence intervals for the marginal attribute values depend not only on the variance of β_a and β_{cost}, but also on the covariance. This is where the random effects specification becomes important for panel data. As noted by Larson, et al. (1999) even when individual coefficients are significantly different from zero, the resulting welfare measures may not be, due to the number of terms involved in calculating the welfare measures. This places a premium on reducing the variances and covariance of coefficients used. It is expected that controlling for individual specific heteroskedasticity in responses, by using a random effects panel estimation will reduce variance and covariance for the model coefficients. Loomis (1997) found a substantial increase in statistical significance of coefficients by using a random effects probit panel model when combining contingent behavior with revealed preferences given by the same respondent.

Since ratings are neither continuous nor cardinal variables, ordinary least squares would be an inappropriate statistical analysis technique. The ordered probit estimator is appropriate with ordinal, discrete responses. This estimator is:

$$P = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\alpha + \beta X_i + \varepsilon_i} e^{-t^2/2} \, dt, \qquad 3.5.1$$

for the non-panel model and

$$P = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\alpha + \beta X_{ip} + u_i + \varepsilon_{ip}} e^{-t^2/2} \, dt, \qquad 3.5.2$$

for the random effects panel model, where P is the probability that Y = J (J is the rating difference), X is a vector of independent variables including price and attributes and t in this case is the standard normal.

This paper will apply both the ordered probit model without panel estimators and a random effects ordered probit model to a set of conjoint data collected to examine preferences for various forest health management programs. This paper will compare the significance levels of the regression coefficients, the overall model goodness-of-fit and the tightness of confidence intervals on individual attribute marginal values with and without the panel estimators.

The Conjoint Application

Healthy forests are non-market goods which are composed of multiple attributes. Management to maximize one or more of these attributes may lead to changes in the levels of other attributes. One aspect of forest health is the prevention or eradication of harmful insect infestations. Management of these pests involves a variety of activities each with differing levels of success and extraneous consequences. Different pest management programs can therefore be expected to vary in the kinds and levels of forest attributes associated with them. Also, different people may have different preferences for the various attributes of a pest management program. Given this degree of complexity, conjoint analysis may be an appropriate tool to estimate the value of the effects of different management activities to protect or restore forest health.

This paper performs a conjoint study examining alternative management programs for three forest pests in the United States. The gypsy moth is an introduced pest, which has little effect on commercial timber, but does have a high impact on ornamental trees and trees in popular recreation areas in the Northeast (Doan and McManus, 1981; USDA Forest Service, 1995). The second scenario describes a program to control the western spruce budworm. This insect is native to most fir stands in the western US, and has a large impact on commercial timber in the Pacific Northwest (Brookes, et al., 1987; USDA Forest Service, 1989). The final scenario is a control program for the southern pine beetle, another native insect, which impacts commercial timber in the Southeast (Thatcher, et al. 1981; USDA Forest Service, 1987).

The questionnaire was developed with input from foresters and entomologists in the forest health field. The survey instrument was refined using the input of focus groups and a pre-test conducted in the three survey regions (the Northeast, the Southeast and Oregon). The first part of the questionnaire consisted of a series of Likert-scale questions dealing with the appropriateness of various forest health management techniques practiced by foresters on both private and public lands. Following these questions was a page containing information about trade-offs in forest health management. The next section of the questionnaire contained descriptions of the three forest pest scenarios. Each scenario contained a brief description of the insect, including its area of impact, and the effects of an uncontrolled infestation. Next was a description of three management options, the first of which was "no action" (the status quo), followed by a moderate pest management option, then an intensive management option. The three management options were then compared in a table showing the cost of the option, along with the expected effects over the next 15 years: the area infested, changes in non-target insect populations, changes in insect-eating bird populations, water resource effects, changes in recreation use and changes in commercial timber. Finally the respondent is asked to rate the three options on a ten-point scale, where 1 is least desirable and 10 is most desirable. The final section asked demographic questions.

Survey Sample and Mailing Procedures

The three scenarios were presented in a questionnaire mailed to 1200 households. The sample was concentrated equally in the three geographic regions most affected by the pests (the Northeast, Oregon and the Southeast). The same questionnaire (with all three pest scenarios) was sent to each region.

Mailing procedures included a personal cover letter with the first mailing. A reminder postcard was sent to all respondents a week later. Non-respondents were then sent a second personal mailing four weeks after the initial mailing. The response rate was 32%. While the sample may not be representative of the population, the contribution of this paper is to evaluate statistical efficiency gains from incorporating panel effects, not to generalize to the population.

All respondents evaluated all three scenarios. Within each scenario was a "no action" option and two options which would actively attempt to control the pest. Following Roe, et al.'s utility difference approach for deriving compensating variation form conjoint data, rating differences were constructed using the "no action" management option which as the status quo. The attribute levels for this management option do not vary. These levels are subtracted from the levels for the attribute levels for the "action" management options which represent changes in the status quo. These attribute level differences are the independent variables in the regression equations. The dependent variable is constructed similarly by subtracting each respondents rating for the "no action" option from their rating for each of the "action" options. In total, each respondent gave nine ratings (three for each of three scenarios) resulting in six ratings differences per individual. This is typical of many conjoint rating studies. The potential correlation and heteroskedasticity of multiple responses from each individual suggests that a panel estimator would be appropriate.

Empirical Model Specifications

The model uses the following as independent variables (variable names in bold): the difference in the number of **acres** still infested within 15 years of implementation of the program, the **cost** per household, expected changes in commercial **timber** harvests, a dummy variable indicating whether the program posed a possible risk of water contamination from the spraying of pesticides (**spray**) and the expected change in recreation visitor days (**rvd**). The ordered probit and random effects ordered probit models are shown in equations 3.6.1 and 3.6.2 respectively.

$$Rate.\ diff. = \beta_1 + \beta_2 cost + \beta_3 acres + \beta_4 timber + \beta_5 spray + \beta_6 rvd + \varepsilon_i \qquad 3.6.1$$

$$Rate.\ diff. = \alpha_1 + \alpha_2 cost + \alpha_3 acres + \alpha_4 timber + \alpha_5 spray + \alpha_6 rvd + u_i + \varepsilon_{it} \qquad 3.6.2$$

Results

Table 3.1 contains the regression results for the ordered probit and random effects ordered probit models. The coefficients on **cost**, **acres** infested, **timber** and **spray** are significant at the 5% level or better in the non-panel model. Recreation (**rvd**) is significant at 20%. When the panel nature of the data is incorporated by using a random effects model the statistical efficiency of the model improves with all variables being significant at 1% or better with the exception of timber at 5%. Furthermore, a likelihood ratio test for goodness of fit of the ordered probit model and the random effects ordered probit models shows that the panel model is an improvement. The likelihood ratio statistic (distributed as χ^2) for the non-panel model is 33.107, for the panel model it is 777.639.

Using equation 3.3, marginal values were calculated for each of the non-cost attributes. Equation 3.4 was then used to calculate confidence intervals for these attribute marginal values. The results are shown in Table 3.2. As can be seen, using panel estimators greatly decreases the width of the confidence intervals. The confidence intervals for timber and recreation contain zero for the non-panel model, implying that these attributes have no value to households. However, in the model accounting for the panel nature of the data, all of the marginal values are significantly different from zero, indicating a gain in efficiency with no change in sample size.

Conclusions

Previous conjoint studies have ignored the panel nature of multiple responses per individual. This may result in inefficient estimates and the resulting large variances yielding insignificant coefficients. This may cause researchers to conclude that certain attributes or products may have zero value. However, these results may be an artifact of the failure to control for the panel nature of the data.

In this study, ordered probit models without panel estimators resulted in one insignificant coefficient and two marginal values not significantly different from zero.

The random effects ordered probit model resulted in all coefficients and marginal values significantly different from zero. If these gains in statistical efficiency are replicated in other conjoint studies it suggests that panel effects should be incorporated in future conjoint research and could allow researchers to economize on sample sizes and avoid misleading inferences about the marginal values of attributes.

Table 3.1. Estimated parameters

	ordered probit	random effects ordered probit
constant	1.9565	3.4780
	(18.391)[a]***	(25.861)***
acres	-0.0010984	-0.001488
	(-4.947)***	(-6.119)***
cost	-0.0020685	-0.003222
	(-2.065)**	(-2.838)***
timber	0.0088133	0.00877
	(2.184)**	(2.105)**
spray	-0.18963	-0.34036
	(-2.355)**	(-4.072)***
rvd	0.011565	0.02465
	(1.567)	(2.585)***
χ^{2}[b]	33.108	777.639
N	1488	1488

***, **, *, significant at α=0.01, 0.05, and 0.10 respectively

[a] ($z = \beta/s.e.$)

[b] Likelihood ratio test statistic for joint significance of coefficients.

Table 3.2. Marginal values and confidence intervals

	ordered probit	random effects ordered probit
acres	-0.5310	-0.4618
	[-2.350, -0.290][a]	[-1.020, -0.291]
timber	4.2607	2.7222
	[-8.644, 26.347]	[0.656, 6.665]
spray	-91.675	-105.635
	[-566.6, -20.7]	[-277.7, -50.5]
rvd	5.5910	7.651
	[-0.313, 25.614]	[3.466, 15.157]

[a] [90% confidence interval]

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CHAPTER 4: RESIDENT AND NON-RESIDENT PREFERENCES FOR THE ATTRIBUTES OF A HEALTHY FOREST: AN APPLICATION FOR THE WESTERN SPRUCE BUDWORM

Introduction

The valuation of non-market goods involves several considerations. One of these is the extent of the appropriate "market area" for the good in question. The market for recreational services can be defined to a large extent by using the travel cost method. Passive use values are more problematic because of their public good nature. In particular, existence and bequest value by definition do not require on-site contact. Sutherland and Walsh (1985) found that non-use willingness to pay for water quality in Flathead Lake, Montana decays to zero at a distance of 640 miles from the lake. Loomis and Gonzales-Caban (1996) found that excluding non-resident values understated the total benefits of fire management programs for old growth forests in California and Oregon. On the other hand, they also found that to simply extrapolate resident values to the rest of the country would overstate total benefits. The extent to which proximity predicts willingness to pay depends upon the good in question, as demonstrated by Pate and Loomis (1997). They found that distance was a significant negative predictor of willingness to pay for wetland improvements and for control of agricultural contamination in the San Joaquin Valley of California. However, the same was not true for improvements to rivers and salmon habitat in the same region.

The literature examining distance effects on the values associated with non-market goods has been done almost exclusively with the contingent valuation or travel cost methods. This paper will describe an application using the conjoint analysis technique applied to estimate the passive use values of forest health. Conjoint analysis (CJ) has been used most often in marketing research, and is only recently being applied to non-market valuation. CJ uses a survey method where a respondent is presented with a set of options, differentiated by the levels of the attributes, including price. The respondent is asked to express preferences for the options, usually by rating, ranking, or by selecting the most preferred. In a CJ experiment, the researcher seeks to determine the probability that a respondent will choose one member of the choice set, and to examine the role of the attributes in that choice (Louviere, 1988).

The flexibility of conjoint analysis has led to a wide variety of applications. For example, food safety issues (Baker and Crosbie, 1993; Halbrendt et al., 1995; and Holland and Wessells, 1998), preferences for crop plants (Baidu-Forsun et al., 1997), and demand for food products (Harrison et al., 1998) are examined using conjoint analysis. Beilock et. al (1986) apply conjoint analysis to examine pricing in the truck transport industry. Conjoint analysis has been applied to estimate values for the attributes of recreation experiences such as waterfowl hunting (Gan and Luzar, 1993; Mackenzie, 1992, 1993), salmon fishing (Roe, et al., 1996), and water based recreation (Adamowicz et al., 1994). Some conjoint studies have also examined non-market values other than recreation, such as groundwater protection (Stevens, et al., 1997), reduction in diesel odors (Lareau and Rae, 1989), forest management (Zinkhan et al., 1994) and forest biodiversity (Garrod and Willis, 1997).

Experimental Design

Forest health is a non-market good composed of multiple attributes. Management to maximize one or more of these attributes may lead to changes in the levels of other attributes. Public preferences for the various amenities of healthy forests can be expected to be quite diverse. Also, forest health management programs may have different impacts in local and non-local areas, leading to differences between resident and non-resident preferences for such programs. One aspect of forest health is the prevention or eradication of damaging insect infestations. Pest management involves a variety of activities each with different levels of success and different extraneous consequences. It can be expected that members of society may have different values for the various attributes of a pest management program. Given this set of circumstances, CJ may be the most appropriate tool to estimate the value of management activities to protect or restore forest health.

This paper presents the results of a CJ study comparing resident and non-resident preferences for alternative management programs for the western spruce budworm. This insect is native to most fir stands in the western US, and has a large impact on commercial timber in the Pacific Northwest (Brookes, et. al, 1987; USDA Forest Service, 1989). The survey also contained conjoint questions for two other forest insect scenarios (the gypsy moth in the Northeast and the southern pine beetle). This study does not examine the resident versus non-resident preferences for the gypsy moth or southern pine beetle programs due to insufficient sample sizes from their respective regions.

Hypotheses

It is expected that residents of Oregon, where the western spruce budworm is an important forest pest problem, will have different preferences for management programs than non-residents. The sample of non-residents is composed of people from two other regions of the country who are also experiencing damaging, but different, insect infestations. Economic theory provides little guidance about how these respondents will rate programs to control a pest outside their own region. On the one hand they may prefer to spend money on a program which will affect their own region and thus prefer "no action" or a less intense program in the other region. On the other hand, having experience with a pest problem in their region may make them sympathetic to those in another region with a similar problem. Macdonald, et. al (1997) surveyed Ontario residents about their attitudes toward paying for environmentally benign pest management programs for two infestations. They found that residents did not differentiate between programs which would affect their own communities and those that would not.

Conjoint analysis is carried out in a regression framework. As demonstrated by Roe, et. al, ratings differences are the appropriate form of the dependent variable when the analyst wishes to calculate welfare measures such as compensating variation. Ratings differences were constructed using a “no action” management option which is the status quo. The attribute levels for this management option are fixed. These values are subtracted from the values for the attribute levels for the “action” management options which represent changes in the status quo. These ratings differences are used as the dependent variable in the regression analyses. Since neither ratings nor ratings differences are continuous or cardinal variables, the ordered probit functional form is the appropriate statistical analysis technique. The ordered probit functional form is:

$$P_i = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\beta_1 + \beta_2 X_i} e^{-t^2/2}\, dt, \qquad 4.1$$

where X is a vector of independent variables including price and attributes. Further, since each respondent answered several conjoint questions, forming a panel data set, a random effects ordered probit functional form was applied. The equality of coefficients was tested using a likelihood ratio test. Formally, the hypotheses are:

$$H_0\colon \beta_{res.} = \beta_{non-res.} \qquad 4.2.1$$

$$H_A\colon \beta_{res.} \neq \beta_{non-res.} \qquad 4.2.2$$

where $\beta_{res.}$ and $\beta_{non-res.}$ are vectors of coefficients for residents and non-residents respectively.

Using the negative ratio of the coefficient on each non-cost attribute (β_a) over the coefficient on cost (β_{cost}), a marginal value (MV_a) can be estimated for each attribute:

$$MV_a = -\frac{\beta_a}{\beta_{cost}}. \qquad 4.3$$

Thus we can examine whether the marginal value of the attributes are the same for residents and non-residents.

Data Collection

The western spruce budworm scenario was presented in a questionnaire mailed to 1200 households. The sample was concentrated equally in three geographic regions (the Northeast, Oregon and the Southeast). The same questionnaire was sent to each region.

The first part of the questionnaire consisted of a series of Likert-scale questions dealing with the appropriateness of various forest health management techniques practiced by foresters on both private and public lands. Respondents were asked to indicate how they felt about each technique by selecting on a scale from "never appropriate" to "always appropriate." Following these questions was a page containing information about trade-offs in forest health management. The next section of the questionnaire contained descriptions of the western spruce budworm scenario. A brief description of the insect, including its area of impact, and the effects of an uncontrolled infestation. Next was a description of three management options, the first of which was "no action" (the status quo), followed by a moderate pest management option, then an intensive management option. The three management options were then compared in a table showing the expected effects over the next 15 years: the area infested, changes in non-target insect populations, changes in insect-eating bird populations, water resource effects, changes in recreation use and changes in commercial timber. Finally the respondent is asked to rate the three management options on a ten-point scale, where 1 is least desirable and 10 is most desirable. The final section asked demographic questions. This questionnaire was developed with input from foresters and entomologists in the forest health field. The survey instrument was refined using the input of focus groups and a pre-test conducted in the three survey regions (the Northeast, the Southeast and Oregon).

Mailing procedures included a personal cover letter with the first mailing. A reminder postcard was sent to all respondents a week later. Non-respondents were then sent a second personal mailing four weeks after the initial mailing. The response rate was thirty-two percent.

Model

The model uses the following as independent variables (variable names in bold): the **cost** per household, the number of **acres** expected to be infested within 15 years of implementation of the program, expected changes in commercial **timber** harvests, an interaction term (**cut**) calculated by multiplying the respondents answer to a question about the appropriateness of clear cutting to manage insect infestations with "timber" and another interaction term (**env**) multiplying a dummy variable on the respondents membership in an environmental organization with a dummy on whether the program option involves a risk of contamination from spraying of pesticides.

$$atings\ diff. = \beta_1 + \beta_2 cost + \beta_3 acres + \beta_4 timber + \beta_5 cut + \beta_6 en \qquad 4.4$$

Results

Table 4.1 presents the regression results for the resident and non-resident models. The model for Oregon residents performs better in the significance of the coefficients with only the coefficient on **acres** failing to be significant at α=0.05 or better. The model for non-residents, however contains only one significant coefficient, that for the interaction term on membership in an environmental organization and the risk from spraying. The sign on the cost of the program, and on acres infested in the future is negative in both models as one would expect, but significant only in the resident model. This may have been due to a perception by residents that they were quite likely to pay the cost, while non-residents may have believed it was less likely they would have to pay the cost for a program not in their region. The sign on the cut interaction term and the environmental interaction term are also negative, indicating that if a person felt more strongly that clear cutting was an inappropriate management tool they would be less likely to rate highly a program which benefitted commercial timber, possibly due to an association between clear cut harvesting and cutting for insect infestation management. The sign on "timber" is positive for residents. This is sensible, since it implies that residents of Oregon, a state highly dependent on the timber industry, are more likely to favor a program which protects commercial timber.

To test the equality of resident and non-resident preferences, a likelihood ratio test was performed on the coefficients of the ordered probit regressions. The test statistic is distributed chi-squared with a value of 38.7408 and is significant at $\alpha=0.05$. The null hypothesis that the coefficients are equal must be rejected.

Confidence intervals for each of the attribute coefficients were also constructed for the resident and non-resident models. These are shown in Table 4.2 The 95% confidence intervals for all the attributes overlap for residents and non-residents. The 90% confidence intervals for residents and non-residents overlap for all but the timber variable, indicating that the difference in preferences found with the likelihood ratio test above is probably due entirely to differences in preferences for programs which protect timber values.

Marginal values for each attribute from the resident model were estimated using Equation 4.3. The results are shown in Table 4.3. As expected, the marginal value of higher numbers of acres still infested is negative for residents, indicating that they place a lower value on programs which result in higher levels of residual infestation. The "cut" term is also negative, indicating that programs which favor timber values are not favored by those who feel that clear cutting for pest control is an inappropriate pest management technique. The "environmental" term is negative and also quite large (-74.326). This indicates that a person who is a member of an environmental organization places a negative value on any program which may result in contamination from spraying of pesticides. Residents' marginal value for "timber" is +11.376, indicating that they place a positive value on programs which will increase commercial timber values.

Conclusions

The test of coefficient equality clearly indicates that the preferences of residents and non-residents are not the same for programs to mitigate western spruce budworm infestations. The coefficients for the resident model were all significant, while only that for the "environmental" term was significant for non-residents. It would appear that non-residents are unwilling to risk contamination from spraying to control the western spruce budworm, at the expense of local timber interests. Cost was not a significant coefficient for non-residents, perhaps indicating they felt it would be unlikely they would actually have to pay for a program outside their own region, despite the fact that all scenarios were presented as publicly funded by all U.S. households. Also, the spruce budworm is a native pest.

Further research on the resident and non-resident preferences for such programs should be carried out to examine the values placed on other programs for other insect infestations, and to examine the role that the attributes of these programs play in the preferences of each group.

Table 4.1. Estimated ordered probit parameters

	resident of Oregon	non-resident
constant	3.6608***	4.3997***
	(4.989)[a]	(7.083)
cost	-0.014273***	-0.003908
	(-2.665)	(-1.033)
acres	-0.024131	-0.007733
	(-0.488)	(-0.193)
timber	0.16237***	-0.02189
	(2.551)	(-0.558)
cut	-0.024759**	-0.001049
	(-1.802)	(-0.124)
env	-1.06086***	-0.44068*
	(-2.388)	(-1.580)
χ^{2b}	37.395	62.004

***, **, *, significant at α=0.01, 0.05, and 0.10 respectively

[a] ($z = \beta$/s.e.)

[b] Likelihood ratio test statistic for joint significance of coefficients.

Table 4.2. Confidence intervals for attribute coefficients

	95% CI Oregon resident	95% CI Non-resident	90% CI Oregon resident	90% CI Non-resident
cost	[-0.0248, -0.0038]	[-0.0113, 0.00351]	[-0.0231, -0.0055]	[-0.0101, 0.00232]
acres	[-0.121, 0.07269]	[-0.0864, 0.07093]	[-0.1054, 0.05713]	[-0.0738, 0.05829]
timber	[0.03763. 0.28711]	[-0.0988, 0.05502]	[0.05768, 0.26706]	[-0.0864, 0.04266]
cut	[-0.0517, 0.00217]	[-0.0176, 0.01553]	[-0.0474, -0.0022]	[-0.015, 0.01287]
env	[-1.9315, -0.1902]	[-0.9875, 0.10613]	[-1.7916, -0.3301]	[-0.8996, 0.01825]

Table 4.3. Attribute marginal values for Oregon residents

Attribute	Marginal Value
acres still infested in 15 years	-1.691
timber (percent change)	11.376
cut (disapprove of clearcut x timber)	-1.735
env (member of env. grp. x spray risk)	-74.326

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CHAPTER 5: CONCLUSIONS

The three studies presented above will contribute to the field of non-market valuation by extending the set of techniques available to researchers. In the past the only method of measuring passive use values such as existence, option, and bequest, was the contingent valuation method. In this method respondents are asked to express their hypothetical willingness to pay for these (often abstract) values by means that may be unfamiliar to most consumers. The contingent valuation method has been controversial in the past due to such issues as discrepancies between actual and hypothetical payments. This discrepancy may have as its origin the lack of "real world" familiarity for many respondents. Conjoint analysis may be a step ahead in that it more closely imitates a real world situation. Respondents are presented with options (much as they are presented with "brands" in a store). Each option will have a set of attributes (including a price), and so each will have "pros" and "cons" for each respondent. They can select which option they would most likely "buy" again, much like they would in a store.

As promising as conjoint analysis appears to be for the measurement of passive use values, its appropriate application requires that researchers are aware of and account for any issues which might be inherent in such a study. Issues arise in survey design, one of which is the format for the conjoint responses. This study has demonstrated that, at least for a small number of options, the rating and ranking formats produce similar results, indicating procedural invariance. Analysis of conjoint data will also present econometric issues. Since most conjoint studies in the past (and presumably in the future) ask multiple questions of each respondent, the panel nature of the data must be accounted for and has been shown in this study that the performance of the models improves when this is done. Further, as with contingent valuation studies and travel cost studies in the past, the extent to which conjoint results can be applied from one region to another must be examined. It was found here that, at least for the case of forest pest management, resident and non-resident preferences can vary greatly. Further methodological testing of the conjoint technique for application to non-market valuation must be conducted to confirm these conclusions and refine the technique for use in policy analysis.

APPENDIX A: SURVEY INSTRUMENT

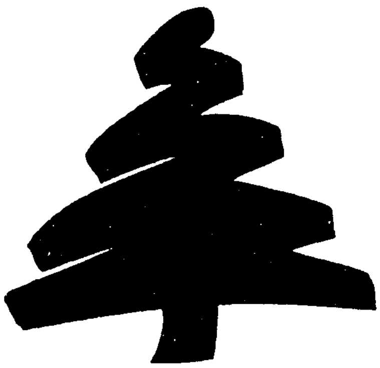
Forest Health Challenges Today

Our forests have undergone significant change during our nation's history. Timber harvests, fire suppression, accidental introduction of non-native forests pests, and air pollution have altered the forest resource and the natural forces which shape it.

Which Options Should Be Used for Managing Forest Health?

There are a variety of tools forest managers might use to maintain or re-establish a healthy, forest ecosystem in the public and private forests in the United States. In the table below, please tell us which tools you feel are appropriate for forest managers to consider using in the forest where you live, work or recreate.

		Always Appropriate to Use	Frequently Appropriate to Use	Rarely Appropriate to Use	Never Appropriate to Use	Don't Know
1.	Trapping undesirable insects to reduce their population	☐	☐	☐	☐	☐
2.	Cutting of individual dead or dying trees	☐	☐	☐	☐	☐
3.	Cutting or thinning of live trees	☐	☐	☐	☐	☐
4.	Clear cutting	☐	☐	☐	☐	☐
5.	Controlled burning	☐	☐	☐	☐	☐
6.	Apply chemical pesticides by hand	☐	☐	☐	☐	☐
7.	Aerially apply chemical pesticides	☐	☐	☐	☐	☐
8.	Apply biological or natural insecticides	☐	☐	☐	☐	☐
9.	Enhance production of native natural enemies of native forest pests	☐	☐	☐	☐	☐
10.	Introduce non-native natural enemies of non-native pests	☐	☐	☐	☐	☐
11.	Reforestation using pest resistant trees	☐	☐	☐	☐	☐
12.	Other (please list):					
______________________		☐	☐	☐	☐	☐
______________________		☐	☐	☐	☐	☐
______________________		☐	☐	☐	☐	☐



Trade-offs in Forest Health Management -
Which Ones Would You Make?

Managers have several preventative options to protect forest health.

- Prevention of insect or disease outbreaks can include such actions as cutting smaller trees to thin forest stands in areas with a high risk of outbreak.
- Monitoring and trapping of insects can help identify problem areas.
- Control actions may be taken, which may or may not stop an outbreak, but could reduce the effects of an outbreak.

When insect or disease outbreaks occur and are in the process of killing trees, there are also several response options:

- Do nothing and let nature take its course
- Take various control actions, including:
  - removal of infested trees
  - removal of dead trees
  - thinning to give remaining trees a better chance to survive
  - controlled burning
  - spraying of pesticides.

All of these choices involve trade-offs. The forests will look different, support different types of wildlife and support different recreational activities, now and in the future. Of course these different actions also have different costs to us as taxpayers and have different risks to the environment.

On the next three pages we ask you to choose the options you would prefer to deal with pest problems. Please read each description carefully and take your time in answering. These scenarios are designed to force you to make trade-offs between various attributes of a pest management program, and may not be realistic in every possible detail. Please make your choices based on your preferences for the various effects of each option.

Scenario A

Insect: **Gypsy Moth** - introduced to the United States from Europe in the 1800's
Tree Species/Forests Affected: hardwoods, especially oaks, and sometimes conifers
Area Impacted: Northeastern United States
Size of Currently Impacted Area: approximately 156 million acres in the generally infested area
Impacts of Uncontrolled Infestation:

- Wildlife impacts: Dead trees can provide nest sites for some birds and small animals
  Insect-eating birds increase
- Water resource impacts: Slight increase in runoff because of loss of vegetation cover, leading to soil erosion and siltation of streams
- Forest ecosystem impacts: Reduced tree growth in moderate outbreaks, trees may die if defoliation occurs year after year
  Other insects or diseases may infect weakened trees
  Large numbers of dead trees will cause fires to be more frequent and severe
- Recreation impacts: Loss of shade, unsightly dead trees, and danger from falling dead trees
- Economic impacts: Quarantines in infested areas have economic impacts on some businesses, since some products may be banned from uninfested areas to prevent the spread of the gypsy moth
  Commercial timber losses are small

Options for Pest Management:

Option 1: **No Action**

Option 2: Application of insecticides in the generally infested area (156 million acres) to reduce the adverse effects of the gypsy moth.

Option 3:
- Adds management actions on an additional 106,000 acres
- This option will use the same insecticide treatments as Option 2, along with non-insecticide treatments (mass trapping, disruption of mating with artificial pheromones, and mass release of sterile insects).
- Elimination of isolated infestations in areas outside the generally infested area
- Suppression of populations within the generally infested area
- Slowing the spread of gypsy moth infestations

Effects of the Options over the next 15 years:	Option 1:	Option 2:	Option 3:
● Acres infested by gypsy moth in 15 years	700 million	650 million	425 million
● One-time cost of the control option to all U.S. taxpayers, including you	0	$75	$125
● Changes in forest resources:			
• non-target insect populations	no change	18% decrease	19% decrease
• insect-eating bird populations	5% increase	13% decrease	14% decrease
• water resources:			
change in runoff	5% increase	5% increase	no change
change in erosion	5% increase	5% increase	no change
possible contamination from spraying	no	yes	yes
• recreation use	10% decrease	9% decrease	4% decrease
• commercial timber	no change	no change	no change

Using the information about the options and their effects given above, please **rate all three** possible management options. Use a scale of one (1) to ten (10), where one is the lowest rating and ten is the highest rating.

Option 1:	Option 2:	Option 3:
☐	☐	☐

Scenario B

Insect: Western Spruce Budworm - native to most fir stands
Tree Species/Forests Affected: Douglas-fir, grand fir, white fir, Engelmann spruce, subalpine fir, western larch
Area Impacted: Eastern Cascade mountains of Oregon and Washington, Northern and Central Rocky Mountains
Size of Impacted Area: approximately 7 million acres
Impacts of Infestation:

- Wildlife impacts: Severe repeated infestation will reduce habitat for some songbirds
- Water resource impacts: Slight increase in runoff because of loss of vegetation cover, leading to soil erosion and siltation of streams
- Forest ecosystem impacts: Large numbers of dead trees will cause fires to be more frequent and severe
  Reduced regeneration and timber production due to growth loss, deformity, reduced seed production and tree mortality
- Recreation impacts: Loss of shade, unsightly dead tress, and danger from falling dead trees
- Economic impacts: Commercial timber losses during severe infestations

Options for Pest Management:

Option 1: **No Action**

Option 2: Aerial application a natural insecticide.

Option 3: Aerial application of a chemical insecticide.

Effects of the Options over the next 15 years:	**Option 1:**	**Option 2:**	**Option 3:**
● Acres infested by western spruce budworm in 15 years	15 million	8 million	14 million
● One-time cost of the control option to all U.S. taxpayers, including you	0	$75	$125
● Changes in forest resources:			
• non-target insect populations	no effect	1% decrease	30% decrease
• insect-eating bird populations	5% increase	4% decrease	5% decrease
• water resources			
change in runoff	5% increase	4% increase	no change
change in erosion	5% increase	4% increase	no change
possible contamination from spraying	no	no	yes
• recreation use	15% decrease	14% decrease	6% decrease
• commercial timber	20% decrease	8% decrease	5% decrease

Using the information about the options and their effects given above, please **rate all three** possible management options. Use a scale of one (1) to ten (10), where one is the lowest rating and ten is the highest rating.

Option 1:	**Option 2:**	**Option 3:**
☐	☐	☐

Scenario C

<u>Insect</u>: **Southern Pine Beetle** - native to the Southern United States
<u>Tree Species/Forests Affected</u>: pines, especially loblolly and shortleaf
<u>Area Impacted</u>: Southeastern United States
<u>Size of Impacted Area</u>: approximately 10 million acres
<u>Impacts of Uncontrolled Infestation</u>:

- Wildlife impacts: Some wildlife species benefit from Southern Pine Beetle infestations:
  - some woodpeckers are predators of Southern Pine Beetle
  - provides standing dead trees for nesting
  - increases habitat for quail, rabbit, deer, and small mammals which require forest openings

  Causes a loss of habitat for the endangered red-cockaded woodpecker

- Water resource impacts: Increase in runoff because of loss of vegetation cover, leading to soil erosion and siltation of streams

- Forest ecosystem impacts: Large numbers of dead trees will cause fires to be more frequent and severe

- Recreation impacts: Loss of shade, unsightly dead trees, and danger from falling dead trees

- Economic impacts: Large commercial timber losses during epidemic periods

<u>Options for Pest Management</u>:

Option 1: **No Action**

Option 2: Use Integrated Pest Management (IPM) in general forest area (9.4 million acres). In addition, direct control actions will be taken as needed in outbreak situations. No actions will be taken in wilderness areas.

1. Integrated Pest Management:
   - reduce acreage in mature trees
   - thinning of dense pine stands
   - replanting cleared forests with more resistant tree species
   - planting a more diverse mixture of tree species
2. Direct Control Actions:
   - cutting and removing infested trees
   - cutting and leaving infested trees
   - cutting and hand spraying infested trees
   - cutting and burning infested trees

Option 3: Expands the acreage treated by the IPM and Direct Control actions of Option 2 into Wilderness Areas (10 million total acres). This is to protect adjacent private, state and high value Federal lands, and also to protect red-cockaded woodpecker habitat.

<u>Effects of the Options over the next 15 years</u>:	**Option 1:**	**Option 2:**	**Option 3:**
● Acres infested by southern pine beetle in 15 years	15 million	14 million	7 million
● One-time cost of **control option** to all U.S. taxpayers, including you	0	$75	$125
● Changes in forest resources:			
• non-target insect populations	no effect	5% decrease	20% decrease
• insect-eating bird populations	no effect	10% decrease	no change
• water resources			
change in runoff	10% increase	9% increase	no change
change in erosion	10% increase	9% increase	no change
possible contamination from spraying	no	no	no
• recreation use	15% decrease	14% decrease	7% decrease
• commercial timber	40% decrease	18% decrease	5% decrease

Using the information about the options and their effects given above, please **rate all three** possible management options. Use a scale of one (1) to ten (10), where one is the lowest rating and ten is the highest rating.

Option 1: ☐ **Option 2:** ☐ **Option 3:** ☐

Wording of the instructions for the rank versions:

Using the information about the options and their effects given above, please **rank the three** possible management options. Assign a rank of one (1) to your most preferred or the best option. Assign a rank of three (3) to your least preferred or the worst option. Assign a rank of two (2) to the remaining option.

Your responses are completely confidential and will only be used for the analysis of this study. You will not be identified in any way.

1. Do you visit National Forests for recreation?

☐ yes ☐ no

If yes, how many days did you spend in a National Forest (for recreation) in the last 12 months? ________ days

2. Check the activities which you have participated in within the last 12 months:

☐ hiking	☐ wildlife viewing	☐ other
☐ camping	☐ mountain biking	(please list)
☐ hunting	☐ backpacking	________________
☐ fishing	☐ snow skiing	________________

3. What is your zip code? ____________________

4. Are you male ☐ or female ☐

5. What is your age: ________ years

6. What is your highest level of formal schooling (please circle one number):

1 2 3 4 5 6	7 8 9	10 11 12	13 14 15 16	17 18 19+
(Elementary)	(Jr. High)	(High School)	(College)	(Graduate/Professional School)

7. Occupation: ____

8. Would you say you **grew up** in (please check one):

☐ a city or urban area	☐ a small town or rural area
☐ a suburban area	☐ a farm or ranch

9. Would you say you **currently live** in (please check one):

☐ a city or urban area	☐ a small town or rural area
☐ a suburban area	☐ a farm or ranch

10. Are you currently a member of an environmental or conservation organization?

☐ yes ☐ no

11. What was your household's combined income before taxes in 1995? (Please check one)

☐ $10,000 - $19,999	☐ $40,000 - $49,999	☐ $70,000 - $79,999
☐ $20,000 - $29,999	☐ $50,000 - $59,999	☐ $80,000 - $99,999
☐ $30,000 - $39,999	☐ $60,000 - $69,999	☐ $100,000 or more

Thank you very much for completing this survey. Please return the survey in the postage paid return envelope. If you have any additional comments, please write them on the back of the survey.

APPENDIX B: COVER LETTERS AND REMINDER POSTCARD FOR SURVEY MAILING

survey respondent
address
City, State, zip code

Dear *Survey Respondent:*

Trees and forests often add much to the quality of our lives. Trees provide shade, beauty and wildlife habitat. Recently, forests have been suffering from insect attacks and disease. Yet little is known about what you, the public believe should be done to address these threats to forest health.

To assist public and private forest managers, we have been asked to perform the attached survey to determine what types of actions you see as appropriate to solve these problems. There are no right or wrong answers. We would like you to take a few minutes to share your opinions on these important matters by answering the enclosed questionnaire.

Since your household is one of a few chosen to receive the survey your opinion is very important to us. The results will be provided to forest managers so they can make more informed decisions about how you want your natural resources managed.

Please be assured your responses are completely confidential. Individual responses are never identified in any way in our results.

After completing the survey, please mail it back in the enclosed postage-paid return envelope. If you would like a copy of the survey results, write "Results Requested" along with your name and address on the back of the return envelope, which will be immediately separated from the survey to protect your anonymity.

If you have any questions or concerns about the survey, we would be most happy to answer them. Please feel free to call us at (970) 491-2485 (John) or (970) 416-9405 (Michelle).

Thank you for your help. We look forward to receiving your completed survey.

Sincerely,

Dr. John Loomis
Professor and Study Director

Michelle Haefele
Research Associate

Last week you should have received a questionnaire from Colorado State University requesting your opinions on forest health. If you have completed the questionnaire and mailed it back to us, please accept our sincere thanks.

If you have not completed the questionnaire please do so today.
Because you are one of a few people receiving the survey, it is extremely important that we hear from you.

If by some chance you did not receive the questionnaire, or it got misplaced, please call me collect at (970) 491-2485 and I will send you another today.

Sincerely,

Dr. John Loomis, Department of Agricultural and Resource Economics
Colorado State University
Fort Collins, CO 80523

survey respondent
address
city, state, zip code

Dear *Survey Respondent:*

About four weeks ago I wrote you asking your opinion about the management of our nation's forests. As of today we have not received your completed questionnaire.

As a taxpayer, you may be affected by the costs of different forest management options. Therefore, it is important to let us know what you think. It is very important that we know how you feel about efforts to protect and enhance forest health. **Everyone's opinion matters!** Please answer the survey even if you have never visited National Forests or Parks or never intend to visit. Also, please do not feel that you are unqualified. There are no right or wrong answers. I am simply interested in your honest opinion. That is why I am writing you again to ask that you take just a few moments to answer the survey and return it in the stamped return envelope. You are one of the few people who were selected to receive this survey, so it is vital that we hear from you.

There are three questions which are asking about your preferences for management of insect outbreaks in forests. Your answers to these questions are especially important to us. Pleas read the Scenarios carefully. For each one, put a number in all three of the boxes at the end of the page (one for each management option).

Please be assured your responses are completely confidential. Individual responses are never identified in any way in our results.

A replacement survey and stamped envelope have been included for your convenience in completing the survey.

If you have any questions or concerns about the survey we would be most happy to answer them. Please feel free to call collect, John at 970-491-2485 or Michelle at 970-491-6872.

Thank you for your help. We look forward to receiving your completed survey.

Sincerely,

John B. Loomis, Ph.D.
Professor and Study Director

Michelle Haefele
Research Associate

APPENDIX C: LETTER SENT TO RESPONDENTS WHO DID NOT ANSWER CONJOINT QUESTIONS CORRECTLY, REQUESTING A SECOND RESPONSE

survey respondent
address
city, state, zip code

Dear *Survey Respondent:*

Thank you for returning your "Forest Health" questionnaire so quickly. We are sorry to have to bother you again, but it has become apparent that some of our instructions were unclear. Some of the questions were asking you to evaluate management options for a set of forest pest scenarios. We were looking for a number in each box for each options. There were several respondents who simply marked an "X" or check mark in one box rather than putting a number in all three boxes. Your input is important, and in order for our research to be statistically valid we are asking you to please re-answer this set of questions, which have been enclosed. Again, we apologize for the confusion, and for asking you to look as these questions again. Your extra effort is appreciated!

Sincerely

Dr. John Loomis
Professor

Michelle Haefele
Research Associate

APPENDIX D: EXPERIMENTAL DESIGN

Generic:

Attribute	V1 Opt 2	V1 Opt 3	V2 Opt 2	V2 Opt 3	V3 Opt 2	V3 Opt 3	V4 Opt 2	V4 Opt 3	V5 Opt 2	V5 Opt 3	V6 Opt 2	V6 Opt 3
acres	L	L	L	H	L	L	H	H	H	L	H	H
cost	L	L	H	L	L	H	H	H	L	H	H	L
insects	H	L	L	L	L	H	H	L	H	H	L	H
birds	H	H	L	L	L	H	L	H	H	L	H	L
streamflow	H	H	L	H	L	L	H	L	L	H	H	L
erosion	L	H	H	H	L	H	H	L	H	L	L	L
RVD's	H	L	H	H	L	H	L	L	L	L	H	H
timber	H	H	H	L	L	L	H	H	L	L	L	H

Scenario A - Gypsy Moth:

Attribute:	V1 Opt 2	V1 Opt 3	V2 Opt 2	V2 Opt 3	V3 Opt 2	V3 Opt 3	V4 Opt 2	V4 Opt 3	V5 Opt 2	V5 Opt 3	V6 Opt 2	V6 Opt 3
acres	426	200	426	425	426	200	650	425	650	200	650	425
cost	30	80	75	80	30	125	75	125	30	125	75	80
insects	-18	-19	-5	-19	-5	-40	-18	-19	-18	-40	-5	-40
birds	4	-14	-13	-30	-13	-14	-13	-14	4	-30	4	-30
streamflow	5	2.5	2.6	2.5	2.6	0	5	0	2.6	2.5	5	0
erosion	2.6	2.5	5	2.5	2.6	2.5	5	0	5	0	2.6	0
RVD's	-5	-4	-9	0	-9	0	-9	-4	-9	-4	-5	0
timber	0	0	0	0	0	0	0	0	0	0	0	0

Scenario B - Western Spruce Budworm:

Attribute:	V1 Opt 2	V1 Opt 3	V2 Opt 2	V2 Opt 3	V3 Opt 2	V3 Opt 3	V4 Opt 2	V4 Opt 3	V5 Opt 2	V5 Opt 3	V6 Opt 2	V6 Opt 3
acres	9	2	9	8	9	2	14	8	14	2	14	8
cost	30	80	75	80	30	125	75	125	30	125	75	80
insects	-1	-30	-14	-30	-14	-15	-1	-30	-1	-15	-14	-15
birds	0	-5	-4	-10	-4	-5	-4	-5	0	-10	0	-10
streamflow	4	2	2.1	2	2.1	0	4	0	2.1	2	4	0
erosion	2.1	2	4	2	2.1	2	4	0	4	0	2.1	0
RVD's	-7	-6	-7	0	-14	0	-14	-6	-14	-6	-7	0
timber	-8	-5	-8	-7	-19	-7	-8	-5	-19	-7	-19	-5

Scenario C - Southern Pine Beetle:

Attribute:	V1 Opt 2	V1 Opt 3	V2 Opt 2	V2 Opt 3	V3 Opt 2	V3 Opt 3	V4 Opt 2	V4 Opt 3	V5 Opt 2	V5 Opt 3	V6 Opt 2	V6 Opt 3
acres	8	1	8	7	8	1	14	7	14	1	14	7
cost	30	80	75	80	30	125	75	125	30	125	75	80
insects	-5	-20	-12	-20	-12	-13	-5	-20	-5	-13	-12	-13
birds	-6	0	-10	-5	-10	0	-10	0	-6	-5	-6	-5
streamflow	9	4	5	4	5	0	9	0	5	4	9	0
erosion	5	4	9	4	5	4	9	0	9	0	5	0
RVD's	-8	-7	-8	0	-14	0	-14	-7	-14	-7	-8	0
timber	-18	-5	-18	-17	-39	-17	-18	-5	-39	-17	-39	-5

APPENDIX E: CALCULATION OF THE CONFIDENCE INTERVALS FOR THE COEFFICIENT RATIOS

Confidence intervals were calculated for marginal values (coefficient ratios) in each of the above papers using the method derived by Fieller (1932) and used by Mackenzie (1992, 1993) and Roe et al. (1996). Rewriting the coefficient ratio as $\beta_a + \beta_{cost}MV_a = 0$, the confidence interval can then be estimated from the quadratic roots of:

$$\frac{(\beta_a + \beta_{cost}MV_a)}{(\sigma_a^2 + 2\sigma_a\sigma_{cost}MV_a + \sigma_{cost}^2MV_a^2)^{0.5}} > t, \qquad 3.4$$

where σ_a^2 and σ_{cost}^2 are coefficient variances , $\sigma_a\sigma_{cost}$ is the covariance, and t is the critical value.

In practice this presented a tedious operation, as each coefficient ratio would have to be calculated by hand, first solving equation C.1 for MV_a, then substituting in the appropriate regression results and critical value. Instead, I input the formula and the regression results for each paper into a spreadsheet and used the "goal seek" feature to find the value of MV_a which satisfied the critical value for the confidence interval of interest. This proved to be effective in the cases where significant coefficients on the attributes had been obtained.

References

Fieller, E. C. "The Distribution of the Index in a Normal Bivariate Population." *Biometrika* 24(1932):428-440.

Mackenzie, J. "Evaluating Recreation Trip Attributes and Travel Time Via Conjoint Analysis." *J. Leisure Research* 24(2) (1992):171-184.

Mackenzie, J. "A Comparison of Contingent Preference Models." *Amer. J. Agr. Econ.* 75(August 1993):593-603.

Roe, B., K. J. Boyle and M.F. Teisl. "Using Conjoint Analysis to Derive Estimates of Compensating Variation" *J. Environ. Econ. Manage.* 31(September 1996):145-159.