VALUING OLD-GROWTH FORESTS AND RELATED QUALITIES IN SOUTHWEST MAINLAND BRITISH COLUMBIA USING CONTINGENT CHOICE

by

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ABSTRACT

The Northern Spotted Owl is an endangered species that requires old-growth forests in southwest mainland British Columbia for its survival. Policies to save the owl focus on habitat preservation and include trade-offs between removing old-growth forests from timber harvesting allocations, and preservation of an animal with no direct market value. The majority of forests are public land and determining the proper trade-offs requires knowledge of the general public's preferences. Existence values for the Spotted Owl may be confounded with their habitat (i.e. old-growth forests), or other old-growth dependent species at risk, where the old-growth forests can exist without these species, but not vice versa. This study uses a stated preference, multi-attribute, trade-off approach to measure these values separately, but in the context of each other. Risk (success of conservation) is also included into the valuation. The study surveyed the general public of the Lower Mainland using a web-based format.

Keywords: Contingent Choice; Latent Class Model; Existence Value; Species at Risk; Risk; Old-Growth Forest; Northern Spotted Owl; Environmental Valuation

DEDICATION

I dedicate this to anyone who is planning, undergoing or has finished a career change;

or any parent pursuing higher education; or both.

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GLOSSARY

Contingent Choice	A stated preference, multi-attribute, trade-off method.
Value	The worth of a forest good or service that can be expressed in an equivalent amount of money or other goods or services.
Existence Value	The value an individual places on an environmental good or service that is independent of use.
Option Price	The maximum, ex-ante, state-independent payment that an individual is willing to make to move from the status quo risk to an improved situation.
Old-Growth Forest	Unique, complex systems, containing live and dead trees of various sizes and species composition that are part of a slowly changing and dynamic ecosystem.
Risk	The probability of an event occurring, multiplied by the magnitude of that event if it does occur.
Species at Risk	A species that is in danger of extirpation or extinction.
Compensating Surplus	The amount of income an individual is willing to give up for an environmental improvement over the current situation so the individual remains at the same utility level as before the change.

CHAPTER 1: INTRODUCTION

1.1 The Northern Spotted Owl

The Northern Spotted Owl is close to extirpation in Canada (Chutter *et al.* 2004). This medium-sized owl's habitat stretches from northern California to southwest mainland British Columbia and the population is declining on both sides of the border. Although total population estimates vary from 3000 to 6000 breeding pairs, less than six breeding pairs currently exist in BC (Chutter *et al.* 2004) which is down from an estimated historic high of 500 breeding pairs (Blackburn *et al.* 2002). In Canada, the Spotted Owl's[1] current and suitable habitat is in southwest mainland British Columbia.

A primary threat to the Spotted Owl's survival is the logging of its habitat (Forsman, Meslow and Wight, 1984; Gutiérrez, Franklin and Lahaye, 1995). Spotted Owls rely on large swaths of forests with old-growth characteristics located in valley bottoms, which coincides with the most economically valuable timber (Forsman *et al.* 1984). The size of its home range depends on numerous factors such as forest fragmentation, forest age and prey availability (Carey, Horton and Biswell, 1992). At the northern extent of the Spotted Owl territory, the size of a home range can vary from just over 1000 hectares, up to 11,000 hectares (Miller, 2004). For management purposes, the Province of British Columbia currently designates 3200 hectares (of which two-thirds

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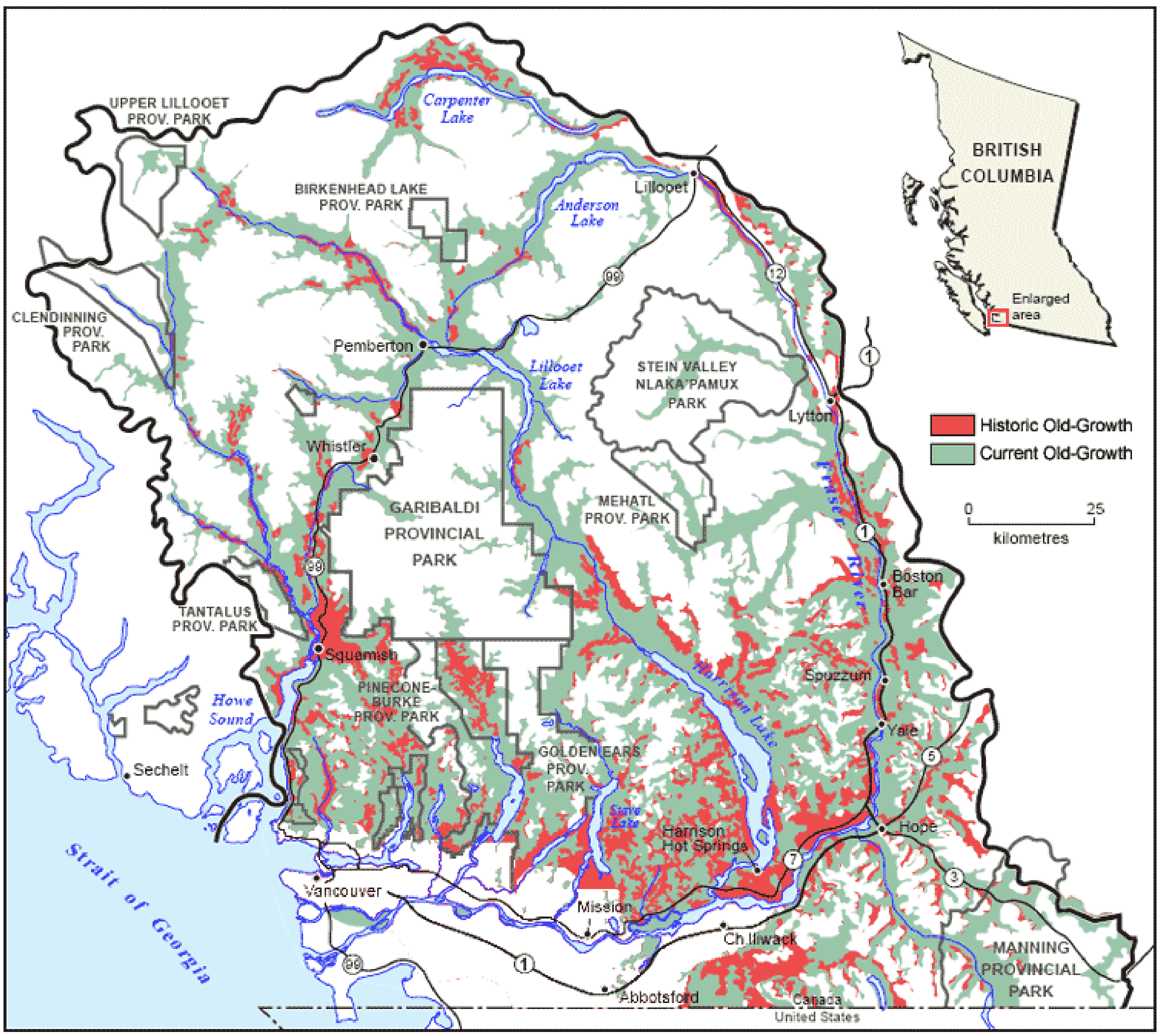
[1] Three subspecies of the Spotted Owl exist in North America. This report focuses on the Northern Spotted Owl (*Strix occidentalis caurina*) whose range extends from northern California to southern British Columbia. In this report, the term 'Spotted Owl' will refer to the Northern Spotted Owl unless otherwise specified.

should be in (Miller 2004. Modified with permission from Western Canada Wilderness Committee)

suitable old-growth condition), for each breeding pair. However, this number may be too low for suitable habitat purposes (Miller, 2004). Figure 1-1 shows the current extent of suitable old-growth habitat in southwest mainland BC; however, at this scale it is impossible to show the fragmentation of the forest, which makes large tracts of land unsuitable as owl habitat.

Figure 1-1: Southwest Mainland British Columbia



The Spotted Owl's habitat consists of forests with old-growth characteristics, such as, large, tall trees, a myriad of standing and fallen dead and woody debris and cool, humid forests (Forsman, *et al.* 1984). Forests with suitable habitat attributes can be as young as 100 years old, but are more common among forests that are 250 years and older (Miller, 2004).

1.2 Legal Framework for Northern Spotted Owl Protection

1.2.1 The Acts

From a legal perspective, the Provincial Government of British Columbian is primarily responsible for the management of most species at risk in the province. The Spotted Owl is covered under BC's *Wildlife Act* (RSBC 1996, c.488), because the Canadian Spotted Owl population only occurs in southwest mainland BC and raptors are not covered by the Federal *Migratory Birds Convention Act* (1994, c.22). Although the Spotted Owl is listed as an Endangered Species under the Federal *Species at Risk Act* (2002, c.29), the federal government adopts the recovery strategies created at the provincial level, and the federal government can only intercede if the provincial authority is not adequately protecting its species at risk. However, to date, the federal government has never exercised this power.

1.2.2 The Spotted Owl Management Plan

With the legal responsibility of protecting the Spotted Owl, the Province created the Spotted Owl Recovery Team (SORT) which, in turn, provides recommendations on different conservation plans. The original SORT was comprised of experts and stakeholders from various groups and provided the government with projections on how different levels of protection for old-growth forest would affect the Owl's chances of survival. After much deliberation, the Province adopted the Spotted Owl Management Plan (SOMP) in 1997, which aims to preserve old-growth forest (i.e. forest suitable for Spotted Owl habitat) without affecting the forestry industry. The goal of the SOMP is to increase and stabilise the Canadian population of the Spotted Owl by setting aside suitable old-growth forest and limiting harvesting within these areas.

Out of approximately 1.2 million hectares of potential[2] Spotted Owl habitat, the SOMP applies to 363,000 hectares of forested area in the Squamish and Chilliwack Forest Districts (which comprise the majority of the Spotted Owl's habitat in BC). About 44% (159,000 hectares) of the plan area is located in protected areas, while the remaining 56% (204,000 hectares) is located within the timber harvesting landbase of the two Forest Districts. The SOMP divides the planning area into 21 Special Resource Management Zones, which divide again into 101 Long Term Activity Centres (LTAC). Each LTAC roughly constitutes the home range of one breeding pair of Owls (approximately 3200 hectares). The Spotted Owl Management Plan does not provide whole scale protection to the forested land it covers as it makes allowances for harvesting. Outside of LTACs, the SOMP places no limits on harvesting. In LTACs located on the timber harvesting landbase, one-third may be harvested provided two-thirds (67%) remain in old-growth condition that is suitable for Spotted Owl habitat. The purpose of allowing harvesting within Spotted Owl habitat is to lessen the impact of SOMP on the timber industry.

[2] Potential habitat is habitat that could grow into suitable Spotted Owl habitat. Therefore, it does not include land with development on it (i.e. much of the Lower Mainland).

However, when the Province adopted SOMP in 1997, the Spotted Owl Recovery Team did not endorse the plan because it only estimated a 60% chance of stabilising the Owl population. SORT believed 70% was the minimum acceptable limit. Conversely, the Province felt that SOMP was the best compromise between conservation efforts and timber harvesting. As a result, the Province dissolved SORT and proceeded with the Spotted Owl Management Plan.

Unfortunately, the 1997 SOMP has shown little, if any, success in halting the decline of the Spotted Owl. In 2002, the Province established a new Spotted Owl Recovery Team, which subsequently created a new interim recovery strategy in 2004 to combat this decline in the Owl population (Chutter *et al.* 2004). The 2004 strategy builds on the 1997 plan by putting a lot more emphasis on research and identification of threats to the Spotted Owl population. It highlights the need to evaluate the qualitative and quantitative aspects of suitable habitat for the Spotted Owl, as well as critically evaluate the requirement of maintaining at least 67% of the Long Term Activity Centres in suitable habitat condition. Although habitat loss through logging may be the primary threat to the Spotted Owl's survival, these animals also face other threats such as competition from and hybridization with the Barred Owl, disease, climate change and the negative effects associated with small population sizes (Chutter, *et al.* 2004). However, a focus on habitat preservation will also allow for the reintroduction and/or re-colonization of the Spotted Owl in Canada, should it become extirpated. A 2007 report by the Spotted Owl Population Enhancement Team evaluates various population augmentation strategies such as captive breeding, or the over-wintering of juveniles, in order to maintain a wild population (Fenger *et al.* 2007).

1.3 The Human Dimension

Beyond the decision makers' perspective, little is understood about how the general public of southwest mainland British Columbia values the existence of the Spotted Owl, and their support for its recovery. Accounting for people's preferences is necessary because the general public gains value from just knowing a species exists. This existence value is essentially a public good because millions of people can simultaneously enjoy it without consumption (Loomis, 2006), and the general public is willing to pay to preserve existence values (Kramer, Holmes and Haefele, 2003; Walsh *et al.* 1990). Measuring existence values allows land managers to gauge the public's support for related policies; and if existence values are monetized, then trade-offs with other land uses such as timber production can be undertaken in similar terms. However, without quantifying existence values, decision makers must rely on anecdotal evidence, arguments from groups possibly not representative of the general public, or economic studies that do not account for existence values, local preferences, or the trade-offs people are willing to make to preserve existence values.

Anecdotal evidence and economic studies from the United States suggest that the general public's existence value for the Spotted Owl in southwest mainland BC may be very high. During the 1980's and 1990's, Spotted Owl preservation was the impetus for mass arrests throughout the Pacific Northwest of the United States as people blockaded logging operations to save the owl's habitat. The Spotted Owl controversy was a presidential platform issue between Bill Clinton and George Bush Sr. who both pledged to end the crisis. Valuation studies undertaken at the height of the Spotted Owl controversy in the US estimated that people were willing to pay between $43.95 to ensure a 50% chance of survival up to $148.22 to avoid a loss (in 2008 Canadian dollars[3]; Richardson and Loomis, 2009). Although the US evidence suggests that the southwest mainland BC public will place a high value on the Spotted Owl, the BC Owl population constitutes only 8% of the total population; and willingness to pay estimates in the US do not necessarily reflect a Canadian perspective. With little empirical work covering a Canadian perspective, it is uncertain how the general public may value the existence of the local Spotted Owl population and related conservation efforts.

Measuring the existence value of the Spotted Owl is a complex issue. Simply asking the general public how they value the existence of the Spotted Owl can be confounded with an existence value for their habitat, that is to say, old-growth forests. Local events and studies suggest that the general public has an especially high existence value for old-growth forests. The largest mass arrest in Canadian history occurred because of clear cutting of old-growth forest near Clayoquot Sound on Vancouver Island. A 1993 provincial government survey of the BC general population showed that the loss of old-growth forest ranked third behind water and air pollution on the environmental issues priority list, ahead of other issues such as overfishing or loss of good drinking water (Vold *et al.* 1995). Furthermore, Vold *et al.* (1995) suggest that British Columbians are willing to pay $136 per year to double the amount of wilderness in BC from 5% to 10% and $168 to triple the amount of wilderness[4]. Although, these studies and events date back to the early to mid 1990's, the issue of managing old-growth forests may still

[3] Reported value = US$65 (in 2006 dollars). Converted to $Canadian in two steps. First, adjust US2006$ to US2008$ using the Consumer Price Index calculator provided by the US Department of Labour Statistics (http://www.bls.gov/data/inflation_calculator.htm) and then convert to Cdn2008$ with the 2008 average exchange rate supplied by the Bank of Canada (http://www.bankofcanada.ca/pdf/nraa08.pdf). All values reported here are in 2008 Canadian dollars.

[4] In 1993 Canadian Dollars.

be a priority with the general public, as recent rallies in the provincial capital show (Vancouver Sun, 2008 and Times-Colonist, 2008). Therefore, given the importance of old-growth forests to the general public of BC, any empirical work that attempts to measure the existence value of the Spotted Owl must also separate, and account for, the value for old-growth forest (i.e. Spotted Owl habitat).

In addition to old-growth forests, any preferences for Spotted Owl preservation may also be confounded with a preference for preserving other species at risk. Due to the large habitat requirements for the Spotted Owl, setting aside old-growth forest can potentially carry benefits for other species at risk (Chutter *et al.,* 2004). Seventy-one species of vertebrates and 67 species of vascular plants rely on similar habitat as the Spotted Owl and part of their home ranges overlap with the raptor (Yezerinac and Moola, 2007). Of these 138 species, twenty-two species are at risk of extinction or extirpation, including the Spotted Owl (Yezerinac and Moola, 2007). If fungi, non-vascular plants or invertebrates are included, this estimate increases dramatically (Yezerinac and Moola, 2007). However, from an ecological perspective, protecting one species' habitat does not automatically guarantee that other species relying on similar habitat will also benefit, because different species have different denning, mating, eating, or foraging requirements (Lindenmayer, Margules and Botkin, 2000), making it entirely possible to recover one species at risk while another species declines. Therefore, measuring existence value for recovery efforts towards one species at risk should be independent from other species at risk.

Beyond the confounding factors of other species at risk and old-growth forests, protecting Spotted Owl habitat requires trading-off between preservation and harvesting, where removing old-growth forest from the timber harvesting landbase (THLB) results in forgone timber benefits. Stone and Reid (1997), show that the opportunity cost of these forgone benefits for each British Columbian household ranges from $6.99 to over $43.69 depending on a partial or full-scale removal of these forests, respectively[5]. However, these figures only report the opportunity cost and do not reflect the benefits associated with preserving suitable Spotted Owl habitat. Van Kooten and Bulte (1999) examined the socially optimal amount of coastal old-growth forest[6] that BC should retain. When accounting for various direct (e.g. timber, mushroom picking, recreation) and indirect (e.g. carbon sequestration) uses of the forest at the margin, their economic model showed that BC should retain approximately 25% to 50% of their coastal old-growth forests, depending on the assumptions used. However, the authors are careful to note that the greatest opportunity cost in harvesting old-growth forests "…is the potential loss of nonuse benefits, or existence value" (p1884), for which they did not account. These studies further underscore the need to measure the existence value of Spotted Owls and their habitat to compare a wider range of costs and benefits associated with mutually exclusive land uses.

A further confounding variable is that preference for old-growth forest might extend beyond an existence value and actually be a value associated with its use. Beyond logging, recreation is one of the major uses of the forests within southwest mainland BC. One quarter of all visitors to the Sea-to-Sky region of British Columbia, participate directly in outdoor recreation activities (BC Prov. Gov., 2008a). A 1993 provincial

[5] Converted from 1997 Canadian Dollars to 2008 Canadian Dollars using the Bank of Canada Inflation Calculator (http://www.bankofcanada.ca/en/rates/inflation_calc.html), which adjusts for inflation with the consumer price index.

[6] Although not specified by the authors, this type of forest could be suitable Spotted Owl habitat.

government survey found that forest recreation participation is high with about half (47%) of all respondents having taken a wilderness trip (i.e. a recreational trip into undeveloped, roadless areas) in British Columbia during that time (Vold *et al.* 1995). In addition, forest recreation and demand for trails is increasing over time (BC Prov. Gov., 2008b).

Any conservation plan that alters the amount and extent of forest coverage must take outdoor recreation into account, because this type of activity carries implications for local flora and fauna. Some animals flee from the presence of outdoor recreationists causing stress and avoidance of otherwise inhabitable land (Taylor and Knight, 2003). It has been shown that hikers can flush Mexican Spotted Owls from their nest if they approach within 12 to 24 meters (Sarthout and Steidl, 2001) and preliminary tests in Washington State showed that motorised activities can cause stress in the male Northern Spotted Owl (Hayward, unpublished results). In addition, common outdoor recreation problems include: erosion, soil compaction, trail widening, and changes in vegetation cover (Godin and Leonard, 1979; Goeft and Alder, 2001). However, proper trail design, maintenance and management can reduce the negative impacts of outdoor recreation (Goeft and Alder, 2001), by stabilising areas prone to erosion, rerouting trails away from known nesting habitats or limiting access to certain uses. Therefore, accounting for existence values associated with old-growth forest, must also account for recreation activities.

Another issue in measuring existence values for species at risk is that conservation plans are never certain. From the perspective of the general public, existence values for the Owl may change significantly if the probability of recovering the species is perceived as too low. For example, the original SORT considered a 60% chance of survival as an unacceptable probability of survival for the Spotted Owl population. The general public may also show a level of acceptability when confronted with the risky prospect of conservation success.

1.4 The Methodological Context

Currently, the only class of methods capable of measuring existence values in a complex environmental context are stated preference methods (Freeman, 2003; Kramer, Holmes and Haefele, 2003). They are survey-based experiments that examine the tradeoffs people are willing to make between different policies or goods (Alberini, Longo and Veronesi, 2007). Various classes of stated preference methods exist, with the most popular being the Contingent Valuation Method (CVM). CVM asks respondents if they are willing to pay a certain amount for a proposed policy or plan in order to move from the current situation to an improved, hypothetical state. By varying the payment level, a researcher is able to estimate a respondent's willingness to pay (WTP) for a proposed policy.

However, CVM describes a policy as a whole and so a respondent's positive WTP can be confounded with other variables associated with the hypothetical policy. For the reasons listed earlier, the existence value associated with the Spotted Owl can easily be confounded with their habitat, or other species at risk, etc. Therefore, contingent choice may be a more appropriate method. Contingent choice presents respondents with multiple alternatives that differ by the levels of their attributes. Each alternative differs in the levels taken by at least one of the attributes. Respondents then select their preferred recovery plan according to the presented levels. A statistical analysis of the choices made by the respondents decomposes each attribute into marginal values and then reassembles the attributes to determine the willingness to pay, or support, for any alternative of interest (Alberini, Longo and Veronesi, 2007). Chapter 2 presents a more thorough description of the methodological differences between CVM and contingent choice.

1.5 Purpose and Research Questions

1.5.1 Purpose

The purpose of this research project is to measure the existence value of the general public living in the Lower Mainland of BC for Spotted Owls, old-growth forests and old-growth dependent species at risk in southwest mainland BC. Using a multi-attribute trade-off approach, this project provides separate estimates for each of these existence values. The study design combines these existence values with preferences for outdoor recreation and timber harvesting to investigate the general public's support for conservation policies.

The project boundaries are the known habitat range of the Spotted Owl in southwest mainland BC and the sample population is the general population of Metro Vancouver and the Fraser Valley; collectively known as the Lower Mainland. Data were collected in a web-based contingent choice survey.

1.5.2 Research Questions

The research questions posited below reflect the purpose of the project.

From the perspective of the general public:

1. What is the existence value of Spotted Owls in southwest mainland British Columbia under conditions of implied certainty?
2. How does the existence value for Spotted Owls change under conditions of risk?
3. What is the existence value of old-growth forests in southwest mainland British Columbia?
4. What is the existence value of old-growth dependent species at risk in southwest mainland British Columbia?
5. What are acceptable trade-offs between the existence values listed above and other prominent forest use values (i.e. recreation and timber harvesting)?

1.6 Organization of Report

Chapter 2 contains a literature review of the concepts, theories and potential problems that are pertinent to environmental valuation. Chapter 3 reviews the development of the contingent choice survey, the rationale and expected results for each of the included attributes, and the deployment of the survey. Chapter 4 summarizes the results from the contingent choice survey. Chapter 5 discusses the relevance of the results to the research questions and Chapter 6 concludes with the main points of this work.

CHAPTER 2: LITERATURE REVIEW

This chapter provides a review of the environmental valuation literature as it relates to the project's topic. The chapter begins with clarifying the terms used in this particular valuation study. Next follows a description of the environmental values relevant to forest ecosystems and the appropriate methods for measuring the various values. A discussion of the strengths and weaknesses of the stated preference methods follows. Finally, the current state of the existence value literature as it relates to forest ecosystems is discussed.

2.1 Environmental Valuation

The purpose of this research project is to estimate the value the general public has for the existence of old-growth forests, the Spotted Owl and other associated old-growth dependent species at risk. Environmental valuation is a complicated procedure that requires careful planning and execution if the results are to be meaningful. As stated by Daily *et al.* (2000), "valuation is a way of organising information to help guide decisions but it is not a solution or end in itself" (p.396). Valuing the environment requires a systematic, analytical approach that can break the components of a relevant ecological system into identifiable and measurable components. Furthermore, the measurement of various ecosystem components requires careful selection and execution of the appropriate analytical method.

2.2 Defining ‘Value’

To avoid ambiguity, it is necessary to define the term ‘value’. For this project, the term ‘value’ refers to the worth of a forest good or service that can be expressed in an equivalent amount of money or other goods or services (Freeman, 2003). In other words, the value of a particular attribute of a forest is the amount of money, or other good or service that a person would be willing to trade, which would leave them with the same amount of utility, or welfare.

For the purposes of this project, existence value is the value someone places on an environmental good or service that is independent of use (Kramer, Holmes and Haefele, 2003; Freeman, 2003). For example, existence value would be the benefits that an individual receives from just knowing a species is extant, or from knowing old-growth forests will be around for future generations. Other terms for existence values include non-use values, or passive-use values (Freeman, 2003) and although there may be subtle differences in definition, no distinction is made between these terms for this project.

Furthermore, existence value is an instrumental value and should not be confused with an intrinsic value. Many people argue that a forest has an intrinsic value and this argument is not without merit; however, valuing the existence of an environmental good or service is not the same as intrinsic value. Intrinsic value is an entity’s value in and for itself and not the value derived from various uses or non-uses of a good or service. In other words, intrinsic value is an end in itself and not the means to another end (Callicott, 1989 as cited by Freeman, 2003, p.6). An instrumental value is the value something has if it helps to achieve a goal (Freeman, 2003). The goal of economics is to provide people with greater well-being (Freeman, 2003) which is through the analysis of trade-offs between the various goods and services available to them (Duffield, 1997). In this case, existence value is an instrumental value because an individual may want to use it later, or for ethical or altruistic concerns (Freeman, 2003).

2.3 Existence Value in the Larger Context

Benefits accrue to society from forests well beyond simply knowing they exist. Old-growth forests are complex ecosystems and provide timber, places for recreation, water filtration, control of soil erosion, and more. In environmental valuation, the Total Economic Value (TEV) framework separates and organises these values into different uses and non-uses (see Table 2-1 below). Use values are divided further into ‘direct’ and ‘indirect’ categories. Direct use values are the immediate benefits gained from the forest such as timber or recreation opportunities. Indirect uses are the benefits gained from the services a forest can provide to support economic activity. For example, indirect use values include erosion control, or water filtration, two services that help maintain clean water for consumption further downstream.

Table 2-1: Total Economic Value Framework.

Total Economic Value		
Use Values		Non-Use Values
Direct Use	Indirect Use	(Existence Values)
Timber products Fruits, vegetables, fungi Game animals, fish Medicinal plants Recreation and tourism Education and research Human habitat	Nutrient cycling Hydrological regulation Control of soil erosion Amelioration of climate Groundwater recharge Greenhouse gas sink Ecosystem stability Weather damage protection	Biodiversity Culture, heritage

(Knowler and Dust, 2008)

The primary purpose of the Total Economic Value framework is to guide valuation work and minimise double-counting by measuring each value independently of one another and is subject to a specific management regime. The summation of these separate values is then an approximation of the economic value of the study site. However, as Pearce and Moran (1994) point out, the TEV framework only accounts for economic values and will be an underestimation of the total value of a study site. However, the specifics of the TEV framework is beyond the scope of this project, the purpose of the TEV framework as presented here is a reminder about the broader context within which existence values are set.

2.4 Measuring Value

Multitudes of methods exist to measure use and non-use values. Not every method is equal in its power to estimate various values as each has its own strengths and weaknesses when it comes to collecting, estimating and interpreting data. At a broad level, two classes of methods exist for measuring preferences for multi-attribute goods and services: revealed preference and stated preference techniques (Louviere, Hensher and Swait, 2000). Revealed preference methods measure the value of different attributes of a good or service through actual behaviour (i.e. choices) in the market. In contrast, stated preference methods aim for the same result by asking respondents to choose their preferred alternative to hypothetical scenarios. Since existence values are akin to public goods, no market data exists to determine how much people have paid or traded in exchange for this type of good (Louviere *et al.* 2000). In the absence of a real market, stated preference methods create a hypothetical market to measure how much the general public is willing to pay, or trade for this type of good (Adamowicz, Boxall, Williams and Louviere, 1998).

2.4.1 Stated Preference Techniques

Two broad categories of stated preference techniques exist with respect to an environmental good or service being valued (Adamowicz, Boxall, Louviere, Swait, Williams, 1999). The contingent valuation method (CVM) belongs to one category while contingent choice (CC), rating and ranking techniques belong to the other.

CVM is a binary approach to valuing the environment. CVM presents respondents with an accurate as possible description of a situation facing the environment. Respondents then face a ‘take-it-or-leave-it’ task where they must either accept or reject a payment to move from the current situation to a hypothetical future situation. By varying the amount of money involved in the choice task across their sample population, a researcher is able to determine how much a respondent is willing to pay for the environmental policy in question (or good, service, etc.). Welfare economics sets the theoretical basis for CVM, which assumes people's stated willingness to pay is reflective of their preferences in a consistent manner (Hanley, Mourato and Wright, 2001). Economists have used CVM to value environmental changes in environmental quality since the 1970's (Adamowicz *et al.* 1999), and this method gained worldwide attention during the 1990's when a blueribbon panel of experts came together to develop guidelines for developing and conducting a CVM (see Arrow *et al.* 1993 for the guidelines).

The second class of stated preference methods diverge from CVM in certain aspects. In this class of method, respondents evaluate profiles describing an environmental policy, good, service, etc. according to relevant attributes. Depending on the method chosen, the respondent then rates, ranks or chooses an alternative from the profiles presented. Applications of these different methods to environmental valuation have achieved varying degrees of success (see Hanley, Mourato and Wright, 2001 for examples). From an environmental valuation perspective, the contingent choice method appears to be the most successful. Rating exercises tend to produce inconsistent welfare estimates (Hanley, Mourato and Wright, 2001) partly because ratings are highly subjective (Louviere, Hensher and Swait, 2000). Ranking methods can produce more statistical information than contingent choice methods, but place a larger cognitive burden on respondents by asking them to rank each profile instead of simply choosing their most preferred profile (Hanley, Mourato and Wright, 2001; Hanley, Wright and Adamowicz, 1998b). A fourth method, sometimes termed the Paired Comparison method is a contingent choice experiment with the added complexity of a rating exercise, which in turn, does not translate readily into welfare estimates for reasons listed above (Hanley, Mourato and Wright, 2001).

As an environmental valuation tool, contingent choice surged in popularity during the 1990s and is now regarded as an alternative to traditional CVM approaches. Early on, applications of contingent choice (CC) were primarily in the marketing and transportation fields (e.g. Ben-Akiva and Lerman, 1985, Louviere and Woodworth, 1983). The rise in popularity of CC experiments was the greater flexibility and wealth of information these types of experiments provided in relation to CVM. By describing scenarios according to attributes, CC experiments can incorporate multiple scenario changes within one survey, whereas the CVM approach would need multiple surveys to gain the same amount of information (Adamowicz *et al.* 1998). CC methods can also measure compensating amounts of other goods (services, etc.) instead of only in monetary terms (Adamowicz *et al.* 1998). In traditional CVM approaches, a respondent may only have two chances to express their preferences for a good, whereas CC methods can provide respondents with multiple opportunities to express their preferences (Hanley, Mourato and Wright, 2001).

Although all experimental methods have various issues and limitations, for the purposes of this project, contingent choice is the most applicable method to answer the research questions posited earlier. The old-growth forests of southwest mainland British Columbia are multi-attribute goods where management of these areas requires knowledge about the trade-offs the general public is willing to make between the various uses and non-uses.

2.5 Environmental Valuation with Stated Preference Methods

The preceding section highlighted various stated preference techniques. This section will present findings from other stated preference methods that can provide insights into expected results for this study.

The expectation is that existence value will be positive (i.e. the general public will gain utility from knowing old-growth forest and associated species at risk are present). Hagen, Vincent and Welle (1992) and Rubin, Helfand and Loomis (1991) found people were willing to pay anywhere from US$15.21 up to US$189.64 (depending on assumptions made) to help protect the Northern Spotted Owl population in the US. Loomis and Ekstrand (1997) found that, on average, people are willing to pay US$40.49 in increased taxes per year to help protect the Mexican Spotted Owl plus 4.6 million hectares of associated old-growth forest. Although these monetary estimates may be debatable, these findings suggest that the general public has a positive WTP for Spotted Owl protection.

In British Columbia, the Spotted Owl faces extirpation not extinction. The presence of a much larger Spotted Owl population in the United States may lower welfare estimates for protection of the BC Spotted Owl population. However, Loureiro and Ojea (2008) found no difference between WTP estimates for protecting a local Spanish bird species from extirpation even when a portion of the respondents were reminded that other Northern European colonies of this bird are stable. Although it is unclear if this result is due to the embedding effect, this study does highlight the potential for local residents to value the extirpation of a local species at risk.

The general public also cares about protecting other species at risk. Loomis and Ekstrand (1997) found that people were willing to pay more for protecting the Mexican Spotted Owl and 61 other species at risk, than for the Mexican Spotted Owl alone. However, the difference between the two WTP estimates were only weakly different (i.e. at the 10% level). Although it is unclear whether this weak difference is due to survey design or a true preference for the Mexican Spotted Owl, the data suggest that the general public may value (albeit small in this case) the protection of other species at risk that inhabit the same area as a charismatic species.

With respect to habitat, the expectation is that the general public will gain utility from knowing specialised habitat is protected regardless of the number of species at risk present. Loomis, Gonzales-Caban and Gregory (1994) used CVM to demonstrate that people are willing to pay to protect old-growth forest against fire risk in Oregon. Beyond North America, Christie *et al.* (2006) found that the general public of the UK support policies that recreate or restore habitat for species at risk. The Danish public also gains utility from knowing a culturally significant heath is protected regardless of the amount of species at risk that may reside there (Jacobsen *et al.* 2008).

However, land is a fixed commodity and allocations made for conservation purposes require trade-offs with other uses. A contingent ranking study by Garrod and Willis (1997) shows that the general public of the UK prefers a balance between forests set aside for conservation versus forests set aside for commercial purposes. On the other hand, Adamowicz *et al.* (1998) reported the Edmonton public prefers increasing amounts of forests set aside for caribou habitat at the expense of taking it away from managed areas. Both these studies suggest that the general public gains utility from knowing land is set aside for conservation purposes, but regional differences may exist for the exact allocation between forests set aside for commercial purposes versus conservation purposes.

When weighing various use values with non-use values, the general public prefers options that do not limit their personal options for forest use. A 2001 survey of British Columbians suggests that the general public sees harvesting rates as the second biggest threat to forest biodiversity, after insects and diseases (McFarlane, 2005). When presented with options for conserving biodiversity, the general public views restricting the public's access to forests as one of the least favourable options (McFarlane, 2005). McFarlane's findings suggest that the BC public perceives threats to local forests from different sources but restricting access to these forests is not the preferred conservation solution. Respondents to a CC experiment from Finland prefer biodiversity management policies to occur at other forest recreation sites if these policies were to affect the scenic beauty at the respondent's local recreation site (Horne, Boxall and Adamowicz, 2005).

In all, the expectation is that the general public of British Columbia will gain utility from protecting old-growth forests, the Spotted Owl and other species at risk. The general public will not prefer any plans that limit their individual options for forest use but may have strong preferences for the level of harvesting that occurs in local forests. In addition, an increase in taxes should result in decreasing utility.

2.5.1 Environmental Preferences for Supply under Conditions of Risk

Conservation efforts to save an endangered species are inherently risky. The Spotted Owl faces many threats to its survival such as competition and predation from other animals, habitat loss, climate change and disease. At best, conservation efforts can only reduce the risk of these threats, not remove the threats entirely. From the general public's perspective, any risk associated with a conservation plan could potentially alter the preferences associated with such a plan. Given that the general public derive value from protecting species at risk and also ultimately pay for such efforts, policy makers can benefit from understanding the public's perception of risk when attempting to preserve any species.

Risk is a multi-dimensional concept and therefore, to avoid ambiguity, it is necessary to define this term. At a broad level, risk is the combination of two properties: the probability or chance of an event occurring and the magnitude or consequence if the event does occur (Hanley, Shogren and White, 2007). A risky outcome is different from an uncertain outcome. Risk refers to a situation where the probability of achieving an outcome is known, and uncertainty refers to situations where there is no way to quantify the chance of an outcome. For this project, we assigned a probability to any potential outcome and, therefore, the correct terminology would be risk.

In environmental economics, two broad types of risk prevail: endogenous and exogenous risk (Hanley, Shogren and White, 2007). Endogenous risk refers to situations where an individual is capable of altering the probabilities or consequences of a risky situation. For example, an individual can alter the health risks associated with drinking tainted water by buying bottled water, placing a filter on their tap, or boiling the water. Exogenous risk refers to a situation where the individual has no control over the probabilities. For example, an individual has no control over the probability or severity of an earthquake, or climate change. In the context of this project, the survival of a species at risk is an exogenous risk because an individual cannot influence the probability of Spotted Owl survival. Although an individual could technically affect the Owl's survival by rounding up the Owls and commencing a captive breeding program, or by purchasing large plots of suitable habitat, these situations appear unfeasible. Given the limited success of captive breeding programs and that buying enough suitable habitat is out of reach of the majority of individuals, suggests this risk is exogenous.

With few exceptions, stated preference surveys present options to respondents with certainty, or at least, implied certainty. A respondent states his or her willingness-to-pay to protect an endangered species under the instructions that any future outcome could happen. As pointed out by Roberts, Boyer and Lusk (2008), some may argue that uncertainty or risk is of no consequence in stated preference work, as the respondent's value for the final state of nature is the primary focus, and adjustments that incorporate risk can occur from an ex-post perspective (i.e. after the state of the world has been revealed).

Expected utility theory (EUT) has played a leading role in modelling people's choices under risk. Generally, the model is formulated as such:

$$EU(P) = \pi_1 * U(x_1) + \pi_2 * U(x_2) + ... + \pi_h * U(x_h) \quad (1)$$

Where the expected utility (EU) of a plan (P) is equal to the utility (U) for outcome (x) multiplied by the probability (π) of this outcome happening, summed over all possible states of the world (where there are '1' through 'h' possible states). Put into the context of this project, the expected utility for a conservation plan that could save the Spotted Owls is equal to the utility associated with all possible states of nature (i.e.

success and failure) multiplied by the probability of each state of nature actually occurring. However, numerous empirical studies suggest that ex-post adjustments to utility may not always reflect an ex-ante perspective (i.e. before the state of the world has been revealed).

Ex-post adjustments using the expected utility formula assume that the general public perceives probability objectively. However, empirical evidence from monetary lotteries suggests that individuals usually perceive probability subjectively (Kahneman and Tversky, 1979). In these instances, a decision weight (n) is attached to the objective probability (π) such that ($n*\pi$) does not always equal (π) (Prelec, 1998). Typically, subjects will over-weight low probability events and under-weight high probability events. Therefore, ex-post adjustments to utility could over- or under-represent a respondent's ex-ante value for a species at risk. If differences between ex-post and ex-ante perspectives are systematic then one can adjust for the differences; however, individuals may have heterogeneous preferences when confronted with a supply that is not certain. A study by Harrison and Rutstrom (2006) [7] shows that approximately half the respondents utilised a decision-making process best described by expected utility theory while the remaining respondents subjectively weight probabilities.

A recent paper by Roberts et al. (2008), with an application similar to ours, supports the idea that the perception of probability may be context dependent. These authors show that respondents to a contingent choice survey on water quality in a recreational lake will significantly under-weight low probability events. In this study,

[7] Working paper.

respondents treat the low probability (approximately 0-35%) of poor water quality as if it were 0% and high probability (approximately 75-100%) as if it were certain.

Applying probability in the context of species at risk, respondents may perceive the associated probability differently because they feel extinction is never certain, in other words, a probability of zero does not exist. Using CVM, Tkac (1998) and Samples, Dixon and Cowan's (1986) found that respondents were willing to allocate part of a budget to save a non-descript species that is certain to become extinct. In addition, these allocations are not consistent, as they increased when respondents were informed that the doomed species was charismatic such as a marine mammal or a monkey (i.e. after the species was iconised). When Samples, Dixon and Cowan (1986) queried the motives of respondents for allocating money to a species with no hope of recovery, respondents' replies ranged from a show of solidarity for a species facing tremendous adversity or investment in the remote possibility that the species will recover.

Beyond an individual's perception of probability, numerous other factors can also alter their preferences for risky outcomes. For example, when facing a risky prospect, respondents may use various heuristics (i.e. rules of thumb) in order to make a decision. Respondents may only focus on one component of risk (i.e. the outcome or the probability of the outcome) and make their decision based on this single attribute (see Hanley, Shogren and White, 2007, p.395 for more information). Respondents may also combine previously held risk beliefs with the stated risk information and make their decisions based on this hybrid information (Viscusi and Evans, 2006). Respondents may also avoid ambiguous lotteries, where the probability of an outcome is unknown, and select a lottery where the risk is explicitly stated (also known as the Ellsberg (1961)

Paradox). Some respondents favour risk-taking if they feel they have a personal stake in making an improvement (Patt and Zeckhauser, 2000). Introducing background risk, (i.e. a non-insurable, exogenous risk that cannot be resolved at the time of making a choice) can make some respondents more risk-adverse while others more risk-loving (see Roberts et al. 2008 for a review). In total, the models that attempt to describe how people make decisions under risk "…number well into double figures" (Starmer, 2000, p.332). For this project, all these factors may or may not play a role in describing how individuals make decisions under risk for endangered species conservation.

At an aggregate level, a number of different possibilities exist in trying to model how our sample population make choices under risk. An ex-post perspective may be sufficient in describing our sample population. Conversely, the sample population may be heterogeneous enough that we need more than one model to describe them accurately. Whatever model ultimately describes how people make decisions under risk requires the proper method for measuring people's choices.

From an environmental valuation perspective, option price (OP) is the correct measure for valuing preferences under conditions of risk. OP is the maximum, ex-ante, state-independent payment that an individual is willing to make to move from the status quo risk to an improved situation (Freeman, 2003, p.213). In order to help a species at risk, an individual cannot afford to wait and see what state of nature actually transpires before making a payment because extinction and falling below a threshold population is irreversible[8]. In addition, in order to help a species at risk, individuals must make certain payments now, which are not contingent upon the event of a successful (or failed) recovery of the species. In other words, an individual must make a payment before the state of the world is known (i.e. ex-ante), that is not contingent on which state of the world actually transpires (i.e. state independent).

Formally, option price (OP) is equal to the expected consumer surplus plus option value (Freeman, 2003). Where option value (OV) is, essentially a risk premium an individual is willing to make to secure provision of an uncertain resource (Shogren and Crocker, 1990). OV is not a separate value but rather the algebraic difference between expected consumer surplus and OP. OV can be positive, negative or zero depending on various conditions such as changes in an individual's marginal utility of money over the various states of nature that can occur[9] (Freeman, 2003). From a micro-economic perspective, neither option price nor expected consumer surplus provide a superior approach to environmental valuation under conditions of risk, because both these welfare measures are simply two points along a willingness to pay continuum (Freeman, 2003). Instead, estimating both welfare measures will provide a more robust economic understanding of the public's preferences for conservation work under risky outcomes.

From the literature presented above, it appears that the value for a supply of an environmental amenity under conditions of risk is dependent on the individual's perception of probability, the context of the environmental issue, heuristics, and the

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[8] The situation facing the Canadian Spotted Owl is technically reversible because owls could be taken from the larger US population to help re-colonisation efforts here. However, convincing the US government to provide Owls to Canada would be almost impossible because of the proven inability of the owl to survive in Canada and its status as endangered in the US.

[9] See Freeman, 2003 for a more thorough examination of how option value can take on various sizes and signs.

measurement method. All these factors can combine in different ways to produce a value for an unsure environmental amenity (in this case, a species at risk) that can differ in size and sign from a sure bet and differ between groups of individuals. In order to account for risk, it is necessary to measure the welfare gained from protecting a species at risk under cases of both certainty and risk, and between groups of respondents. A fuller picture of the differences between certain and risky outcomes provides decision makers with a greater understanding of the general public's perception, and possible acceptance, of a conservation plan that targets species at risk.

CHAPTER 3: METHODOLOGY

The layout for this chapter follows the standard framework for creating a contingent choice experiment (Hanley, Mourato and Wright, 2001 or Hensher, Rose and Greene, 2005 p.102 and summarised in Table 3-1).

Table 3-1: Framework for Creating a Contingent Choice Experiment

Steps		Description
1.	Characterisation of the decision problem	Scope research problem and develop specific research questions.
2.	Selection of attributes and levels	Use key informant interviews, focus groups and literature reviews to determine the salient attributes and associated levels.
3.	Choice of experimental design	Combine choice sets to present to respondents.
4.	Construction of survey	Set up of the hypothetical market.
5.	Collect data	Self-explanatory.
6.	Estimation procedure	Determination of utility for different attributes.
7.	Policy implications	Creation of a decision support tool to inform decision makers about preferences of the general public.

3.1 Step 1: Characterisation of the Decision Problem

For this project, the management issue is to measure the general public's existence value for Spotted Owls under conditions of certainty and risk. However, confounded with Spotted Owl conservation efforts may be preferences for Spotted Owl habitat (i.e. old-growth forests) or other species at risk that depend on the same habitat as the Owl. Furthermore, measuring preferences for conservation work also needs to account for the main uses of forests, namely timber harvesting and outdoor recreation.

3.2 Step 2: Selection of Attributes and Levels

The impetus for the majority of attributes came from the Spotted Owl Management Plan, while information from interviews, focus groups, and literature reviews helped to refine the attributes. Table 3-2 lists each attribute and the associated levels. Also presented in this section are the definitions of each attribute, how information was obtained, and the reason for its inclusion in the choice experiment.

Table 3-2: Attributes and Levels

Attribute	Levels
Old-growth forest	150000; 300000; 400000†; 600000; 800000; 1000000 (ha's)
Recreation zoning in old-growth forest	0, 10, 30, 50† (% motorised)
Recreation zoning in commercial forest	0, 25, 50†, 75 (% motorised)
Amount harvestable in old-growth forest	0, 10, 20, 33† (%)
Number of spotted owls	0, 5†, 10, 25, 50, 85, 125, 200 (breeding pairs)
Other species at risk	0, 7†, 15, 21 (species recovering)
Increase in annual household income tax	0†, 25, 50, 75, 100, 150, 200, 250/300 ($)
Probability of Occurrence‡	25†, 50, 75, 100 (% probability of occurrence)
Confounded Variables*	
Commercial forest	0; 200000; 400000; 600000†; 700000; 850000 (ha's)
Total harvestable area versus status quo	Calculated (% increase or decrease)

* Not a design variable, but shown here for completeness. Pre-tests showed that adding these context variables increased clarity of the choice task.

† Status quo.

‡ Only shown in choice sets 6 to 8.

3.2.1 Old-Growth Forest and Commercial Forest

Placed together, the old-growth forest and commercial forest attributes describe the types of forest that cover the study area. The old-growth attribute describes the amount of forest that is suitable for Spotted Owl habitat and other old-growth dependent species at risk and where harvesting is restricted. The commercial forest attribute is the forested area where harvesting of timber is permitted.

The division between forest that remains in the timber harvesting land base (THLB) and forest that will remain as old-growth is one of the main issues for Spotted Owl survival. Timber harvesting and Spotted Owl habitat are mutually exclusive as fragmentation of old-growth forest caused by logging is one of the leading causes of the Spotted Owl decline in British Columbia (Yezerinac and Moola, 2006). However, setting aside old-growth forest for the Spotted Owl will require taking land out of the THLB, affecting the forestry sector (Chutter *et al.* 2004).

The Spotted Owl Recovery Plan provided the levels for both these attributes (Chutter *et al.* 2004). In total, approximately 1.2 million hectares of forested land cover southwest mainland BC. Currently, 363,000 hectares are already protected for Spotted Owl habitat of which 159,000 hectares are in parks and protected areas. The Spotted Owl Recovery Team estimates about 600,000 hectares of forest actually exist in old-growth condition in southwest mainland BC today, but this will drop to 400,000 hectares in the future.

From discussions with working groups, the actual numbers provided by the recovery plan proved too cumbersome for presentation purposes. Instead, we rounded these levels to a value that provided an approximation of existing conditions. For example, the total forest area was rounded from 1.2 million hectares to 1 million hectares, where the '1,000,000 hectares of old-growth forest' level represents the hypothetical scenario in which all forest in the study area is protected from harvesting. Conversely, the 150,000 hectares level represents the hypothetical scenario in which only parks and protected areas are protected from harvesting (i.e. 159,000 hectares is rounded to 150,000 hectares). Both the commercial forest and the old-growth forest, when summed together in the choice sets, must equal 1 million hectares.

The ratio of these two attributes will give decision makers a clearer picture of the types of trade-offs that the average Lower Mainland citizen is willing to make with regards to forest allocation for timber harvesting versus old-growth at the landscape level.

3.2.2 Recreation Zoning within Commercial and Old-Growth Forests

Recreation zoning is the method for allocating parts of a forest between different uses. For the purposes of outdoor recreation management, the province zones its forests into motorised and non-motorised areas (i.e. large areas where certain uses are permitted).

The survey informed respondents that each type of forest (i.e. commercial or old-growth) has various zoning designations. Motorised zones permit all activities. Non-motorised zones exclude activities that rely on a motor (e.g. off-road vehicles, snowmobiles, etc.) and only include activities such as hiking, mountain biking, backcountry skiing, etc. Respondents also read that for any type of recreation zone (either motorised or non-motorised), they would be able to drive to a parking lot, but their activity on the trail must be in accordance with the recreation zone.

The recreation zoning attribute is included in each type of forest because outdoor recreation is one of the largest direct uses of forests after timber. The Sea to Sky Land and Resource Management Plan designates crown forest as motorised or non-motorised because the greatest amount of conflict between outdoor recreationists occurs between these two user groups. Therefore, this attribute provides a more complete picture and includes the typical trade-offs associated with forest management decisions and how they affect the individual user.

3.2.3 Amount Harvestable in Old-Growth Forest

The 'amount harvestable' attribute has direct relevance to the management strategies associated with Spotted Owl habitat. Under the 1997 Spotted Owl Management Plan, a minimum of 67% of forest managed for Spotted Owls is to be kept as suitable habitat (i.e. forests older than 100 years old, taller than 19.4 meters, and below 1370 meters in elevation; Chutter *et al.* 2004). In other words, 33% of old-growth forest may be harvested on a rotating basis. However, the Spotted Owl Recovery Plan suggests a critical evaluation of this number because of the impacts that harvesting has on Spotted Owl survival (Chutter, *et al.* 2004). Varying the level of this attribute from 0% to 33% harvesting within old-growth forest will provide decision makers with the socially acceptable limits of harvesting within old-growth forests. However, this survey makes no claim about the ecologically acceptable limits of harvesting in old-growth forests.

3.2.4 Number of Breeding Pairs of Spotted Owls

As the name implies, this attribute refers to the number of Spotted Owl breeding pairs that are alive in southwest mainland BC. The importance of using breeding pairs instead of total Spotted Owls is because this animal is monogamous and if single owls are unable to find a mate then total numbers may be meaningless to the long-term survival of the species.

In creating the Spotted Owl attribute the levels 0, 5 and 125 were identified as relevant benchmarks. The zero level represents extirpation of the species. Given the current survival rates, the Recovery Team reports that extirpation of the species is imminent (Chutter *et al.* 2004). Five represents the current status quo (although this number may have decreased since writing the survey). Finally, the Spotted Owl Recovery Team reports that 125 breeding pairs are necessary for a self-sustaining population in southwest mainland BC (Chutter *et al.*2004).

While reaching 125 breeding pairs is important from an ecological point of view, respondents did not receive this information for two reasons. First, if recovery of the Spotted Owl is a socially desirable goal, then the population of Spotted Owls will have to grow through all levels. Second, 125 as a sustainable population is a genetically derived number and does not reflect the reality that many species of animals have survived despite passing through small population bottlenecks (Harestad, per. com, 2008). Overall, the purpose of this attribute is to provide decision makers with the quantitative benefits of growing the Spotted Owl population and avoiding extirpation, not necessarily the value associated with reaching a genetically stable population level.

Selection of the remaining levels fits around these three benchmarks, under the assumption of some simple rules: lower levels must have greater representation than the larger levels (i.e. there are more levels at the low end). Given that the current population and survival rate of the Spotted Owl is very low, any increase in owl population will be relatively small. Therefore, in 25 years time, only marginal gains (if any) are realistic. However, in order to determine if the general public has decreasing marginal utility for the owl, the level of 200 owls was chosen to span a greater range of values.

3.2.5 Number of Other Species at Risk Recovering

The 'Other Species at Risk' attribute shows the number of old-growth dependent species at risk that are recovering to a more stable population level. At least 21 species at-risk[10] rely on the same old-growth forest as the Spotted Owl. Therefore, preserving old-growth forest for the Spotted Owl can help the other species at risk, but unfortunately, does not guarantee their survival. They may have different food, breeding, nesting/denning requirements and their territories may extend beyond the territory for the Spotted Owl.

A literature review provided the levels for this attribute. While the Spotted Owl Recovery Team estimated that approximately 25 other species at risk rely on the same habitat as the Spotted Owl, the survey used the lower estimate of 21 provided by Yezerinac and Moola (2007). The latter, more conservative estimate was selected because their study is more recent (SORT's estimates were from 2003); and they appear to apply a more rigorous methodology.

A potential problem with this attribute was that respondents may not consider 'other species at risk' when compared to the charismatic Spotted Owl. In order to place both the Spotted Owl and all the other species at risk on a similar level, respondents were shown pictures of both the Spotted Owl and two of the other 21 species at risk (i.e. Dwarf Bramble and the Pacific Giant Salamander). Space and time considerations prevented us from naming and showing all the other 19 species at risk. However, by naming, picturing and providing information to respondents that these species are also at risk of

[10] These 21 species include vascular plants (e.g. trees, shrubs, etc.) and animals with a spinal column (e.g. amphibians, birds, mammals). This number will increase if non-vascular plants (e.g. mosses, algae, etc.) and invertebrate animals (e.g. slugs, insects, etc.) are included.

disappearing, helped to ‘iconize’ these species (as per Jacobsen *et al.* 2008) and potentially place them on a similar level as the Spotted Owl.

The status quo was set at ‘7 species recovering,’ because the Province has created recovery strategies for seven of these 21 species at risk. Although creating a recovery strategy does not guarantee survival[11], this number provides a baseline for measuring gains and losses of species at risk. Setting one of the levels at 0 also allows for the measurement of respondents’ utility when all other species at risk are extirpated. Overall, the purpose of this attribute is to remind respondents about other complements and substitutes to protecting the Spotted Owl and permits the measurement of the existence value of other species at risk independently of the Owl.

3.2.6 Total Harvestable Area Compared to Status Quo

‘Total harvestable area’ refers to the change in the amount of forested land that is available for harvesting when compared to the status quo. Each level of the ‘total harvestable area’ is calculated from the amount of commercial forest and the amount of harvestable old-growth forest. The equation below shows this calculation:

Total Harvestable Area = Area Commercial Forest + (Harvestable Area of Old-Growth * (Area of Old-Growth Forest – Area in Parks and Protected Areas)). (2)

For example, the amount of harvestable area in the status quo is 600,000 hectares of commercial forest and 33% of the old-growth forest that is not in parks and protected areas, which combines for a total of (600,000 + 0.33*(400,000-150,000))= 682,500 hectares of harvestable area.

[11] The Spotted Owl would be a primary example of this fact.

For each profile, the total amount of harvestable land was calculated and the percent increase or decrease compared to the status quo was shown to the respondent. For example, if the profile for Outcome A is 600,000 hectares of total harvestable area, then the respondent would see ‘10% less’ in the profile. This is because 600,000 hectares is, approximately, a 10% decrease in total harvestable area compared to the status quo. All changes from status quo were rounded to a simpler number so as not to overwhelm the respondent with a number consisting of complex combinations of digits[12]. The purpose of this attribute was to show how various forest allocations affect forest production and possibly stumpage revenue for the Province.

3.2.7 Increase in Annual Household Income Tax

The ‘increase in annual household income tax’ attribute is the payment vehicle and permits the measurement of all other attributes in monetary terms. Although the general public may detest tax increases, this attribute provides the only reasonable payment vehicle. The Province is responsible for conservation work and owns the vast majority of forested land in southwest mainland BC and a large share of provincial revenue comes from income tax. Therefore, it follows that tax revenue would pay for conservation work. In order to ensure that respondents understood that their payment was earmarked for conservation work instead of general provincial revenue, respondents were instructed that all funds collected would be earmarked for old-growth forest management.

One of the largest challenges with the payment vehicle was assigning levels. All payment levels were considered; from positive (i.e. WTP for conservation work) to

[12] See Appendix A for all levels associated with this attribute.

negative (i.e. WTA compensation for environmental damage). For this particular project, WTP is the proper choice of measure for two reasons. First, respondents are asked to pay an increase in taxes to move from the current situation (i.e. the reference point for this study) to an improved situation; this type of scenario is consistent with the WTP measure (Knetsch, 2007). Second, WTA scenarios did not work for this survey as they implied the government was foregoing their legal responsibilities to protect species at risk by compensating respondents for an impending environmental loss.

'Willingness to pay' scenarios were more effective as respondents understood that taxes may have to increase in order to pay for conservation work. Extensive pre-testing determined payment levels should range between \$0 and \$250, as extremely few respondents chose scenarios with payment levels greater than \$200. In consideration that old-growth forests and Spotted Owls are iconic in BC, the upper payment level was further split into \$250 and \$300[13] to capture all potential payees. These payment levels reflected other stated preference surveys on Spotted Owls. Loomis and Ekstrand (1997) used a range between US\$0 and US\$350 for a CVM-DC on Mexican Spotted Owls, and Hagen, Vincent and Welle (1992) only had 4% of their bids greater than US\$200 for their CVM on the Northern Spotted Owl.

3.2.8 Probability of Occurrence

In total, respondents saw eight choice sets. The first five choice sets had nine attributes describing the forested landscape of southwest mainland British Columbia while the following three choice sets had one additional attribute showing the probability

[13] Seven choice sets were assigned the '+\$250' level and one choice set was assigned the '+\$300' level.

that a certain amount of Spotted Owls would be alive in the future. 'Probability of occurrence' was the probability that one of two states of nature would occur with respect to the number of breeding pairs of Spotted Owls on the landscape in 25 years. The two states reflected a 'successful' and 'unsuccessful' outcome within each profile. The successful outcome was presented as the probability (P) that X amount of breeding pairs would be present in 25 years. The unsuccessful outcome was the residual probability (1-P) that 0 Owls would be present. From an ecological perspective, the survival of the Spotted Owl is more realistically represented through a continuous probability distribution function. However, presenting such information to respondents would have created too much of a cognitive burden. Instead, the survey informed respondents that the presentation of the two states of nature was to simplify this complex topic. The two states of nature had to be shown to respondents, as there is utility, be it positive or negative, associated with either outcome (i.e. successful or unsuccessful).

With respect to presentation, this survey utilized a within-subjects design[14]. Respondents went through five choice sets showing the number of breeding pairs of Spotted Owls to be certain. Thereafter, respondents encountered an information page stating that there is no guarantee of success in conservation efforts and then respondents answered three more choice sets with a probability associated with the Spotted Owl attribute. Very few stated preference studies explicitly incorporate the probability of an outcome into the survey design when valuing an environmental good, making the assignment of levels in this study an additional challenge. Through a series of literature

[14] A split-sample design was assessed, but this would require having two different surveys, where the difference in WTP between the surveys may be attributable to information effects.

reviews, group discussions and pre-tests, ultimately, the 25, 50, 75 and 100% levels appeared to give respondents the least difficulty in conceptualizing probability.

This ‘probability’ attribute only referred to the ‘Spotted Owl’ attribute for practical reasons. Depicting a more realistic outcome to respondents would have required placing the probability of success on the entire choice profile. However, many different stochastic processes, such as disease and wildfire, could influence any of the attributes and therefore lead to a less precise presentation of profiles, as we learned during pre-testing. Respondents disregarded the ‘probability’ attribute, because an unsuccessful state of nature can take on a multitude of unspecified outcomes (e.g. X owls, X species at risk, X old-growth; where X can be any number below the successful level).

One reason for including the ‘probability’ attribute is to gain a better understanding of how people make decisions under conditions of risk for conservation of endangered species. So far little research has incorporated probabilistic outcomes with regard to supply under conditions of risk in stated preference methods. In addition, Roberts’ *et al.* (2008) study seems to be the only research that explicitly incorporates non-linear probability weighting on valuation estimates for environmental amenities.

3.3 Step 3: Choice of Experimental Design

The attributes must be organised in a manner that allows the researcher to test for their effects on respondents’ choices. Ideally, respondents would see all possible combinations of attributes. However, this produces ($6^1 * 4^3 * 8^2$=) 24,576 different profiles and requires a large sample population to determine the significance of each attribute and the various combinations. Instead, this survey used 64 choice sets as defined by a fractional factorial, orthogonal, main-effects design of resolution III (Addelmann, 1962). A fractional factorial design contains only a portion of the total number of possible combinations. A main effects design means that only main effects of attributes can be estimated, but no interaction effects. Orthogonal means that the main effects are independent from all other attributes. Fractional factorial, main-effects designs make the number of profiles more manageable but inevitably reduce the estimation power. Main effects explain the majority of variance in respondents' choices (approximately 70%-90% of the variance; Louviere *et al.* 2000, p.94).

The attributes combine to make profiles. Two or more profiles combine into one choice set. For this survey, the 64 choice sets also contained a 'status quo' option as a third alternative in each choice set. Every profile describes a different outcome of forest management around the southwest mainland BC in 25 years. Each choice set showed an Outcome A and B and a 'Status Quo' option (i.e. an outcome that reflects the future outcome associated with the current management direction). Figure 3-1 and Figure 3-2 provide examples of the choice sets under cases of certainty and risk, respectively. A respondent would choose their preferred profile from each set of three alternatives and repeat this task five times[15]. For the next three choice sets, the number of alternatives was reduced to two (i.e. Outcome A and the 'Continuation of Status Quo')[16]. Pre-tests showed that this structure of choice sets reduced the cognitive burden of having to assimilate the 'probability' attribute. The status quo option remained constant throughout the entire choice task to provide a baseline for comparison between respondents' choices.

[15] The first five choice sets were the choice sets under certainty.
[16] The last three choice sets were the choice sets under risk.

Figure 3-1: Example Choice Set (Implied Certainty)

Characteristics	Outcome A	Outcome B	Outcome C Continuation of Status Quo
Commercial Forest	0 hectares	700,000 hectares	600,000 hectares
Recreation Zoning	0% motorised	75% motorised	50% motorised
Old-Growth Forest	1,000,000 hectares	300,000 hectares	400,000 hectares
Recreation Zoning	50% motorised	0% motorised	50% motorised
Amount Harvestable	None	33% harvestable	33% harvestable
Other Species at Risk	21 species recovering	0 species recovering	7 species recovering
Number of Spotted Owls	10 breeding pairs	50 breeding pairs	5 breeding pairs
Total Harvestable Area (compared to status quo)	100% less	10% more	No Change
Increase in Annual Household Income Tax	+$0	+$100	+$0
Choose one →	○	○	○

Figure 3-2: Example Choice Set (Risky Outcome)

Characteristics	Outcome A	Outcome C Continuation of Status Quo
Commercial Forest	600,000 hectares	600,000 hectares
Recreation Zoning	25% motorised	50% motorised
Old-Growth Forest	400,000 hectares	400,000 hectares
Recreation Zoning	30% motorised	50% motorised
Amount Harvestable	33% harvestable	33% harvestable
Other Species at Risk	0 species recovering	7 species recovering
Number of Spotted Owls	25 breeding pairs (100%) 0 breeding pairs (0%)	5 breeding pairs (25%) 0 breeding pairs (75%)
Total Harvestable Area (compared to status quo)	No change	No Change
Increase in Annual Household Income Tax	+$75	+$0
Choose one →	○	○

3.4 Step 4: Construction of Survey

The survey consisted of 28 web pages, organised in four sections. The first section (2 pages) welcomed the respondent to the survey and contained a statement about the survey's purpose and the need for the respondent's opinion. The second section established the hypothetical market (12 pages) which described each attribute and how they fit together at the landscape level. The third section (10 pages) was the choice tasks, which consisted of eight choice sets. The forth and final section (4 pages) contained the follow-up questions where respondents provided socio-demographic and ethnicity information, and their perceptions of the survey. Respondents went through each of these sections in sequence and did not have the option to go back[17].

The creation of the hypothetical market for this survey presented one of the largest hurdles in the overall design. The biggest challenge was providing information to the respondents so they could make informed choices without overwhelming them with information. Providing information in an internet survey is a particular challenge because most respondents are not interested in reading many instructions, but instead expect to answer questions. Therefore, information and survey questions where closely integrated to keep the appearance of a survey throughout.

The description of the hypothetical market required a total of twelve pages. The first five pages asked respondents about their familiarity with old-growth forests, Spotted Owls and other old-growth dependent species at risk. These pages also included a definition of old-growth forests, the mutually exclusive roles of old-growth versus harvested forest areas, information about some of the other species at risk in the study

[17] Please see appendix B for the web link to the survey.

area, and the status of the Spotted Owl. The next seven pages showed how these attributes fit together for the entire study area and how they related to the survey, especially the choice task.

The 'story' unfolded with a forest cover map of southwest mainland BC that showed the historical and current extent of old-growth forest (see Figure 1-1). The level of detail in Figure 1-1 made it impossible to show respondents how certain sections of the forest could be designated old-growth forest, or commercial forest zones.

In order to relate this information from this map to the choice task in a meaningful yet simple manner, respondents were asked to imagine the 1 million hectares of forested land as a rectangle (see Figure 3-3). The subsequent pages then explained each component of the forest and how various attributes are related to this forest. For example, respondents were told (and shown graphically) that commercial forests and old-growth forests would have different recreation zones (see Figure 3-4). Respondents also saw that old-growth forests could extend beyond parks and protected areas, where they do not enjoy the same level of protection (see Figure 3-5). Careful and repeated pre-testing proved that respondents could readily absorb this graphical information and then make informed trade-offs during the choice task. The use of graphs in this instance greatly reduced the need for text-based information.

Figure 3-3: Simplified Representation of Forested Area in Southwest Mainland BC

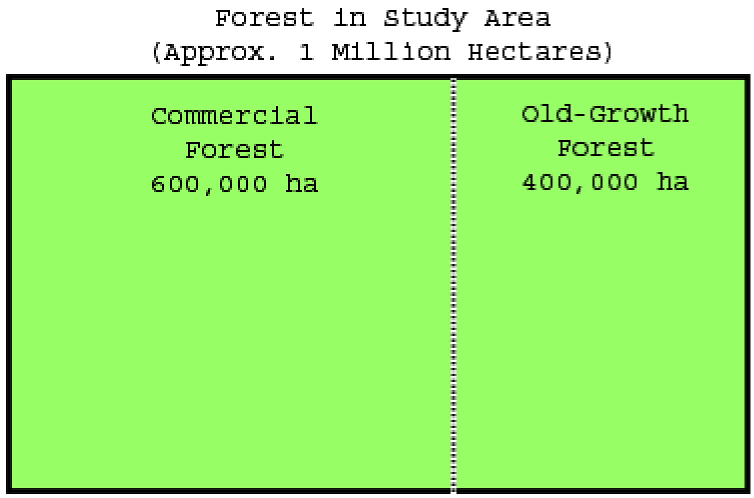


Figure 3-4: Representation of Recreation Zoning in Study Area

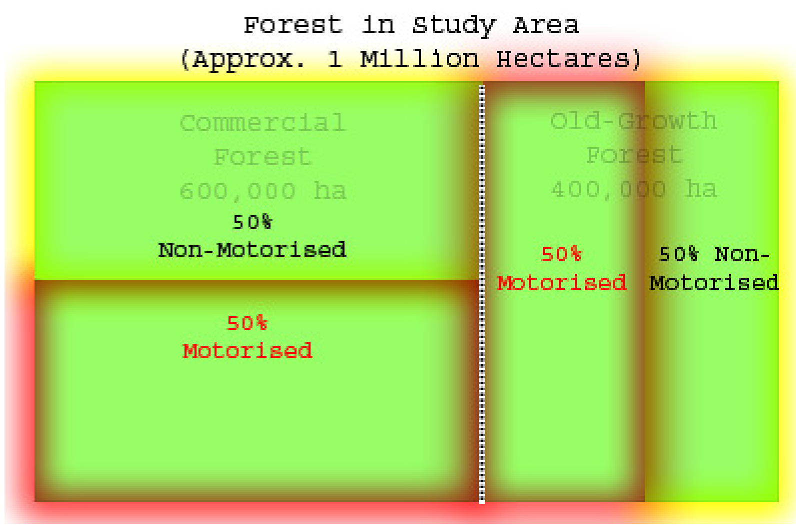
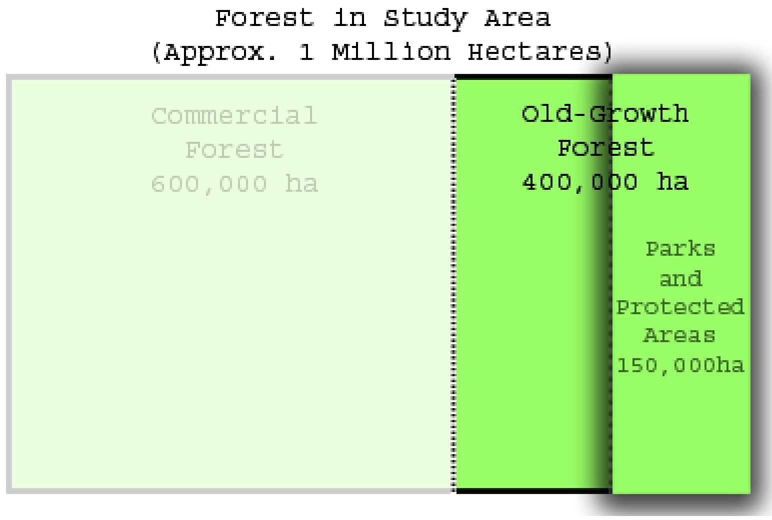


Figure 3-5: Representation of how Parks and Protected Areas fit into the Study Area



3.5 Step 5: Data Collection

Data for the web survey were collected by E-rewards, a market research firm based in Houston, Texas. Invited participants had to be older than 18 years of age with a residence located in the Lower Mainland[18]. The town of Squamish was also included in the selection process; however, no completed surveys originated from that community. The sample of respondents were also narrowed down according to how well they represented the entire census area for income (primary) and then for gender and age (secondary).

E-rewards invited potential respondents by emailing them a web-link to the survey, which was housed at a secure location in REM. Participants who completed the survey, received an incentive in the form of points from E-rewards[19]. Non-responding participants received a follow-up reminder email to help increase response rates. Data collection ran from July 30th, 2008 to August 20th, 2008. The response rate was 18.67%.

[18] Please see Appendix C for the list of postal codes that E-rewards used to locate respondents.
[19] These points can be used towards purchases from eligible businesses.

3.6 Step 6: Estimation Procedure

After data collection, various statistical models estimate how the different attributes affected respondents' choices. This section provides an overview of the models this project used in measuring the different attributes described earlier.

3.6.1 Random Utility Model

The random utility model provides the foundation for stated preference surveys, which makes it possible to combine choice behaviour with economic valuation (Rolfe, 2006). The random utility model formulates the idea that people are rational decision makers and will choose a certain good if the utility gained from that good is greater than the utility associated with the alternative. The formula below describes this relationship:

$$P_{ij} = Prob(U_{ij} > U_{ih}) \quad (3)$$

Where the probability of individual 'i' choosing alternative 'j' is equal to the probability that the utility 'U' of alternative 'j' is greater than the utility of alternative 'h' (for all 'h' in a given choice set where 'j' does not equal 'h').

From the perspective of a researcher, the assumption is that utility is the sum of observable and unobservable components:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad (4)$$

Where V_{ij} is the observable (or deterministic) component of utility and ε_{ij} is the unobservable (or stochastic) component of utility. One of the maintained (i.e. untestable) assumptions of the random utility model is that both the observable and unobservable component of utility are additive and independent (Hensher, Rose and Greene, 2005).

The observable component of utility can be further described as a function of the characteristics of a good and the characteristics of an individual, as represented below:

$$U_{ij} = (Z_{ij}+S_i) + \varepsilon_{ij} \tag{5}$$

Where Z_{ij} is the characteristics of the good or service associated with alternative 'j' (i.e. the characteristics are the attributes from the particular choice set that individual 'i' saw) and S_i are the socio-demographic variables associated with individual 'i'. Expanding the above equation to include all attribute and socio-demographic variables produces the following:

$$V_{ij} = [\beta_{0ij}+\beta_{1ij}Z_{1ij}+ \beta_{2ij}Z_{2ij}+\ldots+\beta_{nij}Z_{nij}]+[\beta_{aij}S_{ai}+ \beta_{bij}S_{bi}+\ldots+\beta_{kij}S_{ki}]. \tag{6}$$

Where Z is the attribute associated with alternative 'j' that individual 'i' chose and there are '1' through to 'n' attributes (denoted by the subscripts '1' and 'n'). In addition, the socio-demographic variables of individual 'i' are represented by 'S' where there are 'a' through 'k' socio-demographic variables included as explanatory variables in this particular model. β_{1ij} is the parameter (or coefficient) associated with attribute Z_1 for alternative 'j' and individual 'i'. The β's are the weight that each attribute and socio-demographic variable has on observable utility (Hensher, Rose and Greene, 2005). The parameter β_{0ij} is not associated with any particular attribute but instead is the intercept and represents all unobserved sources of utility (Hensher, Rose and Greene, 2005). Furthermore, associating parameters with each individual (i.e. β_i) suggests that the weights are not homogenous across a population (although are generally modeled as such) and permits the modeling of segments within the population (Hensher, Rose and

Greene, 2005). The modeling of segments is possible through a latent class model approach, discussed later in this section.

Equation 6 can now be substituted into equation 3, which gives a more detailed expression of the fundamental choice model (shown below):

$$P_{ij} = \text{Prob}[(\beta_{0ij}+\beta_{1ij}Z_{1ij}+\ldots+\beta_{nij}Z_{nij}+\beta_{aij}S_{ai}+\ldots+\beta_{kij}S_{ki}) + \varepsilon_{ij} >$$
$$(\beta_{0ih}+\beta_{1ih}Z_{1ih}+\ldots+\beta_{nih}Z_{nih}+\beta_{aih}S_{ai}+\ldots+\beta_{kih}S_{ki}) + \varepsilon_{ih}] \quad (7)$$

Equation 7 shows that a researcher can determine the probability of an individual choosing a certain alternative out of a finite set of alternatives based on the individual's socio-demographic characteristics, the attributes that make up that particular good or service and other unobservable sources of utility. However, one of the continuing challenges associated with any choice model is what to do with the unobservable components of utility (i.e. ε).

3.6.2 The Multinomial Logit Model

The assumptions made about the distribution of the error term permits the selection from a number of probit or logit choice models. The most common assumption is that the error term is independently and identically distributed (IID) across individuals and with Type I, extreme value distribution. With this assumption, one can define a probability distribution called the multinomial logit (MNL) model which takes the general form:

$$P_{ij} = \exp V_j / \sum_h \exp V_h \quad \text{(for all h in choice set C where } j \neq h) \quad (8)$$

The MNL is considered the workhorse of discrete choice analysis partly because it is computationally easier than other models (Rolfe, 2006). In words, the MNL states that the probability of individual ‘i’ choosing alternative ‘j’ is equal to the components of observable utility associated with the chosen alternative (i.e. ‘j’) raised to the exponent divided by the sum of observable utilities associated with all other alternatives (‘h’) raised to the exponent. From the survey, various software packages calculate the actual frequency that individual ‘i’ chooses alternative ‘j’, which forms the left hand side (i.e. dependent variable) of equation 8. With the known frequency of choice, the same software will then estimate each researcher-specified parameter through maximum likelihood procedures. Knowing the parameters associated with various attributes allows a researcher to predict the probability that an individual will choose a particular environmental amenity as described by various combinations of the attributes. However, the predicted probability that an individual will choose a particular alternative is a relative measure, not an absolute measure of the probability (or utility) associated with that particular alternative (Hensher, Rose and Greene, 2005). In other words, the probability that an individual will choose a certain alternative is only true in comparison to another choice profile with the same attributes (but differing levels).

In addition to helping predict choices, the parameters associated with individual levels of an attribute can provide a researcher with the part-worth utility or marginal utility associated with the attribute in question. Simply put, plotting the parameters of an attribute against one another in utility space show how marginal utility can change with increasing/decreasing amounts of an attribute (Hensher, Rose and Greene, 2005).

3.6.3 Measuring Compensating Surplus

In addition to predicting the probability of choice (or choice behaviour), the coefficients from the MNL model can also be used to estimate the economic value of changes in welfare (Rolfe, 2006). Estimating welfare change from the MNL model is possible with the formula below:

$$CS = -1/\beta_{paymentvehicle}[\ln\Sigma \exp V_{i0} - \ln\Sigma \exp V_{i1}] \quad (9)$$

Where $\beta_{paymentvehicle}$ is the marginal utility of income (represented by the parameter for the cost attribute in the choice experiment), V_{i0} and V_{i1} are the indirect utilities associated with two choice profiles where '1' represents a change in environmental quality from '0' and CS is compensating surplus (the welfare measure). CS is the amount of income an individual is willing to give up for an environmental improvement over the current situation so the individual remains at the same utility level as before the change (Hanley and Spash, 2003). The entire equation is negative, which represents a willingness to pay (WTP) scenario. If the changes in the state of nature reflect an environmental loss (i.e. going from '1' to '0') then the appropriate sign for equation 9 would be positive which implies willingness to accept compensation for an environmental loss (Rolfe, 2006).

If the states described by '1' and '0' differ in only one attribute (i.e. the choice profile between two alternatives is constant with the exception of one attribute that will differ according to its levels), then equation 9 simplifies to equation 10:

$$CS = -1/ \beta_{paymentvehicle} [V_{i0} - V_{i1}] \quad (10)$$

In words, equation 10 represents the amount of money an individual is willing to pay if faced with two alternatives that only differ in the level of only one attribute. If V_{i0} accurately represents the status quo, and not a hypothetical alternative, then the CS estimated from equation 10 will reflect a WTP for an environmental improvement from a real reference point.

In addition, if a researcher is analysing marginal changes in the data (i.e. analysing continuous data), then equation 10 simplifies to equation 11 below (Rolfe, 2006):

$$W = -\beta_{attribute} / \beta_{paymentvehicle} \quad (11)$$

Where welfare (W) is equal to the 'utility per attribute' divided by the 'utility per dollar' which provides a monetary estimation of an attribute in question. Rolfe (2006, p41) describes equation 11 as the "…marginal rate of substitution between income change and the attribute in question." In other words, equation 11 represents the amount of money that could be substituted (assuming weak sustainability) for any given attribute described in the choice experiment.

3.6.4 Latent Class Model

The latent class approach is an expanded, mixed logit[20] form of the MNL and permits measurement of preference heterogeneity. At a broad level, the LCM assumes that the sample population is heterogeneous as a whole but is made up of 'X' relatively, homogenous classes, or segments (Train, 2003; for expression see Semeniuk, Haider, Beardmore and Rothley, 2008), where each class is a combination of invariant

[20] Where respondent characteristics are treated as random parameters with a probability distribution instead of as fixed variables (Rolfe, 2006).

characteristics of the respondents such as socio-demographics, attitudinal and psychometric effects (Boxall and Adamowicz, 2002), and each class will have different preferences or choice behaviour from one another (Train, 2003). The number of classes comprising a sample population is performed endogenously through choice patterns and sorted into 'X' groups according to statistical information criteria (Milon and Scrogin, 2006; Semeniuk *et al.* 2008).

The LCM is the product of two probability distributions, where the probability 'P' of a randomly chosen individual 'i' choosing alternative 'j' is:

$$P_{ij} = (P_{ix})*(P_{ij|x}) \qquad (12)$$

Where P_{ix} is the probability that individual 'i' will be part of class 'x' and $P_{ij|x}$ is the probability that individual 'i' will choose alternative 'j' conditional on membership in class 'x'. These probability distributions (from equation 12) both follow the random utility model and assuming the error term in both of these distributions is independent and identically distributed among individuals with Type I, extreme value distribution, then they can be expressed as follows (Boxall and Adamowicz, 2002):

$$P_{ij} = \sum_{x=1}^{X} \left[\frac{\exp(\alpha_x S_i)}{\sum_{x=1}^{X} \exp(\alpha_x S_i)} \right] \left[\frac{\exp(\beta_x Z_j)}{\sum_{h \in C} \exp(\beta_x Z_h)} \right] \qquad (13)$$

Where, α_x is the parameter associated with the socio-demographics, attitudinal, or psychometric effects 'S' specific to group 'x'. β_x is the class 'x' specific parameters for alternative 'j', chosen from all alternatives 'h' in choice set 'C'. If there is only one class of respondents, then:

$$\frac{\exp(\alpha_x S_i)}{\sum_{x=1}^{X} \exp(\alpha_x S_i)} = 1 \qquad (14)$$

and equation 13 collapses to the MNL.

The advantage of the LCM is that it estimates different parameters for all specified classes. These different parameters across the classes help to identify the heterogeneity of the sample population (Milon and Scrogin, 2006). In turn, accounting for respondent heterogeneity provides decision makers with a greater understanding of how one policy can have varied impacts across a range of stakeholders.

3.6.5 Random Utility Model with Risk

As presented above, the random utility model in this project measures a respondent's preference for preserving old-growth forest and associated qualities. However, the presence of a probabilistic outcome can alter the valuation for many respondents. Incorporating probabilistic outcomes into the random utility model transforms the deterministic component of utility into equation 15 below (Roberts *et al.* 2008):

$$\mathrm{V_{ij}} = \beta_{\mathrm{0ij}} + \beta_{\mathrm{1ij}} \mathrm{Z_{1ij}} + [(\delta\pi)(\beta_{2ij}^{Risk} \mathrm{Z_{2ij}}) + (1 - \delta\pi)(\beta_{2ij}^{Risk} \mathrm{Z_{2ij}^{0}})] + \ldots + \beta_{nij} \mathrm{Z_{nij}} \qquad (15)$$

Where 'Z' is the attribute associated with alternative 'j' that individual 'i' chose and there are '1' to 'n' attributes (denoted by the subscripts '1' and 'n'). In this case, the deterministic component of utility also contains the probability (π) that outcome ($\beta_{2ij}^{Risk} Z_{2ij}$) will occur, summed with the probability (1- π) that a failed state of nature will occur ($\beta_{2ij}^{Risk} Z_{2ij}^{0}$). The superscript 'Risk' represents the parameter under conditions of risk. The probability is multiplied by the decision weight δ, which will be a number different from 1 if a respondent does not perceive probability according to expected utility theory. Socio-demographic variables can be included as explanatory variables but are omitted for simplicity. Incorporating the deterministic component of utility from equation 15 into the multinomial logit or latent class models, allows one to determine the parameter estimates associated with equation 15.

The deterministic component of utility can differ between cases of certainty and risk for three reasons. First, the presence of a probabilistic outcome can alter the parameter estimates for Spotted Owl such that $\beta_{SPOW}^{Risk} \neq \beta_{SPOW}^{Certainty}$. Second, as mentioned above, respondents do not perceive probability according to expected utility theory such that $\delta\pi + (1-\delta\pi) \neq \pi + (1-\pi)$. Third, following Tkac (1998) and Samples *et al.* (1986), respondents might perceive a 0% probability of survival as 0*% where 0*>0.

3.7 Step 7: Policy Implications

Although not shown in this project, common uses for parameter estimates from contingent choice experiments are to create a computerised decision support tool (DST). In broad terms, the DST aids decision makers by estimating the general public's support for conservation plans as described by the attributes from the survey. Specifically, the DST shows two possible outcomes, similar in layout to the survey. The attributes of the survey describe each outcome and the decision maker can specify the level of each attribute for either outcome. Using the parameter estimates to calculate the overall utility of the inputted levels, the decision maker can see the difference between various outcomes from the perspective of the general public. The DST also shows market share, or the probability that an individual will choose a conservation plan based on the levels specified by a decision maker.

CHAPTER 4: RESULTS

This chapter presents the survey results. The variables describing basic characteristics of respondents are presented first. The next section of this chapter show the part-worth utilities estimated from the multinomial logit and the latent class approaches and how these estimates compare to one another. Presented in the final section are welfare estimates for both certain and risky outcomes and how respondents perceive probability.

4.1 Response

A total of 1151 respondents opened the survey and 1004 respondents completed the online task. The median time for completion was 14 minutes[21]. The response rate was approximately 19%, accounting for all respondents who received a survey link but never opened it. Of the 147 respondents who entered and did not finish, 55% dropped out within the first three pages. The other 45% dropped out at approximately even rates among the 25 remaining pages.

4.2 Eliminating Invalid Responses

Three criteria helped identify invalid responses: respondents who took very little time to complete the survey, written comments about the survey, and respondents who

[21] Average time for completion was 30 minutes, however this result is skewed by a number of respondents taking a few hours to reach the final survey page.

did not finish. Deleting these responses reduced the sample population from 1004 respondents to 949.

Respondents who took an exceedingly short amount of time to complete the survey may not have understood the hypothetical market. Pre-testing determined that the survey should take between 20 and 25 minutes if the respondent read very diligently. Completion times for respondents were skewed heavily to the right with a median time of 14 minutes and an average of 30 minutes. A small percentage of the sample population finished the survey in less than 4.5 minutes (n=25) and these respondents were excluded from data analysis.

Also excluded were obvious protestors (n=36). They included respondents who did not accept the hypothetical market (either because they did not understand it or did not agree with it) and were identified based on comments they made throughout the survey. Comments had to demonstrate that the respondent's stated value was a reflection of something other than old-growth forest management before deemed a protest vote. For example, comments such as "Your [sic] all crooks!" and "…you are asking people to take it on blind faith that the statistics and profiles developed to choose from are accurate" are more likely a reflection of the respondent's disgust or disbelief with the hypothetical market or the survey method in general.

Respondents who did not complete the survey were not included in data analysis. The majority of respondents dropping out (81 of 147) did not answer any questions, leaving no information to analyse. A further 38 respondents dropped out before the choice task, providing no indication of their preferences for old-growth forest management. The final 28 respondents answered some, or all, of the choice tasks before dropping out. However, these 28 respondents were not included in data analysis for two reasons: first, ending the survey possibly indicates a significant level of frustration with the survey; second, these respondents represented less than 3% of the sample population and would have no significant influence on parameter estimates.

In the end, using these criteria to identify and eliminate the invalid responses created a better model fit for the data.[22].

4.3 Socio-Demographics

Respondents provided socio-demographic information after the choice task. Questions included age, income, gender, education, length of residency in southwest mainland BC, ethnicity, and place of birth. Table 4-1 compares the sample population with the census data for the Lower Mainland[23].

A series of chi-square tests shows that the sample population differs significantly from the census data with regards to education, age and ethnicity, while the sample did not differ from the census population on gender. The sample population appears highly educated, as the number of university graduates is significantly higher than the census population while the proportion of respondents with a high school education or less is significantly lower than the census population. Of the larger ethnic groups, only respondents who identified themselves as Caucasian, Filipino or Korean were

[22] This test was performed once the final functional form of the parameters (i.e. linear, quadratic) was determined. The likelihood function for the full model (n=1004) is -5312.43 and for the reduced model (n=949) is -5015.6. The likelihood ratio test is -2*(-5015.6 + 5312.43) = -593.65 which is distributed chi-square with seven degrees of freedom. The test statistic exceeds the critical value of 24.322 at the 0.1% level. Therefore, we can reject the null hypothesis that the two models are equal and instead we suggest that removing the invalid responses creates a better model fit for the data.

[23] The census divides the Lower Mainland into Metro Vancouver and the Fraser Valley Regional District; therefore, statistics from both these regions were combined for a comparison with our sample population.

representative of the census population while Chinese were overrepresented and South Asian and First Nations were underrepresented. The sample population has a higher median income and is older than the census population as a whole.

Table 4-1: Socio-Demographics

Socio-Demographic Characteristics		Sample Population	Census Population
Age (n=948)	Under 20	**3.38%**	6.57%
	20-24	**11.29**	6.96
	25-34	**21.31**	13.48
	35-44	**21.84**	16.25
	45-54	**20.25**	15.83
	55 and over	21.94	23.56
Gender (n=935)	Male	49%	49%
	Female	51%	51%
Education (n=948)	Less than high-school	**0.74%**	18.15%
	Completed high-school	**9.60**	32.85
	Post-sec. not completed	**17.93**	n/a
	Trades, non-uni. cert. or dip.	18.04	17.44
	Completed university	**35.97**	14.82
	Post-graduate degree	**17.72**	8.36
Income (n=949)	Average	$75,000-$99,999	$73,258*
	Median	$75,000-$99,999	$55,231*
Ethnicity (n=935)	First Nations	**1.1%**	2.3%
	Caucasian	61.0	61.1
	Chinese	**22.1**	16.4
	South Asian	**3.5**	9.9
	Filipino	2.8	3.4
	Korean	1.2	2.0

Numbers in bold denote sample population is significantly different from census population at the 5% level.

*Figure for Metro Vancouver only (which represents approximately 89% of the population of the study area).

The differences in socio-demographic characteristics between the census population and the sample population may be because some groups have a lower willingness to respond to the survey; or the differences may be a reflection of membership in the E-rewards database by respective socio-demographic groups. E-rewards invites members of sponsoring agencies, (i.e. businesses targeting a usually wealthier clientele, such as Continental Airlines, US Airways, Hilton Hotels), to respond to surveys, and receive reward points for their respective programs. However, it should be mentioned at the outset that any differences between the census data and the sample population is not necessarily a concern because none of the socio-demographic variables was significant in explaining responses to the valuation questions. Therefore, no weighting of results was undertaken in the end.

4.4 One and Two Class Models

Analysis of the data suggests the sample population has heterogeneous preferences. In total, 1, 2, 3, 4 and 5 class models were assessed and Table 4-2 shows these results. In Latent Class Models, the researcher exogenously imposes the number of segments on the data and then judges the resulting models through various statistical criteria (Boxall and Adamowicz, 2002). No formal assessment procedure exists in which criteria should be used; however, similar to Boxall and Adamowicz, (2002) we used the Bayesian Information Criterion (BIC), and the Akaike Information Criterion (AIC and AIC3)[24]. In short, these criteria penalise the improvements in the log likelihood value against the number of segments added by the researcher, where each criterion varies the

[24] BIC = -2*LL+log(N)*npar; AIC = -2*LL+2*npar; AIC3 = -2*LL+3*npar. Where N=sample size, 'npar'=number of parameters, LL=Log Likelihood (Vermunt and Magidson, 2005).

level of penalisation (Vermunt and Magidson, 2005). Considering the BIC, AIC and AIC3 together, suggests that the 2-class model produces the best model fit overall. The BIC is the lowest for the 2-class model and only marginal gains occur for both the AIC and AIC3 when moving from a 2-class to 3-class model or higher. In addition, the R^2 and $R^2(0)$ confirm[25] the goodness-of-fit for the 2-class model, as the improvement of the R^2 from 0.05 to 0.35 between the one and the two class model are huge, as estimates between 0.2 and 0.4 are indicative of a good model fit (Louviere *et al.* 2000, p.54).

Table 4-2: Statistical Criteria Used to Assess Model Fit for Different Latent Classes

	1-Class	2-Class	3-Class	4-Class	5-Class
LL	-4942.67	-4174.07	-4065.82	-3999.33	-3949.08
BIC(LL)	10111.6	8807.5	8824.0	8924.1	9056.7
AIC(LL)	9951.3	8482.1	8333.7	8268.7	8236.2
AIC3(LL)	9984.33	8549.15	8434.63	8403.65	8405.17
$R^2(0)$	0.057	0.343	0.431	0.486	0.5329
R^2	0.046	0.336	0.425	0.480	0.5277

Table 4-3 below shows the results of the contingent choice study for both the 1 and 2-class models. In these models, all attributes were coded as continuous variables and may take different functional forms such as a linear or quadratic specification. Numerous models using both linear and quadratic functional forms were estimated (Table 4-3). Although Table 4-3 shows both the 1 and 2-class results, discussion of results will focus on the 2-class model, while the results of the 1-class model are merely presented as a

[25] R^2 and $R^2(0)$ are more correctly called rho-squared and pseudo-rho-squared, respectively.

demonstration of how heterogeneity in the data set influences the overall model. Figure 4-1 contains a graphical representation of the untransformed levels of each attribute, documenting the exact distribution of each level.

In the 2-class model, 66% (n=629) of respondents belonged to the first class and 34% (n=320) to the second class. In the first class, all parameters are significant at the 5% level. In the second class, all parameters are significant except for the attributes pertaining to recreation zoning for both the old-growth and commercial forests, and the number of Spotted Owls. The intercept for the second class is weakly significant at the 10% level. The differences between the classes occur on the variables ‘percent motorised in commercial forests’, ‘number of Spotted Owl breeding pairs’, ‘tax increase’, and the intercept. All signs remain constant between the classes for significant attributes except for the intercept.

Table 4-3: Part-Worth Utility Estimates for the 1 and 2 Class Models

	1 Class	2 Class	
	Overall (n=949)	Preservationist (n=629)	Bottom-Line (n=320)
Ratio of Old-Growth to Commercial Forests (q)	-0.0325 (0.0035)***	-0.0370 (0.0044)**	-0.0568 (0.0114)**
% Motorised in Commercial Forests	-0.3047 (0.0879)***	**-0.4688 (0.1104)****	**0.2155 (0.2404)**
% Motorised in Old-Growth Forests (q)	-2.3620 (0.882)***	-3.1442 (1.1045)**	-0.0162 (2.5549)
Amount Harvestable in Old-Growth	0.4581 (0.1521)***	0.4597 (0.1879)**	1.2221 (0.4588)**
# Spotted Owl Breeding Pairs	0.5070 (0.0494)***	**0.7104 (0.065)****	**0.1013 (0.1540)**
# Species at Risk Recovering	0.2989 (0.0266)***	0.3495 (0.0319)**	0.4346 (0.0883)**
Tax Increase	-0.3034 (0.0373)***	**-0.2342 (0.0457)****	**-1.6191 (0.1709)****
Intercept	0.1270 (0.0701)*	**1.4593 (0.1057)****	**-0.3747 (0.2009)***

(q) Attribute is quadratic coded (all other parameters are linear)

***Significantly different from a parameter estimate of 0 at the 1% level

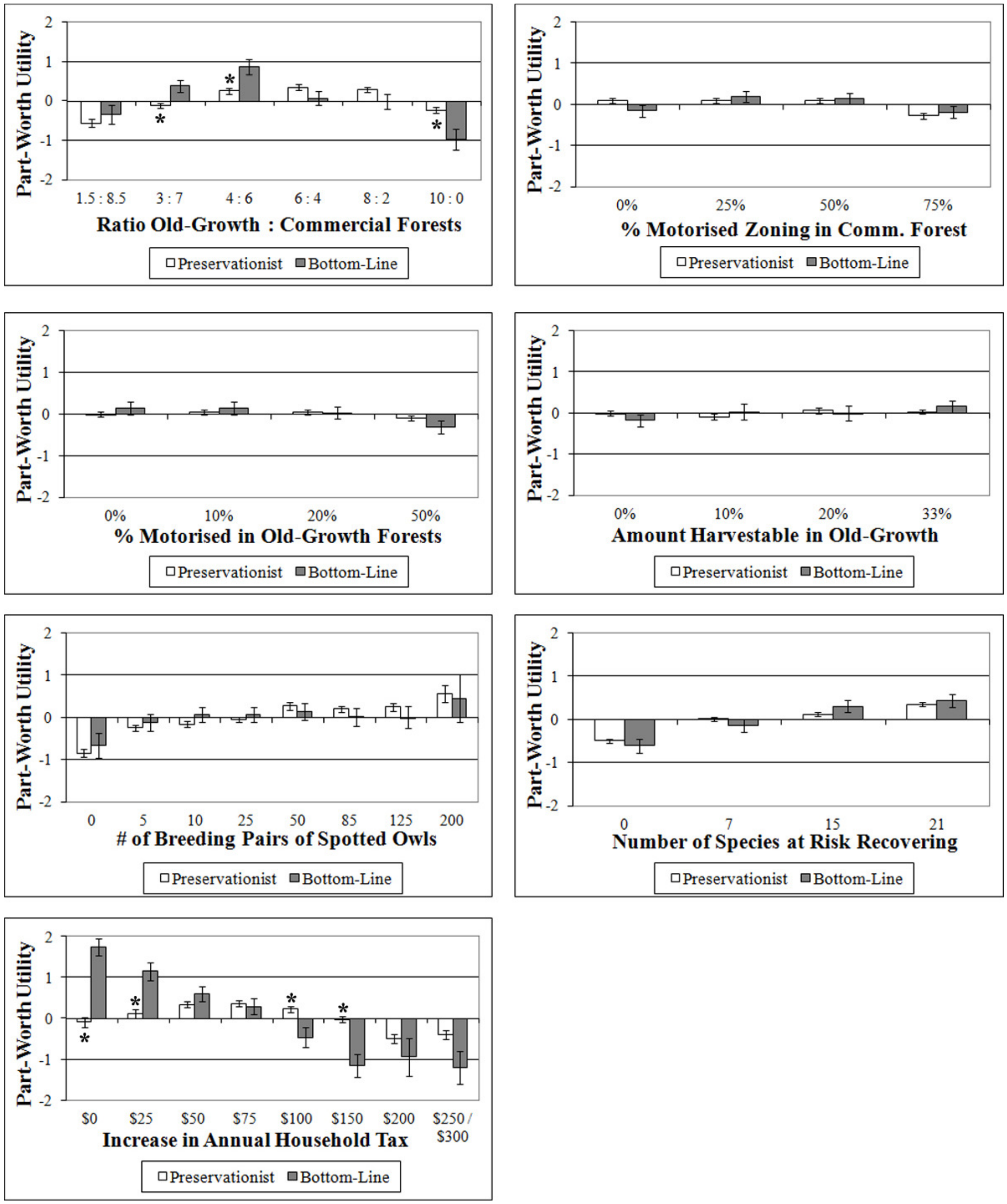
**Significantly different from a parameter estimate of 0 at the 5% level

*Significantly different from a parameter estimate of 0 at the 10% level

( ) Represents Standard Error

Bold values denote significant differences between classes at the 5% level (based on the t-statistic, as per Ben-Akiva and Lerman, 1985, p.202).

Figure 4-1: Part-Worth Utilities for the 2-Class Model



* = Significant difference between the two levels at the 5% level based on the t-statistic (as per Ben-Akiva and Lerman, 1985, p.202).

Members of Class 1 (66%) can be labelled 'Preservationist' because of their strong preferences for protecting increasing amounts of old-growth forest and species at risk. Members of Class 2 (34%) can be referred to as 'Bottom-Line members' because of their focus on minimising their additional tax payment while maximising protection of all other species at risk.

For both classes, the ratio of old-growth forest to commercial forest resembles a quadratic relationship. This implies both classes gain the greatest utility from a balance between the amount of forests set aside for old-growth forests and the amount set aside for harvesting purposes. However, Bottom-Line members are very sensitive to increases in old-growth forest and strongly oppose full protection.

The recreation attributes were only significant for the Preservationist members. They prefer increasing amounts of non-motorised areas within commercial forests and prefer the amount of motorised zoning for old-growth forests to be approximately 20%. Although the recreation zoning attributes were not significant for Bottom-Line members, this class still seems to actively pursue forest recreation, given the lack of statistical relationship between users/non-users of the forest and class membership[26]. However, more specific aspects of recreation behaviour may explain the apathy of Bottom-Line members to motorised zoning. For example, motorised zoning may only concern people who travel into the backcountry (this survey did not make a distinction between front-country and backcountry forest recreation). Alternatively, Bottom-Line members may not perceive a conflict between motorised and non-motorised recreation users.

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[26] A Pearson bivariate test shows a correlation of 0.117 (significant at the 1% level) for non-users of the forest and Class 2 membership. In other words, only 12% of the Class 2 membership are non-users.

The ‘amount harvestable in old-growth forest’ attribute resembles a linear, positive relationship for both classes, implying that respondents prefer not to lower the harvestable area in old-growth forests. Although harvesting seems counter-intuitive to the idea that old-growth represents pristine wilderness, this result could reflect a deeper appreciation of the trade-offs between preservation and the economic value of old-growth timber. The survey informed respondents that only old-growth outside of parks and protected areas would be subject to harvesting and that only a portion of these forests would be harvested conditional that the rest remain in old-growth condition. Therefore, respondents may agree that this practice is a method of sustainable harvesting, in other words, a method to allow harvesting of the economically valuable old-growth timber.

The attributes pertaining to the ‘Spotted Owl’ and ‘species at risk’ provided crucial information about class membership for both classes. The Spotted Owl attribute approximates a positive, linear relationship for Preservationist members, suggesting they gain a great amount of utility from increasing numbers of owls. On the other hand, the Spotted Owl attribute was not significant for Bottom-Line members, which implies this attribute did not affect these respondents’ decisions. One possible interpretation would be that Bottom-Line members may simply not care about protecting endangered species and represent a class of respondents who want to liquidate the forest. However, examining the ‘species at risk’ attribute shows this is not the case. The ‘species at risk’ attribute resembles a positive, linear relationship for both classes, suggesting both classes gain utility by growing and stabilising endangered species populations. While Preservationist members gain utility from protecting all species at risk, Bottom-Line members value the protection of multiple species at risk higher than the protection of one single species, even if it is a charismatic one. An alternative explanation is that Bottom-Line members may perceive the Spotted Owl as doomed with only five breeding pairs left, and therefore did not focus on this attribute.

The cost attribute approximates a negative, linear relationship and is significant for both groups. This finding is theoretically valid, showing that respondents do not like paying more in taxes. Figure 4-1 shows that the Bottom-Line members exhibit a strong dislike for increased taxes, while the Preservationists appear to be indifferent to paying more taxes up to approximately $100.

4.5 Welfare Estimates

When analysing marginal changes from a contingent choice experiment, a change in welfare is equal to $-\beta_{attribute} / \beta_{money}$, when holding all other variables constant. Analysing marginal changes (i.e. results from Table 4-3) as opposed to the non-marginal changes (i.e. results shown in Figure 4-1) allows us to calculate welfare on a per item basis (e.g. dollars per owl). The welfare measures derived from a contingent choice study are multi-attribute versions of the median welfare measures for CVM (Adamowicz *et al.* 1998). Median welfare measures are used because outliers less affect them. In the context of the attributes used in this survey, these changes in welfare can also represent a respondent's willingness to pay (WTP) for various increases in the levels of attributes.

Table 4-4: Welfare Estimates for the 1-Class and 2-Class Models

	1-Class	2-Class	
		Preservationist (n=629)	Bottom-Line (n=320)
Spotted Owl ($/Breeding Pair)	$1.67	$3.03	$0.06*
Other Species at Risk ($/Species Recovering)	$9.85	$14.92	$2.68

*$\beta_{\text{Spotted Owl}}$ is NOT significant

By definition, the WTP estimates shown in Table 4-4 (above) suggest the 1-Class model is an average of the evaluation by two rather disparate groups of respondents. Members of the Preservationist group have a much higher WTP for each Spotted Owl breeding pair and each recovering species at risk in comparison to the Bottom-Line members. Although the Bottom-Line members show a positive WTP for each breeding pair of Spotted Owls, the β_{SPOW} for this group is not significant.

4.6 Preferences under Risk

So far, in this chapter, we have only modelled how respondents make decisions under implied certainty[27], or in other words, from an ex-post perspective (i.e. after the state of the world is revealed). However, we also want to understand decision-making under conditions of risk, or from an ex-ante perspective (i.e. before the state of the world is known). By showing respondents a probabilistic outcome associated with the number of Spotted Owls present in southwest mainland BC, we are able to gauge risk perception and how it affects choice behaviour in the context of this project.

[27] Respondents were instructed to assume that given a choice set, each one of the profiles would occur with certainty.

As discussed in Chapter 2, risk is the magnitude of an outcome multiplied by the probability of that outcome occurring (i.e. Risk = Magnitude * Probability), summed over all potential outcomes. From the survey design, we are able to estimate magnitude and probability independently from one another. The magnitude is equal to the parameter estimates for Spotted Owls which were estimated under conditions of risk (i.e. β_{SPOW}^{Risk}) and implied certainty (i.e. $\beta_{SPOW}^{Certainty}$). Under conditions of implied certainty, a respondent is presumed to perceive probability as equal to 100% (i.e. $\pi = 100\%$), but under conditions of risk, probability is presented as a varying percentage (i.e. $\pi = X\%$; where 'X' varies between 0 and 100%).

This section explores how a difference in perspective (ex-post versus ex-ante) can alter welfare measures. First, we consider how the parameter estimates (i.e. the magnitude) change under conditions of risk and implied certainty. Second, we explore how respondents perceive probability and compare this subjective perception to objective probability. Third, we combine both the altered parameters and the subjective probabilities to explore how welfare measures change under conditions of risk.

4.6.1 Comparing Parameter Estimates

Based on the literature presented in Chapter 2, the perceived magnitude of an outcome (or the preference for a particular outcome) can change under conditions of risk. In other words, $\beta_{SPOW}^{Certainty} \neq \beta_{SPOW}^{Risk}$, independent of the probability associated with the outcome[28]. Table 4-5 shows the parameter estimates for both the 'Spotted Owl' and

[28] The 'Probability' and 'Spotted Owl' attribute are independent of one another in the survey design, and as such, allows us to estimate these parameters separately from one another.

'Cost' attributes for the 1-Class and 2-Class models under cases of risk and implied certainty[29]. All signs remained the same between choices under both conditions; however, the size of the parameters appears to have changed. In the 1-Class model, the respondents receive less utility from gains in the number of Spotted Owls and associate a greater disutility with increasing household income taxes. In the 2-Class model, the Preservationists also receive less utility from increasing numbers of Spotted Owls and perceive a greater disutility with increasing household taxes. For the Bottom-Line members, the Spotted Owl attribute is now significant. In addition, the cost parameter for the Bottom-Line members is not as large, suggesting these members are more willing to experience an increase in household income tax under conditions of risk.

Table 4-5: Part-Worth Utilities for the 2-Class Model under Conditions of Certainty and Risk

	1-Class		**2-Class**			
	Overall (n=949)		Preservationist (n=629)		Bottom-Line (n=320)	
	Certainty	Risk	Certainty	Risk	Certainty	Risk
# SPOW Breeding Pairs	0.5070 (0.0494)**	0.1012 (0.0508)**	0.7104 (0.065)**	0.3841 (0.1484)**	0.1013 (0.1540)	0.5539 (0.1909)**
Tax Increase	-0.3034 (0.0373)**	-0.3536 (0.055)**	-0.2342 (0.0457)**	-0.3754 (0.074)**	-1.6191 (0.1709)**	-0.8012 (0.1307)**

SPOW = Spotted Owl
( ) = Standard Errors
** Significantly different from a parameter estimate of 0 at the 5% level or lower

[29] Please see Appendix D for the parameter estimates for the full model.

Although Table 4-5 provides an indication of how respondents' preferences may alter with risky outcomes, model parameter estimates are confounded with a scale factor (denoted as λ). The correct specification of $\beta_{SPOW}^{Certainty}$ and β_{SPOW}^{Risk} is actually $[\lambda^{Cer}\beta_{SPOW}^{Cer}]$ and $[\lambda^{Risky}\beta_{SPOW}^{Risk}]$, respectively (Louviere *et al.* 2000). Casual examination of parameters between models, as we have just done, might show that preferences have shifted (i.e. $[\lambda^{Cer}\beta_{SPOW}^{Cer}] \neq [\lambda^{Risk}\beta_{SPOW}^{Risk}]$), while the reality may be that preferences have not shifted (i.e. $\beta_{SPOW}^{Certainty} = \beta_{SPOW}^{Risk}$) but rather the difference is caused by a scale factor as can be stated by $\lambda^{Cer} \neq \lambda^{Risk}$ (Holmes and Boyle, 2003). Although the scale parameter is confounded with the parameter, it is possible to estimate a relative scale factor ($\lambda^{Risk} / \lambda^{Cer}$) and then test the hypothesis that $\beta_{SPOW}^{Certainty} = \beta_{SPOW}^{Risk}$, by controlling for this factor (Holmes and Boyle, 2003).

Swait and Louviere (1993) and Holmes and Boyle (2003) describe the steps necessary to test the hypothesis that $\beta_{SPOW}^{Certainty} = \beta_{SPOW}^{Risk}$. First, we created a joint model by pooling the data from both choice sets. Then, we held λ^{Cer} constant at one and multiplied the data points from the uncertain choice sets by a relative scale factor ($\lambda^{Risk} / \lambda^{Cer}$) until the log-likelihood function was maximised for the joint model. The estimated scale factor for the maximized joint model is 0.7575. With $\lambda^{Risk} / \lambda^{Cer}$ optimally rescaled, the hypothesis that $\beta_{SPOW}^{Certainty} = \beta_{SPOW}^{Risk}$ can be tested through the likelihood ratio test statistic:

$$a = -2[L_{jointmodel} - (L_{certainty} + L_{risk}). \quad (16)$$

$L_{joint\ model}$ is the log-likelihood value for the joint model, $L_{certainty}$ and L_{risk} are the log-likelihood values for the choice models under conditions of certainty and risk, respectively. The likelihood ratio statistic calculates out to be (-2 * (-6954.8473 - (-5017.2347 + -1911.5546)) = 52.116, which is distributed chi-square[30] with 14 degrees of freedom[31]. The critical value of the chi-square test at 95% with 14 degrees of freedom is 23.685. Therefore, we can reject the hypothesis that $\beta_{SPOW}^{Certainty} = \beta_{SPOW}^{Risk}$. According to Swait and Louviere (1993), this result implies that respondents are using a different cognitive process when choosing alternatives between risk and implied certainty[32]. In other words, the presence of a probabilistic outcome alters respondents' decision making altogether which in turn affects their utility.

However, it is extremely important to note that the risky choice sets differ from the certainty choice sets in certain respects. The choice sets without probability (choice sets 1 to 5 for each respondent) consisted of three profiles (status quo and two hypothetical alternatives), while the choice sets with probability (choice sets 6 – 8) contained only two profiles (status quo and one alternative), and the 'Spotted Owl' and 'probability' attribute were highlighted in blue. Therefore, observed differences between the certainty and risky choice sets may be due to structural differences between the

[30] For all three models, neither the chance attribute nor the intercept were included. Although not including these variables alters the log-likelihood values slightly, it should not alter it enough to fall below the chi-square critical value.

[31] Degrees of freedom are calculated as number of attributes from both the certainty and uncertainty data sets (7*2) plus 1 (for the relative scale factor).

[32] It is important to note that we estimated a relative scale factor that applies to all common attributes between the choice tasks. This approach seems appropriate compared to estimating a scale factor for only the Spotted Owl attribute because all attributes are significant in respondent's decision making (see parameter estimates in Table 4-3).

choice sets as opposed to fundamentally different ways of processing the information provided. These implications are discussed further in Chapter 5.

4.6.2 Welfare Estimates under Risk

Although we can reject the hypothesis that the parameters are equal under cases of implied certainty and risk, respondents may still have similar welfare estimates because both the marginal utility of money and marginal utility of Spotted Owls have altered under cases of certainty and risk. Converting parameters into welfare estimates for the two respective models produces Table 4-6 below.

The 1-class model shows that welfare estimates have altered. Respondents' welfare in the 1-Class model decrease from $1.67 per breeding pair of Spotted Owls to $1.00 per breeding pair. However, the 2-Class model portrays a different picture than the 1-Class model. Under conditions of risk, the difference between the Preservationists and the Bottom-Line members shrinks when compared to the welfare estimates under certainty. The Bottom-Line members gain greater welfare from an increase in taxes going towards Spotted Owl conservation efforts, while the Preservationist members experience a decrease in welfare.

Table 4-6: Welfare Estimates under Conditions of Risk

		Spotted Owl (\$/Breeding Pair)	
		Certainty	Risk
1-Class (n=949)		\$1.67	\$1.00
2-Class	Preservationist (n=629)	\$3.03	\$1.02
	Bottom-Line (n=320)	\$0.06*	\$0.69

However, risk is a function of probability times the magnitude of the outcome. As shown above, the perceived magnitude (i.e. parameters and welfare estimates) has altered under risk, but the perception of probability also plays a part in distorting the welfare estimates. Therefore, the next section shows how the perception of probability affects the welfare estimates for Spotted Owl.

4.6.3 Integrating the Probability Attribute

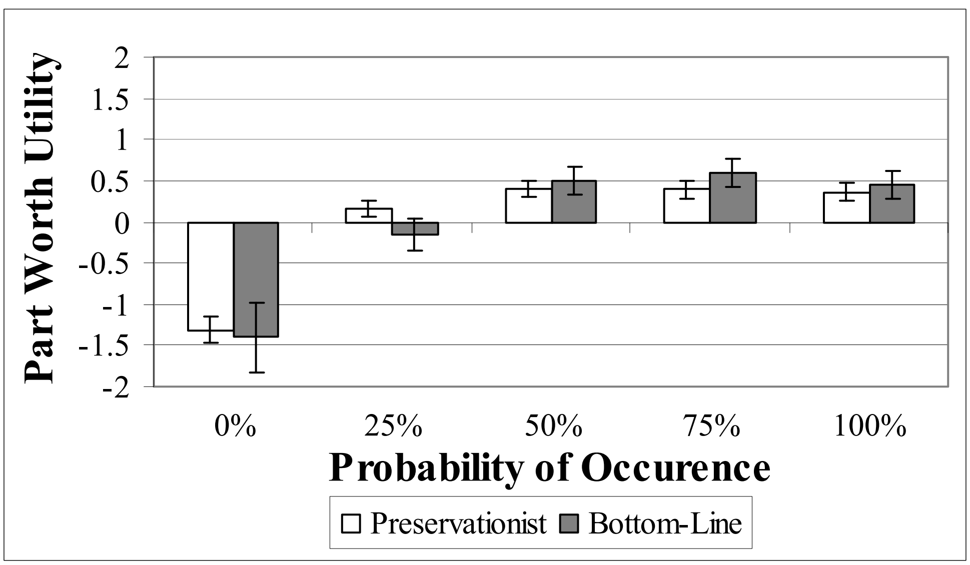
By presenting a probability associated with the number of Spotted Owls that may be present on the landscape in the future, it is possible to determine how respondents perceive the different levels of probability. If respondents perceive probability objectively, then probability should follow a linear path; for example, a 50% probability of success is twice as good as a 25% probability of success. However, parameter estimates for both the 1-Class and 2-Class model suggest that respondents' utility rises quickly between 0% and 50%, and then remains constant between 50% and 100% (see Table 4-7 and Figure 4-2). This trend is similar between the two classes, which suggest a homogenous preference structure across the entire sample population for the 'probability of occurrence' attribute.

Table 4-7: **Part-Worth Utilities for the 'Probability of Occurrence' Attribute**

	1 Class	2 Class	
Probability of Occurrence	Overall (n=949)	Preservationist (n=629)	Bottom-Line (n=320)
0%	-1.1745 (0.1387)***	-1.3107 (0.1618)***	-1.4053 (0.4216)***
25%	0.1076 (0.078)	0.163 (0.1021)	-0.1477 (0.1928)
50%	0.3958 (0.0754)***	0.4052 (0.1005)***	0.5052 (0.1703)***
75%	0.3549 (0.0814)***	0.3892 (0.1117)***	0.5996 (0.1745)***
100%	0.3162 (0.0795)***	0.3533 (0.1087)***	0.4482 (0.1748)***

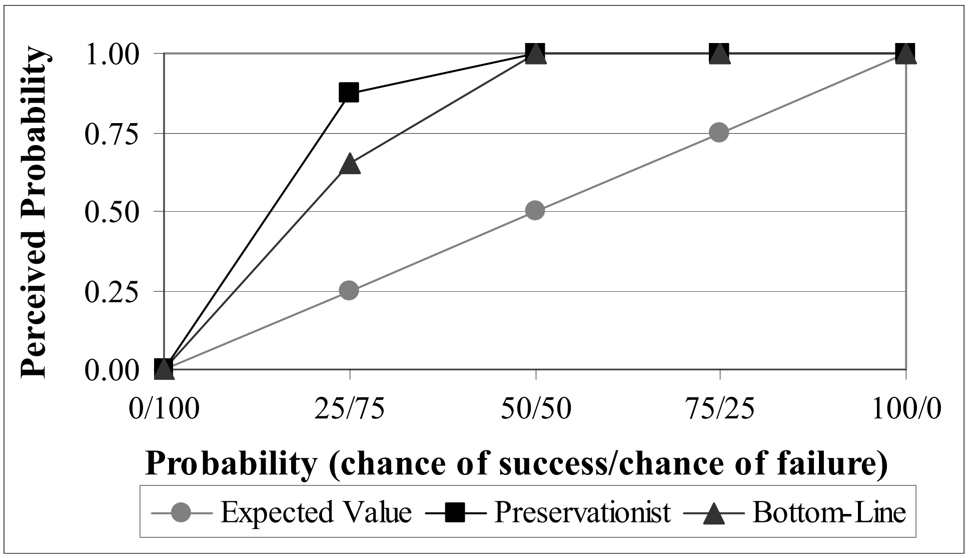
*** Significantly different from a parameter estimate of 0 at the 1% level.

Figure 4-2: Part-Worth Utilities for the 'Probability of Occurrence' Attribute



Although the overall trend for the perception of probability is not significantly different between the two classes, the PWU's suggest that neither class perceives probability in a linear manner. Converting the part-worth utilities from Table 4-7 into a weighting function for probability produces Figure 4-3[33]

Figure 4-3: Probability Weighting for Class Members



From an objective perspective, one would assume that people perceive the probability of 25% as 25% (i.e. 0.25 on the 'Perceived Probability' axis); however, the Preservationist class members perceive 25% as equivalent to 87%, and the Bottom-Line members perceive the same value as 65%. Furthermore, both groups of respondents perceive any probability from 50% to 100% as equivalent to certainty. Correlated with the probability of occurrence is the probability of failure. This survey assumed two states of nature; therefore, Preservationists who perceive a 25% probability of success as 87% are presumed to perceive the 75% probability of failure as 13%.

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[33] Creating this figure involved several steps. First, we assumed that respondents perceived 0% and 100% probability as certain outcomes; and therefore, constrain the perception of these levels at 0 and 1 respectively. Second, we constrain the 50% and 75% levels at 1 as well, because the part-worth utility appears to reach its maximum after the 50% level. Third, to obtain the respondents' perceptions of the 25% level, the part-worth utility for this level was divided by the average part-worth utilities of the 50%, 75%, and 100% levels.

4.6.4 Measuring Risk

Evaluated separately the parameter estimates for magnitude of the outcome and probability appear to be different between the ex-post and ex-ante perspective. However, risk is a function of both magnitude and probability summed over all states of nature, and as such, welfare estimates could still be equivalent under either perspective.

Table 4-8 shows the differences between ex-ante and ex-post welfare measures. For the ex-ante[34] perspective, we multiplied the parameter estimates from Table 4-5 by the subjective probability calculated from Figure 4-3 (where the results for a successful and failed stated of nature were summed together). We followed the same procedure for the ex-post perspective, except we used the parameter estimates from Table 4-3 and multiplied them by objective probability. In the table below, the only difference between the two choices (i.e. the Alternate Outcome and Status Quo) is the probability of the number of Spotted Owls occurring on the landscape in 25 years (i.e. all other attributes would be the same between the two options). The ex-ante measurements for both the 1-Class and Preservationist class are lower than the ex-post measurements. However, the inverse appears to be true for the Bottom-Line members, where ex-post welfare measures are lower when compared to an ex-ante perspective.

[34] Recall from Chapter 2 that the ex-ante welfare measure for risky outcomes is option price.

Table 4-8: Incorporating Probability into Ex-Ante and Ex-Post Welfare Measurements when the Alternate Outcome has an Explicit Probability of Success.

Attributes	Alternate Outcome		Status Quo
Number of Spotted Owls	5 breeding pairs (100%) 0 breeding pairs (0%)		5 breeding pairs (25%) 0 breeding pairs (75%)
Class	Welfare		
	Ex-Ante (Option Price)	Ex-Post (Expected Compensating Surplus)	
Overall (1-Class) (n=949)	$0.80	$6.27	
Preservationists (n=629)	$0.67	$11.37	
Bottom-Line (n=320)	$1.21	$0.23*	

* Spotted Owl parameter estimate is not significant.

However, the results between the ex-post and ex-ante welfare measures will differ according to combinations of the probability and the magnitude of outcome used in the calculations. Table 4-9, shows how ex-post measures may underestimate the welfare when implementing a riskier conservation plan. In this example, ex-post measurements show that an individual, regardless of class membership would be indifferent between the two options presented below. However, using ex-ante welfare measurements suggests that all individuals, regardless of class membership, will gain welfare from implementing a riskier conservation plan that has the potential for larger pay-offs than the 'smaller-outcome, sure-bet', option. The reason for such a discrepancy is that from an ex-ante perspective, respondents perceive 50% probability of success as equivalent to 100%.

Table 4-9: Incorporating Probability into Ex-Ante and Ex-Post Welfare Measurements when the Alternate Outcome has an Explicit Probability of Success and Failure.

Attributes	Alternate Outcome		Status Quo
Number of Spotted Owls	10 breeding pairs (50%) 0 breeding pairs (50%)		5 breeding pairs (100%) 0 breeding pairs (0%)
Class	Welfare		
	Ex-Ante (Option Price)	Ex-Post (Expected Compensating Surplus)	
Overall (1-Class) (n=949)	$4.99	$0.00	
Preservationists (n=629)	$5.12	$0.00	
Bottom-Line (n=320)	$3.46	$0.00*	

* Spotted Owl parameter estimate is not significant

As a further note, the welfare measures used in the tables above do not include the alternate specific constant (ASC), as the purpose of the welfare measures used here is to illustrate the differences between probability and the magnitude of an associated outcome from an ex-ante and ex-post perspective. Including the ASC will confound the welfare measurements with the unobserved sources of utility.

The data suggest that a difference exists between welfare measures under implied certainty and risk, where the difference between the two is dependent on the specified conditions and the perspective of the respondent. Tests of the data also suggest that the difference between the ex-ante and ex-post welfare measures are due to a change in the preference structure of the respondents when faced with risky prospects that cannot be resolved at the time of making a decision. These research findings may provide general advice and specific direction for conservation planning here in southwest mainland British Columbia and this provides the focus of the next chapter.

CHAPTER 5: DISCUSSION

The purpose of this project was to measure the existence value of the Spotted Owl. However, simply asking the public for their willingness to pay for Spotted Owl conservation efforts might be confounded with a value for the Owl's habitat (i.e. old-growth forests), or other old-growth dependent species at risk. Furthermore, setting aside habitat for the Spotted Owl also affects direct-use values (i.e. recreation and harvesting) associated with such land. In addition, conservation efforts are inherently risky, where risk can alter the value society places on such efforts.

In order to control for all these potentially confounding relationships, we applied a multi-attribute trade-off approach (i.e. contingent choice), which enabled us to measure the value for these attributes separately, yet in the context of each other. We also compared our measurements for different classes of respondents in order to explore and describe the heterogeneity of preferences within the sample population.

5.1 The Existence Value of Old-Growth Forest and Related Qualities

Existence value is the value someone places on knowing that an environmental amenity exists, regardless of use. 'Value' is the worth of the environmental amenity, expressed in an equivalent amount of money, or other goods or services. For this project, existence value is the amount of money the general public is willing to pay through increases in provincial household income tax for conservation policies to help the Spotted Owl, old-growth forest, and other old-growth dependent species at risk.

Before quantifying the existence values relevant to this study, it is necessary to highlight the fact that the marginal existence values for Spotted Owls and other old-growth dependent species at risk follows a linear relationship. In other words, the general public gain the same level of utility from every additional breeding pair of Spotted Owl, or every additional species at risk that is protected, regardless of the numbers of Owls or other species that may already be present on the landscape. This linear relationship appears to contradict current economic theory, which suggests that marginal existence values should diminish with successive gains. However, this apparent contradiction may be due to the scope of the survey. For example, our study elicited preferences for only a small proportion of the entire Spotted Owl population and other old-growth dependent species at risk, essentially focusing on one small section of the entire willingness to pay curve. Therefore, as suggested by Rollins and Lyke (1998), our study may not have the appropriate range to detect diminishing marginal existence values.

Quantifying existence value is not straightforward. If the population of the Lower Mainland is assumed to have homogenous preferences for Spotted Owls, then the existence value of a breeding pair of Spotted Owls is worth $1.67 per household in increased taxes. The fact that existence values are positive accords well with other valuation studies of the Northern or Mexican Spotted Owl (e.g. Hagen, Vincent and Welle 1992; Rubin, Helfand and Loomis, 1991; Loomis and Ekstrand, 1997); however, the magnitude of the existence values between this study and other studies differs according to the assumptions made. A meta-analysis by Richardson and Loomis (2009) shows an average willingness to pay of $74 to help avoid a loss[35] of the Northern or

[35] All monetary values in this chapter are shown in 2008 Canadian Dollars, unless otherwise noted.

Mexican Spotted Owls. Specifically for the Northern Spotted Owl, CVM-derived value estimates ranged from a low of $43.95 to ensure a 50% chance of survival up to $148.22 to avoid a loss. Placing our existence values within a similar context to the studies above suggests our values cover a wider range. For example, assuming that five breeding pairs of Spotted Owls are present in southwest mainland BC today, then our model predicts that households would be willing to pay $8.35 to avoid any type of loss for the Owl. However, if we assume that 125 breeding pairs constitutes a sustainable population, then our model predicts households are willing to pay $208.75 for the continued survival of the Spotted Owl in Canada. Although the existence values provided by this project cover a wider range, they are extremely sensitive to the assumptions on what constitutes a surviving population. Furthermore, the difference between our study and the values derived from the other studies might be due to any number of variables, for example, the cited studies pertain to the US, a larger Spotted Owl population, a different time period (i.e. the 1990s), and were derived with CVM. The fact that the existence values derived from this study are similar to other studies suggests a certain amount of convergent validity for the welfare associated with the continued existence of the Northern Spotted Owl.

Measured independently of the Spotted Owl, the existence value for recovering an old-growth dependent species at risk is $9.85. Although this attribute pertains to actual species, the survey did not inform respondents which particular species were recovering, making comparisons with other studies problematic. However, instead of comparing values for the same species, we can compare welfare estimates of different species. For example, comparing welfare estimates from Richardson and Loomis' (2009) meta-analysis, other species that generate similar welfare estimates include the Striped Shiner ($9.10), the Squawfish ($13.67) and the Wild Turkey ($14.80), which suggests the value for an almost non-descript species at risk may be within reason.

In addition, measuring the existence value for the Spotted Owl and other species at risk within the same choice set permits us to check for embedding issues. Examining the welfare estimates (Table 4-4) it appears that embedding may not be an issue. In all cases, the welfare estimate for the Spotted Owl is lower in comparison to other species at risk recovering. However, the two estimates are not so easily comparable, as welfare for the Spotted Owl pertains to one breeding pair, while welfare for species at risk pertains to the entire species. The difference in magnitude between the two measures shows the species at risk welfare measure is approximately six times greater than the welfare associated with the Spotted Owl suggesting that respondents are willing to pay approximately the same amount to recover an entire species, as they are to have six breeding pairs of Spotted Owls. Six breeding pairs of Spotted Owls do not necessarily reflect a 'recovering' Owl population, but this result suggests that respondents perceive a difference between individuals of a species versus an entire species. In other words, respondents are willing to pay a substantial amount to save another species, even in the presence of the iconic Spotted Owl.

In contrast to the 'Spotted Owl' and 'Other Species at Risk' attributes, the existence value for old-growth forests does not follow a linear distribution but instead is a quadratic function dependent on the ratio of commercial forests to old-growth forests in southwest mainland BC. Therefore, it is impossible to calculate a per unit welfare estimate for old-growth forests (e.g. the value per hectare of old-growth). Instead, calculating the maximum value from the quadratic function suggests that the socially optimal amount of old-growth that should be retained in southwest mainland BC is approximately 54%. In other words, any ratio of old-growth forest to commercial forest that moves away from the 54:46 ratio, will decrease society's welfare. The notion of maintaining a ratio of working forest to old-growth forest lends support to the idea that the general public likes conservation work but not at the expense of other use values, and vice-versa. Garrod and Willis (1997) also show similar results, where the general public of the UK prefers a mixture of conservation and working forests. In a similar finding, the general public of the Lower Mainland appears to prefer a certain amount of logging in old-growth forest, provided it does not harm local species at risk. This finding further suggests that people prefer to maintain use values within the old-growth forests, which agrees with McFarlane (2005), who found that the general public of BC prefers conservation work, but limiting access to the forest is not the preferred method for meeting conservation goals. In a related study, van Kooten and Bulte's (2001) cost-benefit analysis estimated the socially optimal amount of coastal old-growth to be retained at 25% to 50%, whereas our value is slightly higher at 54% when we assume homogenous preferences for the entire sample population.

However, large urban centres such as the Lower Mainland will rarely have homogenous preferences for large-scale land-use decisions. Therefore, we explored the data to determine if we can better describe the population by a number of different groups, where, each group will have its own homogeneous preferences that are different from other groups. The data suggest that the existence values reported above are the combined preferences from two disparate groups of individuals. The existence value is driven by the homogenous preferences of two-thirds of the respondents we labelled as Preservationists, who have strong preferences for preserving the Spotted Owl, old-growth forest and other old-growth dependent species at risk. The other third we labelled as Bottom-Line members and they show no specific preferences for the Spotted Owls per se, but have specific preferences for helping other species at risk and strongly oppose raising taxes. Obviously, any policy that attempts to collect revenue to help the Spotted Owl specifically will not be the preferred form of conservation action by a large minority of the population. Instead, this large minority may prefer to see revenue directed to conservation efforts that aid the broader species at risk population.

A thorough investigation of which variables best describe the Preservationists and Bottom-Line members revealed that socio-demographic characteristics, including income, did not explain these differences well, while psychometric data (i.e. environmental attitude and perception of the survey) best describe these groups. Although participation in forest recreation is a weak explanatory variable in describing the different classes, this variable is less powerful than the environmental attitude statements or survey perception statements in explaining class membership. From a policy perspective, identifying the preferences of individuals through easily obtained information such as census data may not be possible. The relatively poor performance of socio-demographic variables in explaining different classes of environmentally sensitive people is a common theme in western cultures, as these values now seem to be wide-spread across all socio-demographic groups (Diamantopoulos *et al.* 2003).

Another important topic is the significance of the intercept in the estimated relationships. The intercept represents all unobserved sources of utility and it was significant and positive for Preservationists but weakly significant (i.e. at the 10% level) and negative for Bottom-Line members. These contrasting results may not be surprising considering the amount of media attention focused on environmental issues over the preceding years prior to this survey. For example, Preservationists may see old-growth forests as a tool to combat global warming through carbon capture and storage, which is supported by the comments from three respondents fitting this group classification. Comments throughout the survey also provide clues for why the intercept for Bottom-Line members may be weakly significant and negative. These members may believe other forest issues, especially the pine beetle epidemic, should take priority over conservation issues focussing on old-growth forest and species at risk.

In addition, considering the history of both the Spotted Owl and old-growth forests in BC, the intercept may represent the political nature of these icons, such as jobs versus owls, loggers versus environmentalists, or broader environmental concerns (Yaffee, 1995). Such factors may explain why the intercepts differ between both classes. Individuals may feel that moving away from the status quo is a reflection of a larger, polarised political debate where an ‘us’ versus ‘them’, or an ‘all-or-nothing’ mentality may prevail.

5.2 The Existence Value of Spotted Owls under Risk

Conservation efforts are rarely certain when they pertain to saving species at risk. This study suggests the general public gains welfare from protecting species at risk even in the presence of a risky outcome. However, risk is the outcome of an event multiplied by the probability of that event occurring, and respondents appear to be distorting both these factors such that it affects overall welfare for Spotted Owl conservation efforts when comparing ex-post and ex-ante perspectives.

Under risky prospects, the underlying utility for Spotted Owls changes when compared to implied certainty (i.e. the utility is not equal between ex-post and ex-ante perspectives). For example, if we assume homogenous preferences for the Lower Mainland then utility decreases for the Spotted Owl under conditions of risk. However, the direction of change appears to be dependent on the attitudes of the individual. Two-thirds of our sample population (i.e. Preservationist members) lose welfare from risky outcomes, whereas, the other third (i.e. Bottom-Line members) gain welfare. Apparently, the majority of respondents are risk adverse with respect to their welfare from Spotted Owls under risky choices, while the remaining respondents appear are risk-seeking. This finding lends support to Harrison and Rutstrom (2006), who found that groups of individuals use different decision rules when faced with the same risky choices. Therefore, attempting to characterise the entire sample population with one decision rule may be a satisficing instead of a maximising characterisation.

However, Bottom-Line members only found the Spotted Owl attribute significant once the ‘probability of success’ attribute was introduced. Although this finding supports the idea that Bottom-Line members are risk-seeking, there may be other explanations for such behaviour. For example, the introduction of probability may have made the choice task more realistic for these members and, therefore, increased their preference for such an attribute. Another explanation may be that Bottom-Line members are behaving according to the Ellsberg (1961) Paradox, which suggests individuals will select a lottery with a known probability as opposed to an ambiguous lottery. If this paradox applies to our study, then we must assume that Bottom-Line members did not actually perceive the first five choice sets as certain, but as uncertain. Unfortunately, we did not explicitly test for this perception.

The other factor that can alter someone's preferences for a risky outcome is the perception of probability. Respondents appear to consistently overweight the objective probability of success, a result that differs from other findings in other studies about the distortion of probability. In the context of monetary lotteries, researchers have found that individuals will consistently overweight low probability events and underweight high probability events. Conversely, Roberts *et al.* (2008) found the opposite effect when examining individual's perceptions of probability that various water quality events will occur at a recreational lake. In our study, respondents do not underweight probabilistic events at all, but instead consistently overweight any probability of success. However, our survey does not permit the testing of how respondents perceive any probability between 0 and 25%; therefore, it is possible that respondents actually view the range of probabilities from 0 to 24% as equivalent to 0%. However, as described in Chapter 2, results from Tkac (1998) and Samples *et al.* (1986) suggest that respondents perceive 0% probability of survival as something greater than 0% as evidenced by their willingness to allocate part of a fixed budget to a species doomed to extinction. If these results are applicable to our findings, then the assumption that respondents overweight all probabilities as greater than objective probability may be more correct.

However, other factors may also explain the functional form of people's perception of probability from this experiment. For our project, the status quo for risky outcomes was set at 25% success for five owl pairs. The sharp negative slope from 25%

to 0% relative to the moderately positive slope from 25% to 100% may be due to a loss aversion bias. Where, from an individual's reference point, losses will have a greater effect on a person's choices than gains of the same magnitude (Kahneman and Tversky, 1979). However, the results from this project are not sufficiently conclusive to test for this effect. The levels for success were set at 0, 25, 50, 75 and 100%[36] and the movement from the status quo of 25% either up or down 25 percentage points leaves the individual at either 0% or 50% probability of success, where the difference between certain failure and a 50:50 chance of success is radically different. To measure loss aversion bias our study design would have needed to test for multiple levels on either side of status quo for both the 'probability of occurrence' attribute and the 'number of Spotted Owls' attribute. We know from our pre-tests that respondents find such tasks rather challenging, and for that reason, we stayed with one simple 'risk' task.

Although differences exist between outcomes with implied certainty and risk, these observed differences may be due to structural differences between the choice sets as opposed to fundamentally different preferences. As outlined in Chapter 4, the differences between the two choice sets are the number of alternatives presented, the number of choice sets seen and the inclusion of the 'probability of occurrence' attribute and highlighting the Spotted Owl and 'probability' attribute in blue. Both Rolfe and Bennett (2009) and Boyle and Ozdemir (2009) report differences between contingent choice experiments that present two versus three options. Rolfe and Bennett (2009) report that serial non-response is higher for the two versus three alternative format and Boyle and Ozdemir (2009) report that there is a lack of convergent validity between choice sets that

[36] 0% chance of success was shown as 100% chance of 0 breeding pairs.

differ between two and three alternatives. While these findings suggest that the change from three to two alternatives might be the reason for a change in preferences, both these studies used a between-subjects survey design as opposed to the within-subjects survey design in our study. Unfortunately, we are unable to test whether a within-subjects design is free from the problems listed above. However, the lack of comments from respondents and very few respondents (n=6) dropping out of the 'risky' choice sets suggests that, at the very least, respondents did not find the changes from the certain choice sets to the risky choice sets to be distracting enough to warrant action against it. In addition, the 'probability of occurrence' attribute was significant, signifying that individuals were able to assimilate this information into their decision making process.

5.3 Management Implications

The results from this project may provide some insight into how different governments, non-governmental organizations and industry groups can gain greater support from the general public for their conservation strategies. First, any broad-based land-use plan for southwest mainland BC should explicitly look to balance old-growth forests with commercial (or working) forests. Although the provincial government is already allocating forests in such a manner, the socially optimal levels are approximately 54% old-growth versus 46% commercial forests, which is in contrast to the 40:60 ratio that is forecast by the province. In other words, our model suggests the socially optimal level is reached, if the provincial government sets aside 54% of all forested areas in southwest mainland BC for conservation (i.e. 54% of forests in southwest mainland BC will remain as, or grow into, old-growth forest), while the remaining 46% is part of the timber harvesting landbase. This finding also extends beyond the provincial government and suggests that any group, or industry, who advocates for setting aside more, or less, forest for conservation will receive less support from the general public.

Second, the discrepancies emerging between the two classes in the latent class models show that to gain greater support for conservation work, it is necessary to position Spotted Owl conservation within the broader context of preserving other species at risk. In other words, at least a significant fraction of the general public may provide greater support for an overarching, coherent plan that brings together the conservation work for multiple species at risk instead of a single species focus.

Finally, the existence values presented here suggest the amount of revenue (or at least the starting point in negotiations) the Province could potentially capture from each household to perform conservation work to help protect the Spotted Owl. The latest Spotted Owl Recovery Plan proposes that the interest from a $20 million dollar investment should be sufficient to cover the costs involved in the recovery work (Chutter *et al.* 2004). If the existence value for a breeding pair of Spotted Owls could be aggregated to households at the Lower Mainland or the Provincial level, then this would generate approximately $1.4 to $2.7 million dollars (per year, per breeding pair, respectively) for conservation work, which would be equivalent to, approximately, 5% to 10% annual return on investment from a $20 million dollar investment. In other words, our model suggests that from the perspective of the general public, the welfare accrued through conservation work to help protect a particular old-growth species at risk such as the Spotted Owl can be greater than the cost of such work.

5.4 Limitations

Many caveats remain with economic valuation work. All recommendations presented above represent the perspective of the general public on what should be done, and the reader must keep in mind the political or institutional realities of implementing such items. For example, politicians would be extremely hesitant to raise taxes given the current economic climate. Furthermore, creating a comprehensive species at risk plan requires the necessary coordinating infrastructure, budget and people to make it happen. In addition, different species have different requirements beyond habitat (i.e. mating, dietary, denning, etc.; Lindenmayer, Margules and Botkin, 2000), which suggests that the biological reality of performing conservation work that could help multiple species at risk is a different question altogether. However, the results from this study can be used in any cost-benefit analysis involving the existence value of certain species at risk.

However, one continual challenge with economic valuation work is the potential for misinterpretation of the welfare measures. In the context of this project, the monetized existence values of the Spotted Owl and other species at risk represent the level of support for conservation work to protect these species. These values do not suggest that the life of a breeding pair of Spotted Owls is worth $1.67 per household, where, as suggested by Ackerman (2004), an anti-environmentalist billionaire could simply pay an equivalent amount for a hunting permit.

Another limitation with this study is that it only examined main effects and not interaction effects. In other words, we assumed that the attributes by themselves were significant in explaining respondents' choices and that various attributes did not combine (or interact) to have a significant impact on respondents' preferences. Unfortunately, the statistical design of the choice sets did not allow us to estimate interaction effects and although including interaction terms may have helped create a better model fit, main effects explain the majority of variance in respondents' choices (approximately 70%-90% of the variance; Louviere *et al.* 2000, p.94).

The temporal stability of existence values is also an issue. Given that these data were collected just before a major, economic recession elicits a very relevant question: how would the results change if the population received the survey today? The expectation would be that the magnitude of the welfare measures may indeed change, but none of the signs of the parameters should change. In other words, people may be willing to pay less to protect species at risk through increases in taxation, but their preferences should not alter from caring about species at risk to all of a sudden, hating species at risk. A number of factors point to this conclusion. First, the results from this study compared to other stated preferences studies performed just under two decades ago demonstrate that welfare from protecting this endangered species has remained, consistently positive. In addition, this positive value has remained despite the large drop in media attention from the early 1990's. Second, this study examines the value of old-growth forest and related qualities, it does not examine the multitude of other economic and political factors that affect real payments. In other words, this study examines the value, or worth, of these environmental amenities, not the effectiveness of the institutional arrangements in capturing this welfare. Finally, Richardson and Loomis's (2008) meta-analysis of the public's willingness to pay to help protect threatened and endangered species shows that people's willingness to pay has increased from 1983 to 2001. All these factors suggest that, at the very least, the general public gains value from protecting species at risk regardless of external factors.

CHAPTER 6: CONCLUSION

An overarching goal of this study is to aid decision makers in land-use decisions involving local forests. Tangible benefits can be reaped by incorporating the public's preferences in the policy-making arena, as it is this group that ultimately owns the provincial forests. One tangible value associated with local forests is the knowledge that this area is providing habitat to local species, irrespective of use. To this end, this study examined the existence value the general public places on the Spotted Owl. However, we widened the scope to include other relevant, possibly confounding attributes, such as old-growth forest, old-growth dependent species at risk, and different use values. Through a random sample of the general public of the Lower Mainland, we were able to estimate existence value for this group.

The results suggest that the general public places significant value on the existence of old-growth dependent species at risk. However, they do not appear to place conservation over all other values, but instead gain the greatest welfare when both use values (in the form of harvesting and recreation) are balanced with non-use values (in the form of old-growth dependent species at risk). Purely from the perspective of the general public, just over half of the forests in southwest mainland BC should be preserved in old-growth condition.

However, conservation work is rarely certain. Simply informing the general public about the potential outcomes of a plan without communicating the risk involved may not adequately capture the general public's welfare for such decisions. Instead, for policies involving species at risk, it may be beneficial to incorporate the risk involved in such plans, as welfare appears to be path dependent.

With respect to decision making under risk, the purpose of this project is to provide a useful starting point for further work involving risky outcomes. The results from this project further this goal in two important ways. First, the results suggest that the public are capable of understanding probabilistic outcomes (exemplified by the significance of the ‘probability’ attribute), and second, are willing to make choices in the presence of risky outcomes (as exemplified by the negligible dropout rate during the uncertainty choice sets). This information should help researchers and land-use decision-makers not to shy away from incorporating probabilistic outcomes in their management or research plans when involving the general public. Furthermore, hopefully this research will provide a useful stepping-stone for further work into incorporating risk into the general public’s preferences for public goods.

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APPENDICES

Appendix A: Total Harvestable Area Attribute and Associated Levels

Levels used for the 'Total Harvestable Area (compared to status quo)' Attribute

	Amount Harvestable in Old-Growth			
Amount of Old-Growth (hectares)	**33%**	**20%**	**10%**	**0%**
150,000	n/a	n/a	n/a	25% more
300,000	10% more	10% more	5% more	5% more
400,000	No Change	5% less	10% less	10% less
600,000	20% less	30% less	35% less	40% less
800,000	40% less	50% less	60% less	70% less
1,000,000	60% less	75% less	90% less	100% less

n/a = not applicable. 150,000 hectares of old-growth represents the parks and protected areas in southwest mainland BC; therefore, harvesting of any level is not permitted.

Appendix B: Web Link to Survey

The internet survey instrument has been permanently archived at the following web address: http://www.oldgrowth.rem.sfu.ca/index.php?id=ws&ftouch=remmers.

Appendix C: Postal Codes used to Target Respondents

Postal Codes used for Targeting Respondents.

Area	First 3 Digits of Postal Codes
ABBOTSFORD	V2S, V2T, V3G, V4X
BURNABY	V5C, V5G, V5H, V5J, V5A, V5B
CHILLIWACK	V2P, V4Z, V2R
COQUITLAM	V3J, V3K
DELTA	V4L, V4M, V4G, V4K, V4C, V4E
LANGLEY	V2Y, V2Z, V3A, V4W
MAPLE RIDGE	V2W, V2X, V4R
MISSION	V2V, V4S
NEW WESTMINSTER	V3L, V3M, V3N, V5E
NORTH VANCOUVER	V7N, V7P, V7R, V7L, V7M, V7J, V7K, V7G, V7H
PITT MEADOWS	V3Y
PORT COQUITLAM	V3B, V3C, V3E
PORT MOODY	V3H
RICHMOND	V6Y, V6V, V6W, V7A, V7E, V6X, V7B, V7C
SQUAMISH	V8B
SURREY	V1M, V3S, V4N, V3V, V3W, V3X, V3R, V3T
VANCOUVER	V7X, V5T, V5V, V6H, V6J, V6M, V6N, V5M, V5N, V5P, V6R, V6S, V6T, V5K, V5L, V6P, V5W, V5X, V5R, V5S, V7Y, V5Y, V5Z, V6K, V6L, V6B, V6E, V6G, V6Z, V6A, V6C
WEST VANCOUVER	V7S, V7T, V7V, V7W
WHITE ROCK	V4A, V4B, V4P

Appendix D: Full Model Parameter Estimates

Part-Worth Utilities for the 2-Class Model under Certainty and Risk (Full Model)

	1-Class		2-Class			
	Overall (n=949)		Preservationist (n=629)		Bottom-Line (n=320)	
	Certainty	Risk	Certainty	Risk	Certainty	Risk
OG/Com Forest (q)	-0.0325 (0.0035)***	-0.0152 (0.0058)***	-0.0370 (0.0044)***	-0.017 (0.0079)**	-0.0568 (0.0114)***	-0.0173 (0.0121)
Comm Rec	-0.3047 (0.0879)***	-0.1719 (0.1518)	-0.4688 (0.1104)***	-0.3768 (0.2064)*	0.2155 (0.2404)	0.2237 (0.3158)
OG Rec (q)	-2.3620 (0.882)***	-2.2431 (1.5508)	-3.1442 (1.1045)***	-1.2648 (2.1491)	-0.0162 (2.5549)	-5.256 (3.0868)*
Amt Har	0.4581 (0.1521)***	0.4841 (0.2844)*	0.4597 (0.1879)**	1.0008 (0.3917)**	1.2221 (0.4588)***	0.2554 (0.5933)
# SPOW Breeding Pairs	0.5070 (0.0494)***	0.353 (0.1022)***	0.7104 (0.065)***	0.3841 (0.1484)***	0.1013 (0.1540)	0.5539 (0.1909)***
SAR	0.2989 (0.0266)***	0.1012 (0.0508)**	0.3495 (0.0319)***	0.1134 (0.0696)	0.4346 (0.0883)***	0.1546 (0.1031)
Tax Increase	-0.3034 (0.0373)***	-0.3536 (0.055)***	-0.2342 (0.0457)***	-0.3754 (0.074)***	-1.6191 (0.1709)***	-0.8012 (0.1307)***
Intercept	0.1270 (0.0701)*	0.4499 (0.1467)***	1.4593 (0.1057)***	1.3428 (0.2016)***	-0.3747 (0.2009)*	-1.0527 (0.3195)***

(q) Attribute is quadratic coded (all other parameters are linear)

***Significantly different from a parameter estimate of 0 at the 1% level

**Significantly different from a parameter estimate of 0 at the 5% level

*Significantly different from a parameter estimate of 0 at the 10% level

( ) Represents Standard Error