Economics of forest ecosystems

CHOICE EXPERIMENTS AND

VALUING FOREST ATTRIBUTES

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Abstract

This chapter considers the use of choice experiments to value services of forest ecosystems that are not traded in markets and conditions that might be marketed but have not been experienced in the market. A choice experiment is a survey-based valuation method in which the unique focus is the estimation of marginal values for individual elements of forest ecosystems. We begin with an explanation of the state of the art in choice experiments and then discuss common types of forest ecosystem applications from around the globe. The application of choice experiments to forestry issues has grown rapidly in recent years, and we anticipate continued growth. Concurrent with this growth in applications, there have been substantial enhancements in the design of choice questions and the econometric analysis of the choice data. Future forestry applications should search for the best procedures in study design and data analysis when implementing studies. Overall, choice modeling has provided forest decision makers in both the public and private sectors with richer information on economic values to enhance the quality and sustainability of forests at the local, national and global levels.

Keywords

Choice modeling, choice experiments, nonmarket valuation, use value, nonuse use value, experimental design, attributes, conditional logit model, random parameter logit model

Introduction

Around the globe, forests provide a suite of ecosystem services that are valued by people. Over time, as economies develop and household incomes increase, the relative value of specific ecosystem services can change from an emphasis on resource extraction (such as timber or fuelwood harvesting) toward a greater emphasis on nonmarket goods and services (Cubbage, Harou and Sills, 2007). In the United States, for example, this transition is evidenced by legislation requiring that national forests be managed for timber, range, watershed, recreation and fish and wildlife resources (Multiple Use-Sustained Yield Act of 1960, P.L. 86–517) and that long-range plans be established to balance the multiple uses of the nation’s national forests (Forests and Rangeland Renewable Resources Planning Act of 1974, P.L. 93–378; National Forest Management Act of 1976, P.L. 94–5888). The emphasis on the provision of multiple goods and services from national forests provided a rationale for developing estimates of nonmarket values of forests that could be used for planning purposes (e.g. Loomis, 2005). The broadening of forest management objectives to include the provision of nonmarket values is not unique to the United States. The European Union (EU) Forest Action Plan, for example, recently called for new research and the development of databases on the nonmarket value of forest resources to support forest-related initiatives (Stenger, Harou and Navrud, 2009).

We also note that, over the past decade, the number of nonmarket valuation studies focused on forest ecosystems has grown rapidly, not only in the United States and Europe, but also in Asia and South and Central America. People who visit public forests for recreation, hunting or fishing typically do not pay a fee, so there is no market price to assess the marginal values of these experiences. In addition, people who do not visit public forests can hold nonuse or passive use values for forest resources that are not expressed through market prices. These conditions require economists working on forest plans to consider nonmarket valuation methods such as travel-cost models and contingent valuation surveys to estimate values for current and future forest conditions (Champ, Boyle and Brown, 2003). Travel-cost models are used to estimate recreation use value based on people’s actual recreation experiences (Parsons, 2003; see Zanderson and Tol, 2009, for examples of travel-cost applications in Europe). Contingent-valuation surveys provide more flexibility, as this method can be used to estimate use, nonuse use and total values (Boyle, 2003; see Barrio and Loureiro, 2010, for contingent-valuation applications around the globe). Travel-cost models are restricted to conditions that people have actual experience, whereas contingent valuation does not have this restriction. Contingent-valuation scenarios can be designed to estimate the loss in recreation use values when a forest is damaged by disease or a pest infestation. If this degraded condition had not been previously experienced, there would not be observed use behavior to estimate a travel-cost model. Nonmarket-valuation approaches naturally evolved to include choice experiments (Holmes and Adamowicz, 2003), and a number of the early applications valued forest characteristics (Adamowicz, Boxall, Williams and Louviere, 1998; Hanley, Wright and Adamowicz, 1998). A choice experiment, like contingent valuation, is a survey-based nonmarket valuation method. The unique feature of a choice experiment is that the change to be valued is described via a number of attributes, and marginal values can be estimated for each of these attributes. A contingent valuation scenario provides a single value, whereas a choice-experiment scenario allows the estimation of multiple values. Thus, forest managers can learn what attributes provide the highest value and how values change with the levels of each attribute. For example, in a study of changes in forest management practices in the state of Maine in the United States, we used a choice experiment to investigate different logging practices that would reduce the ecological impacts of timber harvesting (Boyle, Holmes, Teisl and Roe, 2001). Attributes included in the design of the choice experiment included the density of logging roads, dead or dying trees left in harvest openings, live trees left in harvest openings, size of harvest openings, percentage of land available for timber harvesting, size of riparian protection zones and slash disposal. This choice experiment with these attributes allowed forest managers to learn about the values that the public placed on reducing different aspects of timber harvesting and customize forest regulations and harvesting guidance to minimize environmental concerns and maximize public satisfaction, while considering the productivity of forest operations. Thus, the complex nature of forest management and the multiple services provided by forests are the stimulating factors for considering choice experiments to value changes in forest conditions to support forest planning and management. It can be logically argued that considerations of multiple uses of public and private forests is a stimulating factor in the expansion of choice experiment applications to support forest ecosystems decision making around the globe (Bengston, 1994; Jensen and Bourgeron, 1994; Kennedy, 1985). Although some current applications of choice experiments to value forest attributes still consider recreational use values for forest-based recreation, many current applications typically estimate total values for changes in forest ecosystems that include both use and nonuse values. Although the outcomes of choice experiments have broad management appeal, the rigor of doing a high-quality study has advanced considerably in recent years in terms of the design of choice experiments and the econometric analysis of the resultant data. In this chapter we provide an overview of the design of choice experiments and data analysis, as well as a summary of the types of empirical applications in the literature.

Choice experiments

Choice experiments are a survey-research approach to collecting data to estimate values people place on items that are not traded in markets, or for items traded in markets for which the conditions to be valued have not been experienced (Hanley et al., 1998; Holmes and Adamowicz, 2003). An example of the latter would be a change in forest management that created conditions that people recreating had not experienced previously, such as cessation of timber harvesting or other change that would impact forest recreation experiences. The choice experiment is applied in a survey that is typically administered through mail, in-person interview or Internet modes. The choice experiment portion of the survey proposes alternative profiles that are defined in terms of attributes. Respondents typically are asked to choose between two or more alternatives where one alternative is the current or status quo condition (no change) and the other alternatives represent improvements or decrements in forest conditions. The alternatives are typically described in three or more attributes where one attribute is a monetary cost. If there were only two attributes, one forest attribute and the cost, the question would be equivalent to a dichotomous-choice, contingent-valuation question. Although it is possible to design a choice experiment that does not include a monetary attribute, the exclusion of the monetary attribute would preclude the possibility of developing monetary values for each forest attribute to use in decision making. A sample choice question is presented in Table 9.1, which is taken from a study whose goal was to estimate household willingness to pay for public and private programs that would reduce home owners’ risk of economic damages from forest fires (Holmes, González-Caban, Loomis and Sánchez, 2013). To convey different risk levels, which are very small, the authors included graphic displays in the survey (similar to graphics used to display changes in health risks in health valuation experiments).The key elements in designing a choice experiment include six steps: (1) selecting the attributes, (2) choosing levels for the attributes, (3) deciding the number of alternatives for each choice question, (4) picking the number of choice questions each survey subject will be asked, (5) developing the experimental design to select the combinations of attribute levels to be presented in each choice question and (6) analyzing the response data. These are the elements that are unique to choice experiments. Other elements of the application of choice experiments would be common to the design of contingent valuation surveys and other types of economic surveys.

Experimental design

The foundation of any choice experiment is completing steps 1 through 5 identified previously. Steps 1 through 4 do not need to be followed in the order we present here, but they do need to be considered before completing the fifth step. Most choice experiments have a decision making goal, whether it is a primary or secondary goal, and attributes and attribute levels are chosen to support the anticipated decisions. Thus, the attributes are selected to represent features that will be affected by (change due to) the anticipated decisions. For example, in the Boyle et al. (2001) study cited previously, forest policy decision making could involve reducing the environmental impacts of timber harvesting, reducing the density of logging roads, leaving more dead or dying trees in harvest openings, leaving more live trees in harvest openings, reducing the size of harvest openings, limiting the percentage of land available for timber harvesting, increasing the size of riparian protection zones and changing slash disposal practices. Likewise, the Gelo and Kock (2012) study considered changes in forest type, increasing and productivity and differing levels of wood biomass harvesting by households. Thus, attribute and attribute level selection are not creations of the investigator, but reasoned choices based on three considerations: needs of decision makers, concerns of survey respondents and practical design features of the choice experiment.

The first element is developed through discussion between investigators and decision makers to select attributes and attribute levels, and the second step involves pretesting of the survey instrument. The discussions and pretesting can reduce or expand the number of attributes and possibly change attribute levels. If economic analyses are warranted, one of the attributes will always be a cost or payment where the estimated preference parameter on this attribute is interpreted as the marginal utility of money and is used to compute implicit values for each of the Table 9.1

Public fire prevention

Alternative #2:

Private fire prevention

More will be said about the role of this attribute when we turn to the econometric analysis discussion subsequently. A reduction in the number of attributes might occur if pretesting shows that an attribute of interest to decision makers has no relevance to respondents or is too difficult to convey to respondents. An example might be some element of the ecological functioning of a forest that does not easily translate into use or nonuse services of the forest that survey respondents’ value. An added attribute might arise because survey respondents have a concern that is not fundamental to decision making, but if omitted from the study it could potentially bias the estimated effects of the included attributes. An example of this occurred in a study we are doing for the National Park Service to value improvements in visibility from reductions in anthropogenic haze (Paterson et al., 2013). The initial choice question did not have an attribute for the effects on forest flora and fauna from changes in haze. To avoid confounding the haze attribute with ecosystem effects, we found that it was necessary to include a forest ecosystem impact attribute in the design. In addition to the number of attributes in a choice question, the design complexity of a choice experiment can be affected by the number of alternatives respondents are asked to consider in a choice question and the number of questions that are posed to each respondent. At a minimum, choice questions should have two alternatives, a status quo and a proposed change from the status quo. The status quo alternative is needed because the statistical outcome of a choice experiment is an unanchored utility index. If the results are to be used for economic analyses, particularly in cost-benefit analyses, then the status quo is crucial for measuring changes in value from baseline conditions. Beyond the status quo, a choice question may have one or more proposed changes that respondents are asked to choose from. For example, Rolfe and Bennett (2009) considered choice questions with two and three alternatives where one alternative in each design was the status quo defined as current conditions. Day et al. (2012) considered ordering effects when subjects are presented with multiple choice questions in a single choice survey. These and other studies have shown that increasing the number of alternatives and number of choice questions can have desirable and undesirable effects on estimated preference parameters; when designing a choice study, the analyst must carefully consider the information needs and the insights provided in these and other studies in the peer-reviewed literature. A fundamental advancement in the design of choice questions in recent years has been the development of optimal design strategies for assigning combinations of attributes to choice questions (Kanninen, 2002; Rose, Bliemer, Hensher and Collins, 2008; Scarpa and Rose, 2008). Software for design includes Ngene (www.choice-metrics.com/features.html) and SAS (<http://support.sas.com/techsup/technote/ts723.html>). The fundamental feature of choice experiments that enhances the appeal of this valuation method to researchers and decision makers is that it is possible to increase the amount of valuation information that can be gleaned from a fixed sampling budget. However, investigators must balance this desire for more information with caution that they do not create a design that is too complex for survey respondents, is not statistically efficient for estimating preference parameters and does not induce undesirable experimental effects such as anchoring or order effects.Conceptual framework for welfare evaluation and data analysis Analyses of choice experiment data are based on the standard random utility framework, but because survey respondents are asked to answer multiple choice questions in a single choice survey, panel data sets are collected. Thus, there are a variety of econometric approaches that have been employed to analyze these data. We will review two of these approaches here conditional logit (CL) model that does not consider the correlation between panel data observations, and the random parameters logit (RPL) model that does allow for this correlation. In addition, the CL model assumes that preference parameters are fi xed, whereas the RPL model allows for heterogeneity in preference parameters across survey respondents. The random utility framework is based on the assumption that survey respondents can make choices over alternatives, but from an econometric perspective, the analyst only observes a systematic component of respondents’ utility/preferences ( νij), and there is a random component that is not observable ( εij). Assuming that utility is a linear function of preference parameters over the attributes included in the choice question design for a particular study, the systematic component of utility.

The analyst specifies which parameters are random and the distribution of the random parameters (e.g. normal, triangular or log normal). It is typically the case that λ (marginal utility of money) is not randomly distributed to facilitate computation of WTP.Probabilities in a RPL model are weighted averages of the standard logit formula evaluated at different values for β. The weights are determined by a density function f(β|θ), where θrepresents the underlying parameters of the density function (such as the mean and covariance). ij

represent the probability that individual i chooses alternative. A triangular distribution might be used when an analyst has good reason to restrict a parameter estimate to be only positive or only negative. All forestry studies we reviewed treated the price variable as fixed. Statistically significant estimates of the attribute parameters were reported in these studies and, in some cases, it was found that some of the sampled population had the unanticipated sign on their preferences. When part of the estimated distribution indicates that some respondents have the wrong preference-parameter sign, caution is warranted in evaluating the statistical results, and the analyst must ask if there were problems in their prior expectations of parameter signs or in implementing the choice experiment, or if an inappropriate statistical model is being used to analyze the data.

When computing WTP and MWTP using estimates from a random parameters model, it is recommended that MWTP include the standard deviation of each distributed parameter. In particular, Next, we discuss some peer-reviewed publications that dealt explicitly with a forestry application. We exclude studies that included a forestry attribute, but for which the parameter estimate was not significantly different than zero. The included studies were conducted in Europe (n =13), North America (n =6), Asia (n =4), South or Central America (n =2), Australia (n =1) and Africa (n =1). The first study we identified was published in 1998, and more than half of the studies have been published since 2007.Although the literature review is not exhaustive, it will provide the reader with a flavor for the types of forestry applications where choice experiments are useful in informing decision making. We have categorized studies according to three major themes: (1) forest ecosystem services and nonuse values, (2) forestry contracts and (3) forest risk analysis. Forest ecosystem services and nonuse values Natural systems are increasingly viewed as critical capital assets that provide a broad suite of ecosystem services valued by people (Mäler, Aniyar and Jansson, 2008). The Millennium Ecosystem Assessment (2003) listed four categories of ecosystem services: provisioning (such as food, water and timber), regulating (such as carbon sequestration), cultural (such as recreation) and supporting (such as nutrient cycling). None of the forestry applications we reviewed were explicitly concerned with supporting services, and only a few forestry studies focused on tradeoffs that included provisioning services, such as timber (Boyle et al., 2001; Holmes and Boyle, 2005) and nontimber forest products (Riera and Mogas, 2004; Mogas, Riera and Bennett, 2005; Mogas, Riera and Brey, 2009). Several studies included attributes related to regulating services, such as carbon sequestration (Riera and Mogas, 2004; Mogas et al., 2005, 2009; Brey et al., 2007; Balderas Torres, MacMillan, Skutsch and Lovett, 2012) and soil retention (Boyle et al., 2001; Riera and Mogas, 2004; Holmes and Boyle, 2005; Brey et al., 2007; Wang et al., 2007; Mogas et al., 2009). Studies focused on trade-offs involving cultural services have also been popular, such as recreation and ecotourism (Riera and Mogas, 2004; Mogas et al., 2005, 2009; Naidoo and Adamowicz, 2005; Horne, Boxall and Adamowicz, 2005; Brey et al., 2007; Christie, Hanley and Hynes, 2007; Elsasser, Englert and Hamilton, 2010). Although biological diversity is not an ecosystem service per se, but rather is a structural feature of ecosystems that influences ecological outcomes, forestry studies investigating the value of biodiversity conservation have been popular. One of the primary challenges of including biological diversity in a choice experiment is the determination of ecosystem endpoints that enter the utility functions of respondents which also have relevance to managers and policymakers. One approach has been to link indices of biological diversity (such as avian species richness) with the likelihood of viewing such species during visits to conservation areas (Naidoo and Adamowicz, 2005). However, it has been more common to treat biological diversity as a nonuse value in forestry studies, where diversity has been characterized by measures of species richness (Rolfe, Bennett and Louviere, 2000; Lehtonen, Kuuluvainen, Pouta, Rekola and Li, 2003; Horne et al., 2005; Ohdoko and Yoshida, 2012) or by protecting natural processes in conservation areas (Bienabe and Hearne, 2006; Horne, 2006; Czajkowski, Busko-Briggs and Hanley, 2009). Non use values estimated in forestry applications of choice experiments have demonstrated that nonuse values are a critical component of the total value of forest protection and conservation programs. In some cases, nonuse values have been found to exceed use values for attributes such as scenic beauty (Bienabe and Hearne, 2006), although trade-offs between scenic beauty and nonuse values have also been shown to be spatially dependent (Horne et al., 2005).

Failure to recognize nonuse values for forests in decision making is a type of market failure that leads to misallocation of resources (Rolfe et al., 2000). Further, the identification of non use values can help forest managers decide where to implement protection and conservation activities, as nonuse values may be associated with remote locations that are seldom or never visited by recreationists or other users of forest ecosystems (Moore, Holmes and Bell, 2011).

Forestry contracts

Private forest land produces both private and public goods. The supply of public goods from private forests is underprovided when private forest owners do not account for the public benefits they produce or receive from other forest owners. Because the production of public goods (such as biodiversity) from private forests may require diminished production of private goods (such as timber), one approach to maximizing social welfare from private forests is to establish voluntary contracts that compensate forest owners for decreases in commercial value. Voluntary contracts may be more socially acceptable than establishing new rules or regulations for the provision of public goods, and an emerging forestry literature has used choice experiments to investigate the preferences of private forest owners (or those who gain property rights) for attributes of forestry contracts. Concern with biological diversity and endangered forest organisms in Finland led, in 2002, to a pilot program to enhance the conservation of forest biodiversity. Nearly three-fourths of the forest land located where biodiversity concerns are greatest is owned by private nonindustrial owners, and a choice experiment was designed to evaluate private forest owners’ preferences for the attributes of a voluntary incentive program (Horne, 2006). The results indicated that forest owners would accept compensation for restrictions on the use of small patches of their land and the development of a nature management plan, although they disliked restrictions on silvicultural activities. Forest landowners also preferred shorter contracts to longer ones, thereby maintaining autonomy over long-run decisions. Forest protection programs are also public goods in that the protective actions taken by one landowner convey protection benefits to neighboring landowners. The southern pine beetle (SPB) is the most damaging insect in southern U.S. forests, and forest management activities, such as thinning or planting resistant tree species, can reduce the risk of timber damage that benefit owners of forest on neighboring land. To understand the preferences of forest landowners for selected forest management treatments offered under a hypothetical cost-share program, a choice experiment was designed and implemented (Rossi, Carter, Alavalapati and Nowak, 2011). The authors found that replanting was the most preferred management option, whereas prescribed burning significantly reduced landowner utility, and landowners were indifferent regarding thinning activities – perhaps because they would occur many years in the future. Landowners were also indifferent regarding an attribute describing what percentage of their neighbors participated in the program.

Economists generally argue that clear property rights are necessary for investment and economic growth. Experiments with property rights are currently occurring in China, and a recent choice experiment was undertaken to investigate the preferences of Chinese farmers for the property right attributes of forest contracts (Qin et al., 2011). The authors concluded that farmers are very concerned with the types of rights provided by a contract and favor contracts that reduce the risk of contract termination and offer the priority to renew the contract at expiration.

Forest risk analysis

During the past decade, public concern has grown rapidly in many regions around the world regarding the threat of wildfires. Wildfires are a natural element in fire-prone forest ecosystems, and fire management involves a complex set of relationships between homeowners living in those ecosystems and fire managers faced with the responsibility of protecting life, homes and other resource values. A relatively new and emerging forestry literature has applied the choice experiment method to two aspects of the wildfire problem. One line of research has focused on decision making by fire managers faced with making fire suppression trade-offs. Within the United States, there is concern that past fire suppression paradigms have led to inefficient firefighting strategies and tactics under current conditions. To investigate the trade-offs that fire managers are willing to make among multiple objectives, a two-tiered choice experiment was designed and implemented with fire managers who were asked to provide expected responses (based on agency and political expectations) and their preferred responses (ignoring agency and political expectations) (Calkin, Venn, Wibbenmeyer and Thompson, 2012). The authors found that, for the expected response model, fire managers preferred more expensive options, while the opposite result was found for the preferred response model, and concluded that fire managers currently treat firefighting budgets as a free good.

A standard economic assumption is that, when faced with risky outcomes, decision makers attempt to maximize expected utility. This hypothesis was tested using a choice experiment on fire managers in the United States in which the probability of a successful outcome was varied across fire suppression alternatives (Wibbenmeyer, Hand, Calkin, Venn and Thompson, 2012). Study results led to the conclusion that fire managers’ decision making is inconsistent with the expected utility model, and that managers may overspend firefighting resources when the likelihood or potential magnitude of damages is low. In the United States, homeowners living in fire-prone landscapes are being asked to engage in vegetation management and home construction activities that reduce the risk of wildfire damages. To evaluate how homeowners make trade-offs between wildfire risks, potential loss and cost of risk-reducing measures, a choice experiment was developed and implemented with homeowners living predominantly in medium- and high-risk areas of Florida (Holmes et al., 2013). Similar to the study results described previously (Wibbenmeyer et al., 2012), the authors concluded that homeowner choices were generally inconsistent with expected utility theory. Rather, they suggested that their results were more consistent with prospect theory, under which people place greater weight on a certain loss (the cost of risk reduction) rather than on a probabilistic loss. Wildfire risk is also a concern in many Mediterranean forests. In order to understand the trade-offs that citizens in Catalonia, Spain, would make between fire management programs which resulted in varying levels of fire intensity (trees per unit area killed) and total area burned (Farreras and Mavsar, 2012). The results showed that respondents are concerned about wildfire risks and that they preferred programs that focus on the reduction of the area burned.

Conclusion

The application of choice experiments to issues of concern in forestry has grown rapidly in recent years and we anticipate continued growth in applications for the foreseeable future. Concurrent with this growth in applications have been substantial enhancements in the design of choice experiments and the econometric analysis of the choice data. Future forestry applications should search for the best procedures in study design and data analysis when implementing studies. As such, we emphasize the importance of developing meaningful survey instruments through the rigorous use of focus groups and pretests. Choice experiments need to be consistent with current ecological knowledge, and have forest management and policy relevance. Discussions with natural scientists and forestry decision makers during the survey development phase are prerequisite to the development of a meaningful survey instrument. This recommendation is particularly germane to the issue of identifying the endpoints of forest ecosystem attributes and attribute levels that are of interest to decision makers and enter the utility function of respondents, especially regarding nonuse values. This qualitative design must be followed with rigorous experimental designs that assign attributes to choice alternatives, and to the econometric analysis of the response data. The literature on the validity of choice experiments is expanding rapidly in the transportation, environmental and health economics literatures, and forest economics researchers are encouraged to stay current with these developments. Our review of the choice-experiment literature suggests that forestry applications have been mainly empirical applications to support decision making and are not always consistent with the frontiers in the methodology of choice experiments. A relatively new innovation in forestry applications of choice experiments is to use this methodology to investigate trade-offs that agency decision makers are willing to make when outcomes are uncertain. This type of application appears poised to provide substantial insights into how public expenditures are weighted vis-à-vis other agency objectives when making public choices. A related innovation is the use of choice experiments to investigate decision making under conditions of risk. The few forestry applications of this topic have revealed that decision makers tend not to use the expected utility framework, but rely on other modes of decision making. It seems that there is much that can be learned from the application of choice experiments under conditions of risk and uncertainty, especially as applied to natural disturbances such as wildfires and forest pest outbreaks, and in the protection of forest ecosystems. Overall, choice modeling has provided forest decision makers in both the public and private sectors with richer information on economic values to enhance the quality and sustainability of forests at the local national and global levels. Empirical applications have only begun to consider the many applications where choice experiments can help to improve forest decision making.

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