The Economics of Protecting Old Growth Forest: An Analysis of Spotted Owl Habitat in the Fraser Timber Supply Area of British Columbia

Final Report

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Executive Summary

The spotted owl is one of British Columbia's most endangered species and its population is dwindling as logging continues in the coastal old growth forests upon which it depends for survival. Many other species depend on this habitat, some of which are endangered as well, and old growth forests provide a host of other benefits to humans. The two major land use options at issue are logging or protection of these old growth habitats. Protection of old growth forest carries an opportunity cost in terms of the foregone surplus (producer surplus or economic rent) from timber harvesting. However, the harvesting of old growth timber carries an opportunity cost in terms of other foregone values, such as certain recreation opportunities, stored carbon and ecosystem services (e.g. watershed protection).

The goal of this study was to take a first step towards a rigorous examination of the main land use options for coastal old growth forest with the intent of determining which one is optimal for society. We do not estimate the value of all costs and benefits associated with the different land use options; instead, we focus on estimating the forest values related to timber, non-timber forest products, recreation and carbon sequestration/storage. We do not attempt to estimate other ecosystem services such as watersheds, nutrient cycling, and control of soil erosion. The study assesses the opportunity costs of preservation of old growth forests with adjustment for these selected potential benefits from preservation. As such, the study is concerned with spotted owl conservation but not exclusively so.

The study methodology involves an economic analysis of preserving old growth forest habitat, based on welfare economics criteria. We were able to use forest data generated from a spatio-temporal model designed by Gowlland Technologies Ltd. and forest management scenarios previously designed by the Canadian Spotted Owl Recovery Team, Cortex Consultants and Gowlland Technologies for their recent report, *A Framework to Support Landscape Analyses of Habitat Supply and Effects on Populations of Forest-dwelling Species: A Case Study Based on the Northern Spotted Owl.*

Our study considers a specific forest area, the Fraser Timber Supply Area (TSA), which is located in southwestern Bristish Columbia to the east and northeast of Vancouver. We estimated the *net forest value*, or total value generated through timber harvesting, non-timber forest products, recreation opportunities and carbon sequestration/storage, under different management scenarios. There is a baseline scenario, which is similar to the current management plan in the Fraser TSA, and two preservation scenarios that involve increased protection of old growth forests. The baseline scenario entails forest management practices that only include the minimum spotted owl habitat preservation guidelines laid out by the Spotted Owl Management Inter-Agency Team in their Spotted Owl Management Plan (SOMIT, 1997). Both of the preservation scenarios stipulate an increase in habitat compared to the baseline scenario, but differ slightly in where the protected areas would be located. One preservation scenario involves protecting all existing spotted owl habitat, regardless of how fragmented the areas may be, and the second scenario involves protecting contiguous territories used by spotted owl, even if some of the areas

have not yet reached the height and structural requirements to constitute spotted owl habitat.

The net forest value estimates are present values for a stream of annual benefits over a 100 year period. Once the net forest values are estimated for each of the three scenarios, the *opportunity cost* associated with implementation of either of the two preservation scenarios is calculated as the difference in net forest value between the preservation scenario on question and the baseline scenario. We include sensitivity analyses for many of our parameter assumptions, such as log prices, harvesting costs, the shadow price of carbon and the choice of discount rate for adjusting future values.

Our results suggest that under a broad range of parameter assumptions there would be a net benefit rather than an opportunity cost associated with increased preservation of old growth forests. In other words, the benefits of preservation in terms of increased recreational opportunities, non-timber forest products, and carbon sequestration and storage outweigh the costs in terms of lost producer surplus from timber harvesting. The only exception occurs when log prices are allowed to rise in future and a low value for sequestered carbon is used; in this case, the opportunity cost turns positive. For most set of assumptions, however, our estimates indicate that there would be a net gain to society by preserving more old growth forest in the Fraser TSA.

Further research is needed to estimate other benefits from preservation of old growth that were not estimated in this report, such as ecosystem services other than carbon sequestration (e.g. watershed protection values) and non-use values such as existence, cultural, spiritual and historical values. However, inclusion of these other values would only strengthen the argument in favour of increased preservation of old growth habitat in the Fraser Timber Supply Area.

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Acknowledgements

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List of Acronyms

AAC	annual allowable cut
BCR	benefit cost ratio
BEC	biogeoclimatic ecosystem classification
CBA	cost benefit analysis
CFD	Chilliwack Forest District
CFR	Coast Forest Region
COWSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSORT	Canadian Spotted Owl Recovery Team
LTAC	long term activity centres
NPV	net present value
NTFP	non-timber forest products
RUD	recreational user day
SELES	Spatially Explicit Landscape Event Simulator
SOMP	Spotted Owl Management Plan
SORT	Spotted Owl Recovery Team
TAMM	Timber Assessment Market Model
TEV	total economic value
TFL	Tree Farm License
TSA	Timber Supply Area

1. Introduction

The spotted owl is close to extinction in BC, yet logging continues in spotted owl habitat. Two major land use options are at issue: logging of forests containing spotted owl habitat or protecting spotted owl habitat. Although the perceived costs of foregoing logging appear to be high, there are few economic studies that have examined these two land use options in BC in sufficient detail to determine which best meets society's interests, and of studies that exist most are out of date. Beyond the moral and ecological arguments to protect spotted owl habitat, there may be an economic argument as well. Alternatively, protecting spotted owl habitat may impose substantial and even prohibitive economic costs on society.

Spotted owls are now considered 'endangered' by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and are classified as 'red listed' by the BC Conservation Data Centre.[1] A Spotted Owl Management Plan (SOMP) was established in 1997 to manage some prime old growth timber areas containing spotted owl habitat for conservation, but only "as long as their impact has no more than approximately a 10% reduction in long term timber supply" (SOMIT 1997, p2). Despite these measures, owl numbers continued to decline by as much as 67% from 1992 to 2002, an annual rate of 10.4%. As a result, a Spotted Owl Recovery Team (SORT) was re-established in BC to develop a Recovery Strategy and Action Plans (Pierce Lefebvre Consulting, 2005). Our study builds on the work of the SORT by taking physical data from their modeling that describes the impacts of various management scenarios and subjecting this data to economic analysis. Ultimately, the study is the result of an extensive literature review and collaboration with representatives from the sponsoring agencies, together with members of the SORT and BC Government, who kindly provided the modeling data.

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[1] Red listed species are those that are considered threatened, endangered, or extirpated in British Columbia. Species are considered extirpated if they exist only outside of the wild; endangered species are considered to be facing extirpation or extinction; and threatened species are considered likely to become endangered.

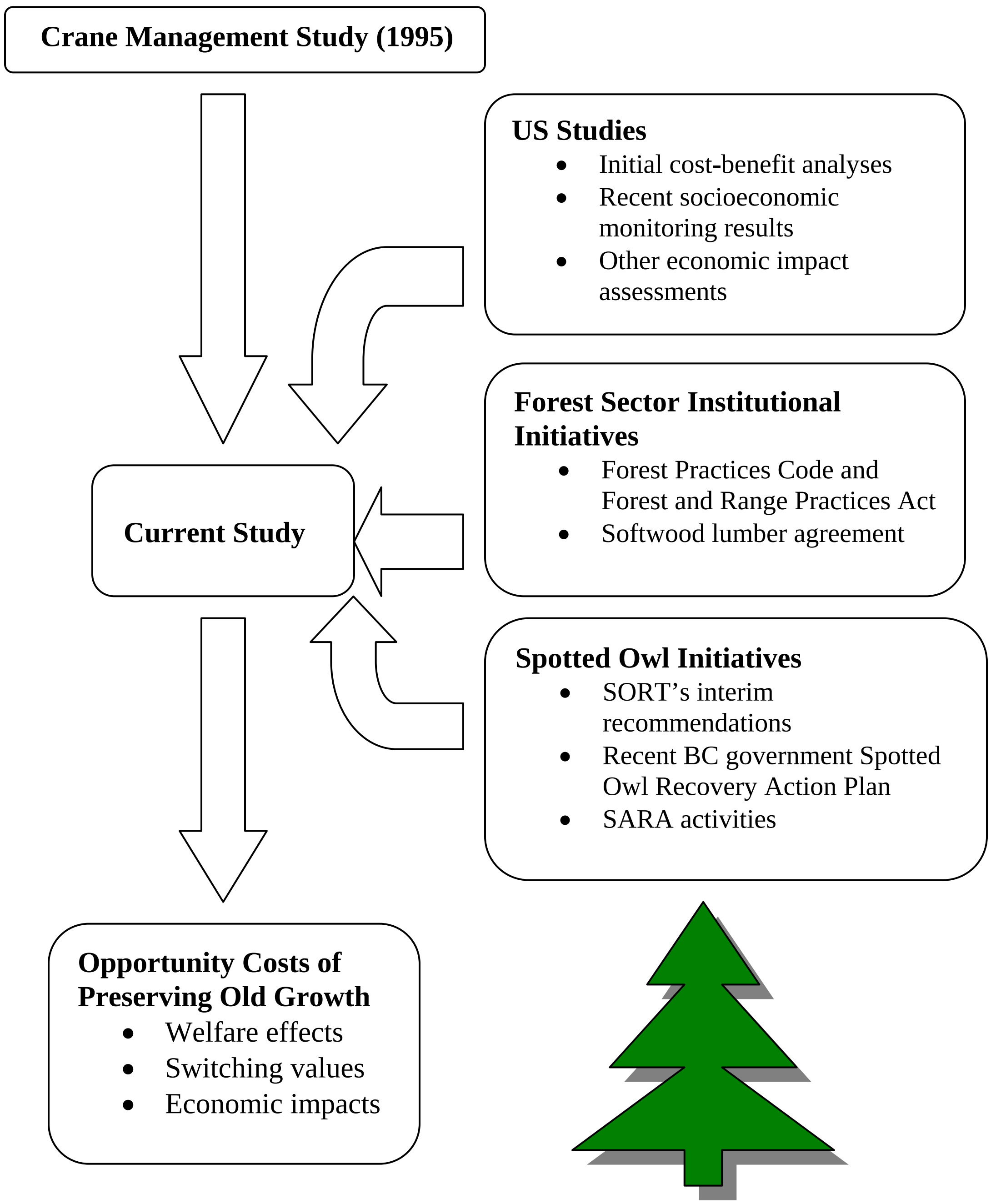
The study presents an assessment of the opportunity costs of protecting selected areas of old growth forest in BC, together with consideration of selected use benefits from forest protection. As such, it is concerned with spotted owl conservation but not exclusively so. Since old growth forest contains many species (some endangered as well), and provides many ecosystem services, the benefits from protecting the forest are more than just those associated with the spotted owl. The study methodology involves an economic efficiency analysis of preserving spotted owl habitat in old growth forests, based on welfare economics criteria. No attempt is made in this study to value the benefits of conserving the spotted owl itself, nor to capture the economic values associated with several important ecosystem services such as watersheds, nutrient cycling, or control of soil erosion. Other non-use values such as cultural values and biodiversity are also not included. Therefore, the study does not constitute a full cost-benefit analysis of land use alternatives. Further research is now underway by the authors to address some of these shortfalls.

As noted in Figure 1, the study represents an attempt to improve on the Crane Management Report (1995), which was an earlier attempt to assess the costs to society of setting aside old growth habitat of the spotted owl in BC and is reviewed in a subsequent section. In doing so, we not only wish to improve on some of the methodological approaches but we must also take into account the changing institutional and economic environment and new knowledge that may be available. These latter considerations are evident in the figure on the right hand side. Here, we acknowledge the insights that can be gained from a review of the U.S. experience in analyzing the economic effects of spotted owl-related timber withdrawals, the ongoing SORT process and the changing forest institutional framework (e.g. Forest Practices Code and softwood lumber dispute with the U.S.).

In the following chapter we examine the background for the study, concentrating on the US experience first, and then follow this with analysis of the Canadian experience and a review of the Crane Study addressing the problem in BC. We complete the chapter with a description of our study area, which consists of the Fraser Timber Supply Area in Southwestern BC. Following this we present the general methodological approach in Chapter 3 – applied cost-benefit analysis – and discuss the total economic value approach for structuring values and the various data sources we used. We provide a summary explanation of our assumptions and parameters in Chapter 4, organized according to the timber and other benefits/costs we consider. The findings of our analysis are presented and discussed in Chapter 5. We conclude with a brief consideration of the implications of our findings and areas for future research.

Figure 1

The Economics of Protecting Old Growth Forest Study Approach



2.0 Background and Literature Review

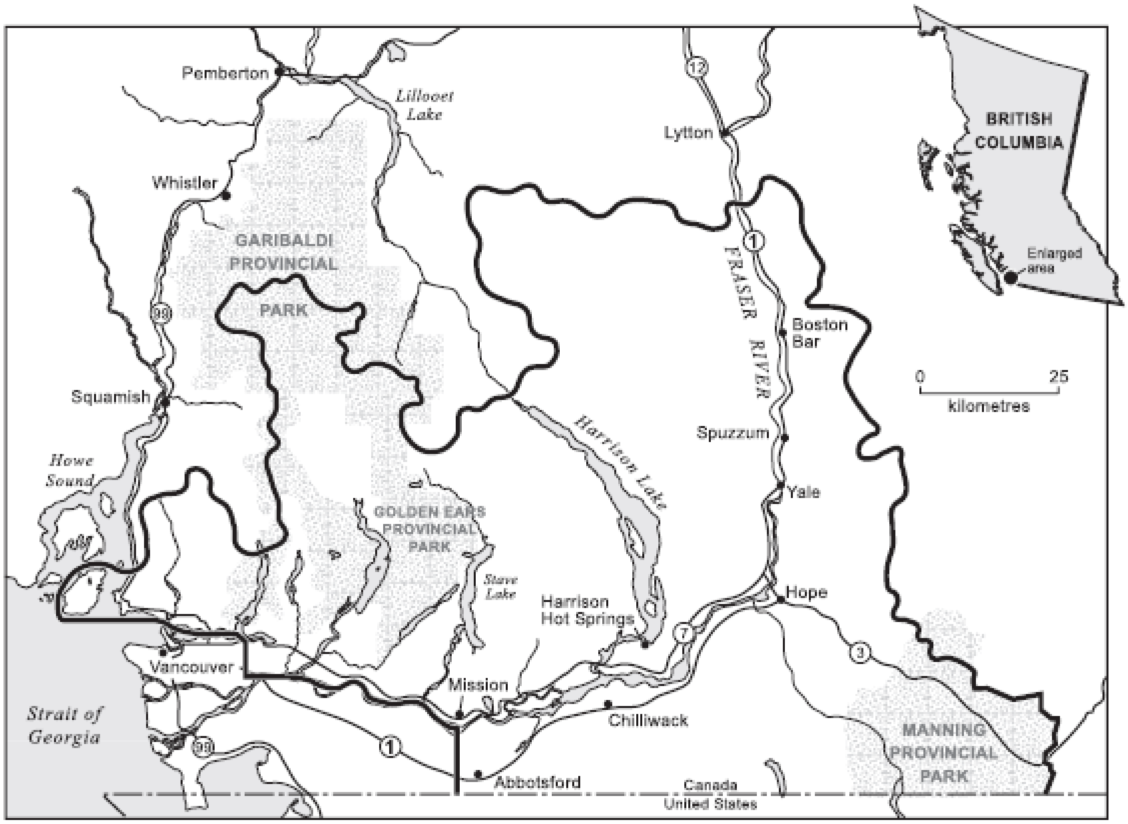
This section presents selected background information that helps to set the context for the study. A concern for the spotted owl and its old growth habitat is not unique to British Columbia, since the spatial range of the species extends throughout the old growth forest region of Western North America. Indeed, the issue of endangered species conservation and the spotted owl has been a controversial public policy in the US Pacific Northwest for several decades, reaching a climax some years ago. Thus, an effort to assess economic features of the situation here in BC must be seen within this broader continental perspective. We start with an overview of the US experience.

In addition, the study of spotted owl and old growth conservation is not new to BC. A major study of this public policy problem was initiated in the mid 1990s by the BC government (Crane Management Study, 1995) and this study represents a stepping stone or reference point for our work. Finally, a description of the study area is provided since we were neither concerned with the entire range of the spotted owl, nor the entire distribution of old growth forest in BC. Instead, the study is limited to the Fraser Timber Supply Area (TSA), which is roughly bounded by Manning Park to the southeast and Howe Sound to the west, and stretches north into Golden Ears Provincial Park and just past Nahatlatch Lake Provincial Park on the northeast. See Figure 2 for a map of the Fraser TSA.

In reviewing the economics literature on spotted owl protection and, by inference, its old growth habitat a few words on methodology are warranted. Further discussion of the methods used in our study is reserved for the next chapter. Cost-benefit analysis involves a comparison of the costs and benefits of projects. Total costs and benefits are compared to determine whether or not a project should go ahead (to harvest timber or not). For the spotted owl case, cost-benefit analysis involves estimating the costs and benefits of a proposed conservation policy, in which benefits are the value of spotted owls and their old-growth habitat, and costs are the foregone economic profits and income that could have been generated from the timber harvest. For

Figure 2

Chilliwack Forest District & Fraser Timber Supply Area



The Fraser TSA consists of all land within the Chilliwack Forest District managed by the BC Forest Service. Source: Paul DeGrace, Coordinator, Environment Co-operative Education, Department of Geography, Simon Fraser University.

simple cost-benefit analysis, the decision criterion is that the benefits must outweigh the costs for the project to proceed on economic grounds. Some decision criteria require the benefit-cost ratio to be greater than one, while others require a lower benefit-cost ratio if intangible and uncertain benefits have been left out of the analysis. In some cases, a threshold or 'switching value' approach is used to determine what value these intangibles must take in order to tip the balance in favor of conservation.

Several studies have used dynamic optimization as the modeling basis for their economic analyses. Dynamic optimization models estimate an optimal resource allocation using dynamic functions to quantify competing use values of forests. The commercial value of forest harvesting varies over time with changes in demand and supply for wood and wood products, and growth of timber volume. Use values of forest preservation vary depending on income elasticity of demand for wilderness and protected species, and changes in preferences for, and global supply of, wilderness areas.[2] Spotted owl populations are also dynamic, their survival being a function of the population growth rate and a changing environment.

2.1 U.S. Experience

Given the longer experience with policy implementation to conserve spotted owls and a generally interventionist approach, there has been more academic study of the consequences of such actions in the US. These studies can be divided into those concerned with assessing the net benefits or cost effectiveness of specific policies for spotted owl conservation and those dealing with the economic impacts of conservation policies on the regional economy. While there are additional economic studies of the conservation of old growth forests in the US that are not strictly related to the spotted owl, we do not review these here.

2.1.1 Economic Analyses of Spotted Owl Protection

Hagen et al. (1992) carried out a cost-benefit study using contingent valuation to estimate the benefits of conservation policy for old growth forests and the spotted owl. The survey attempts to capture recreation value (part of use value), option value, and existence value, but does not attempt to capture other use values such as fish habitat or water quality (so does not capture total benefits).[3] The authors estimate the average amount each household would be willing to pay

[2] The income elasticity of demand for wilderness is proportional change in the quantity of wilderness demanded as a result of a change in income.
[3] For a discussion of the different components of value mentioned here see the discussion of total economic value in chapter 3.

each year to support conservation policy. They determine a threshold price as the starting value of a stream of growing discounted benefits (willingness to pay increasing with income), the net present value of which equals the present costs of preservation. They estimate a threshold price of $3.39 (the minimum the average household willingness to pay per year for conservation policy would have to be to make conservation worthwhile).

The costs of preservation are the value of timber taken out of the market as well as loss of consumer welfare due to higher prices caused by the decrease in timber supply. This price effect must be the net long run effect (depends on long run demand elasticity) after timber substitutes have been fully utilized. The authors use cost estimates from Mead et al. (1990), which are not long run.

The authors find a benefit-cost ratio for the conservation policy of between 3.5 and 42.5, depending on the assumptions made and the conservation plan. The policy evaluated in this paper allowed for a decline in the owl population, while in BC a decline would likely lead to extirpation. In BC the opportunity costs of conservation could be much higher because a larger reduction in timber harvest may be needed immediately to increase the probability of survival of the spotted owl. However, given that there may be a higher risk premium in BC due to the high likelihood of spotted owl extinction, the benefits could also be higher (higher option and existence values).

Using a dynamic optimization approach, Montgomery and Brown (1992) built a marginal cost curve[4] for probability of spotted owl survival. Habitat is the only input into the production function for spotted owl survival, a function that describes the relationship between habitat availability and spotted owl survival. The relationship between owl survival and the marginal opportunity cost (measured as foregone timber harvest) is built around four issues: (a) probability of survival as a function of habitat capacity, (b) minimum acreage necessary for one owl pair to survive as a function of habitat quality in the protected area, (c) loss of timber inventory as a function of timber quality in the protected area, and (d) the change in producer and consumer surplus resulting from a reduction in timber harvest.

The authors determine the function relating habitat quality to owl survival using a survey of biologists and a population dynamics simulation model. To determine habitat acreage requirements, the authors divide the study area up into broad categories based on biogeoclimatic features. Acreage requirements are for one owl pair, but allow for a 25% overlap between adjacent pairs. The authors do not account for elevation or habitat fragmentation, and use only rough estimates of suitable habitat density to estimate habitat requirements. More detailed information, such as map measurements of habitat quality in small blocks, would provide better estimates for a spotted owl study. To determine the likely reduction in timber inventory, the authors use map measurements to categorize public land according to suitability for timber

[4] The marginal cost curve for probability of owl survival describes the increase in the opportunity cost of owl conservation when the probability of spotted owl survival rises by one percentage point.

harvest.
To estimate the value of foregone timber inventory and the changes in producer and consumer welfare, the authors use a partial equilibrium Timber Assessment Market Model (TAMM), which does not incorporate related non-timber markets or export/import markets. TAMM models a stumpage supply curve and a derived demand curve for stumpage by wood product manufacturers. Since the model analyzes a closed economy, supply shifts due to habitat preservation decrease supply and increase the equilibrium price. Total surplus decreases, with wood product manufacturers and consumers losing welfare, private producers gaining welfare (they produce more at a higher price), and producers on public land gaining or losing welfare depending on elasticity of demand. In the long run, the model predicts a decrease in local demand for logs as some mills will close and others will look elsewhere for lower priced logs. This shift in local demand will offset the original increase in log price and changes in producer and consumer surplus, as well as generate positive welfare changes to the regions now filling in the reduction in local supply.

In a further study of the spotted owl, Montgomery et al. (1994) define the probability of owl survival as the probability that the owl population is above some minimum threshold at the end of a specified time horizon, given the carrying capacity of the protected owl habitat, measured in owl pairs. Their model defines a price, or opportunity cost, for each tract of land, as the ratio of the tract's annual log supply to its carrying capacity for spotted owls. From this they derive functions for welfare in wood products markets and probability of survival of the owl, using a population dynamics simulation model. The population model accounts for habitat clustering, a search function for dispersing owls, environmental stochasticity, and density dependence. The model does not incorporate the Allee effect, so a minimum population threshold is set, below which the owl is assumed to become extinct.[5] Data for habitat suitability was gathered from biologists. From these estimates, the authors derive a marginal cost curve in terms of million board feet per owl pair.

Calculations of welfare loss in wood products markets were derived from the Timber Assessment Market Model (see TAMM above), from which a relationship was estimated between welfare loss and the timber harvest reduction required for habitat preservation. The welfare loss was calculated as the present value of the stream of welfare impacts within relevant markets over the specified time horizon of 150 years. The final step was to create a marginal cost curve for probability of species survival in terms of welfare loss. The authors do not estimate a marginal benefit curve, but do evaluate three proposed spotted owl recovery strategies, with different associated survival probabilities, within their model. The three proposals are estimated to lead to survival probabilities of 95%, 91%, and 82%. The authors estimate a marginal cost per percentage point of probability of $3.8 billion to move from the first proposal to the second, and $1.4 billion to move from the second proposal to the third.

[5] The Allee effect refers to the idea that population density and population growth rate tend to be positively correlated. Therefore at very low population densities the population growth rate can be very low, presumably because the probability of finding a mate is lower.

2.1.2 Economy-wide Effects of Spotted Owl Protection in the Pacific Northwest

The consequences of reductions in timber supply due to attempts to protect the Northern spotted owl have already been experienced in the Pacific Northwest. The listing of the spotted owl as an endangered species in 1990 in the United States prompted legislative action to protect old growth forests beginning in the early 1990s. California, Oregon, and Washington experienced significant reductions in allowable harvest levels of old growth timber on federal land under the legislated Northwest Forest Plan which was finalized by 1994. The outcome of this reduction can provide valuable insight into the possible consequences of increasing preservation of old growth forests in the Fraser TSA.

Harvest levels on US federal forest land in the 1990s were 92% less than in the 1980s. Overall harvest levels went from 15.7 billion board feet in 1988 to 8.3 billion board feet in 1996, a reduction of about 17.5 million cubic metres (Niemi et al., 1999). This drastic decline was also accompanied by industry instability, the loss of about 30,000 jobs, and over 300 mill closures. Despite the shrinking forest industry, the Pacific Northwest economy grew substantially, with 47 new jobs being created for every forest industry job lost (Power, 2006). According to a recently released report on the impacts of the Northwest Forest Plan by Charnley et al. (2006), the change was not spread evenly, however, as some communities experienced socioeconomic deterioration while others experienced a boom.

Charnley et al. (2006) report that the 30,000 forest industry jobs lost between 1990 and 2000 occurred because of both the reduced harvest and because of restructuring in the wood processing sector. Of the 30,000 job losses, about 19,000 were lost before 1994 and about 11,400 of these were attributable to reduced harvest levels. Of the 11,000 jobs lost after 1994, only about 400 can be attributed to reductions in federal timber harvesting. The remainder of the lost jobs was largely in the wood processing sector, and was a result of changes in mill technology and changes in demand for wood products.

The link between local timber supply and local mill employment is not clear for three reasons: first, timber is sold to the highest bidder, so local timber does not necessarily supply local mills; second, timber harvest reductions were on federal land only; and third, technological changes in mill production reduced the demand for labour.

Using census data, USFS researchers estimated socioeconomic changes between 1990 and 2000 in communities within the Northwest Forest Plan area. The average number of people who completed high school increased from 77% to 83%; the number of people with a university degree increased from 15% to 19%; median household income increased from $35,214 to $42,351; the poverty rate fell from 13% to 12%; and the unemployment rate remained unchanged at 7.3%. These changes were not evenly distributed, however. Using a socioeconomic well-being index devised from education and employment related measures, the USFS estimates that 37% of communities experienced a decline in well-being, 27% experienced little or no change, and 36% experienced an increase in well-being. The degree and direction of change for communities caused by the Northwest Forest Plan depended on how strongly a community relied, by 1990, on logging, and how much of the local logging occurred on federal land. Some communities had already experienced a significant reduction in logging employment in the late 1970s and 1980s, while others had maintained a relatively strong logging sector until the implementation of the Plan (Charnley et al., 2006).

There are three main reasons that the decline in logging did not have negative effects on the Pacific Northwest economy as a whole. First, since the Northwest Forest Plan only affected federal land, the reduction in logging was compensated by increases in logging on other lands, such as private land, in response to the increasing price of timber. Second, the forest industry had been shrinking in economic importance in the region since the early 1980s. Between 1979 and 1989, the decade before any legislated logging reductions, the timber products industry in the Pacific Northwest had lost 27,000 jobs and wages had declined by almost 20% (Niemi et al., 1999). Third, there was increasing demand in the US, and especially in the Pacific Northwest, for preserved wilderness areas. People are increasingly attracted to preserved areas not only for short-term recreational purposes, but also for permanent residence. The forest product industry was only a small part of the Pacific Northwest economy by 1990, so only a small proportion of the population, primarily residing in small, forest-dependent communities, felt significant negative effects. People who lost jobs in the forest industry but lived near metropolitan areas, or in small but less forest product dependent communities, were more easily absorbed by other growing sectors.

2.2 Canadian Experience

As noted above, the Canadian experience with policy intervention and, consequently, academic analysis of the protection of spotted owl is more limited than in the US. Instead, there has been some study of the broader economics of conserving old growth forests and only one study of the economics of protecting spotted owl. However, this latter study (Crane Management, 1995) is important for the current study and reviewed in some detail below.

2.2.1 Economic Analyses of Conserving Old Growth Forests

Van Kooten and Bulte (1999) use a dynamic optimization model to estimate how much old growth forest society should maintain to maximize the net value of present and future benefits. The optimal old growth stock occurs where the marginal present value of benefits of preservation[6] equals the sum of the immediate benefits of old growth harvest plus the marginal

[6] The marginal present value of benefits of preservation is the incremental increase in the present value of preservation benefits from an extra hectare of preserved area.

present value of future forest plantation production. At this point the benefits and the opportunity costs of preserving another ha of old growth are balanced. To estimate the marginal benefit function, the authors estimate the annual benefit ($ per hectare of mature forest) of non-timber forest products (mushrooms, plants, biodiversity prospecting, and First Nations subsistence); recreation (hunting, fishing, wildlife viewing, camping, and hiking); nonuse values (existence value, or willingness to pay for the existence of old growth regardless of use); and carbon uptake. They estimate the total benefit but do not attempt to estimate the slope of the function (the marginal benefit). The benefits of harvesting and subsequent plantation production are commercial production and carbon uptake.

The authors estimate that the optimal amount of old growth forest to preserve is between 25% and 60% of current stock, depending on: (a) how carbon uptake is accounted for, (b) the extent to which non-BC residents value BC old growth forests, and (c) the slope of the marginal benefit curve. Inclusion of endangered species preservation in the marginal benefit function may increase the optimal holdings of old growth forest. This paper assumes that additional hectares of preserved forests will be of the lowest quality, but conservation policy would likely require preservation of higher quality habitat. This may decrease the estimated optimal stock of old-growth forest because of its higher opportunity cost for timber harvest.

2.2.2 Crane Management Study (1995)

The Crane study (Crane Management, 1995) represents the most extensive economic analysis of spotted owl management options in Canada (that we are aware of). It was followed up by a published paper by Stone and Reid (1997) that summarizes the economic analysis in the Crane report; we use this paper as the basis for our description of the cost-benefit analysis carried out in the Crane study. The study estimated the opportunity costs of each of the six management options laid out by the Canadian Spotted Owl Recovery Team. The six management options range from full to no protection of Spotted Owl habitat, and the likely Spotted Owl status (de-listed, vulnerable, threatened, endangered, or extirpated) associated with each option is estimated by a panel of independent experts. The authors mention but do not attempt to estimate non-timber costs of preservation: some species thrive in second growth forests (e.g. the Barred Owl), and a greater range of recreation activities may be possible in forests with a more open understory.

In the study, the value of foregone timber harvests is estimated by calculating the net flow of timber revenue and costs (including regeneration costs). For each management option, the net commercial value is estimated for specific time periods, then discounted and summed to generate a net present value of timber harvests over a 400 year period. The authors use a computer model that simulates harvest plans and generates harvest forecasts and changes in forest inventory. To estimate the value of timber in the Spotted Owl management area, the authors calculate a conversion value, or the selling price of logs using data from the Vancouver Log Market. From this they derive average monthly values based on grade and species. Harvesting costs (e.g.

transportation, wages, depreciation, and insurance) are gathered through the provincial timber appraisal system of the Ministry of Forests Revenue Branch.

The authors assume that a reduced supply of BC timber for Spotted Owl management would not affect either BC or world timber prices; however, they acknowledge that a continued reduction in world supply of old growth forest timber may have a significant real price effect. They allow for a 0.34% annual increase in the real price of timber for the first 50 years. The authors also allow for an increase in costs due to the introduction of the Forest Practices Code, which introduced stricter standards around harvesting, road construction, and silviculture. They allow for a \$5 per m^3 increase in harvesting costs over a five year period.

Using a discount rate of 4%, the authors estimate the opportunity costs for each management option as the difference in net present value between the management plans and no spotted owl management plan. They find opportunity costs from \$1,223 million for full protection (no harvesting), to between \$20 and \$200 million for management plans that involve various degrees of allowable harvest. They perform a sensitivity analysis by varying the discount rate, price and cost increases, and find that the value of the opportunity cost is most sensitive to changes in the discount rate.

The original Crane Report used a multiple accounts framework to cover all direct and indirect impacts of a change in timber harvests. At the regional level, accounts considered are economic development, community structure, and First Nations issues. At the provincial level, economic development, the environment, and government revenue accounts are analyzed. The economic development analysis measures the total amount of fluctuation in the economy generated from the change in timber supply, including direct, indirect, and induced impacts.[7] Direct changes in employment and income are estimated from licensee employee information, and indirect and induced employment changes are estimated using employment multipliers. Information on forest sector incomes is used to estimate direct income losses, while income impacts for indirect and induced employment changes use an average provincial income multiplier.
Looking this study over, we find that there are a number of assumptions that are open to question. Some examples include the following:

a) There is no consideration of declining timber quality over time; that is, the mix of species harvested and associated stumpage, for a given market price, is assumed to stay constant over time. This assumption seems dubious and needs to be tested.

[7] There are several ways of estimating the economic impact of wilderness preservation. The Timber Assessment Market Model (TAMM) was discussed in the context of dynamic optimization. Waters, et al (1994) use a core-periphery, multiregional, input-output model to estimate the changes in employment resulting from timber harvest cutbacks after spotted owls were listed as endangered. This model estimates the impact of a primary resource shortage on employment in all affected sectors across regions, including urban areas.

b) No externalities from timber harvest are considered (e.g. water quality, downstream fisheries, etc). We have several studies to support inclusion of these costs (Knowler et al., 2003; Loomis, 1988), although we must be careful because of the institution of the Forest Practices Code, which may have reduced their incidence significantly.

c) Similarly, the possible role of depletion has not been considered: if BC is not harvesting sustainably, then timber withdrawals for conservation cannot be treated simply as lost stumpage and employment, as their harvesting would have represented depletion of natural capital and not true income. Of course, this view hinges on the withdrawals not simply leading to increased pressure on remaining forests.

d) No consideration is given to the likely response of timber companies to timber withdrawals; for example, if timber companies respond by accessing higher cost timber, then the true cost of withdrawals is the difference in supply cost and not the loss of the full stumpage. In effect, what happens is that the long term supply stream of timber shifts forward to make up for the withdrawals. This appears not to be discussed in the report.

e) Similarly, how will timber markets respond? The economic cost of withdrawals includes the impact of changes in prices in input markets and on consumers (if timber is used within Canada). It appears most of the timber in the study area is exported and that local mills actually use timber from other regions (Crane, 1995), which may have different implications, but these issues need to be explored and considered correctly. The Crane study simply assumes the impact of withdrawals is too small to have any effect on prices.

In Chapter 3 we describe the benefit-cost methodology that we use in our study. We would argue that many of the shortcomings pertaining to the Crane study described above have been addressed.

2.3 Description of Study Area

The Fraser Timber Supply Area is contained within the Chilliwack Forest District, which is located in the southwestern corner of mainland British Columbia (Figure 2). The Fraser TSA covers approximately 1.4 million hectares, although the current timber harvesting land base includes only 260,000 hectares. The excluded land consists of non-forested or non-productive forest, land not *managed* by the B.C. Forest Service, and land not considered harvestable for a variety of reasons, such inoperability or preservation for wildlife and recreation (Fraser TSA Report, 2003).

The timber harvesting land base consists of 51% Western Hemlock/Balsam Fir, 36% Douglas Fir, 4% Spruce, 3% Cedar, 1% Pine, and other deciduous species (BC Ministry of Forests, 2003). Average species composition of the timber harvest between 1999 and 2005, however, has consisted of 37% Hemlock/Balsam, 37% Douglas Fir, 2% Spruce, 18% Cedar, and 0.3% Pine.[8] About 11% of the current timber harvesting land base is over the age of 250 years, and about 60% is less than 60 years of age. According to the 2003 Fraser TSA Analysis Report, the long-term harvest forecast is to harvest about 1.25 million cubic metres annually, 1 million of which will be old growth for the next two or three decades, after which the harvest will have to switch to primarily managed and naturally regenerated stands. After about 80 years the harvest will consist primarily of managed stands.

Within the Chilliwack Forest District there are numerous mills for chips, log homes, lumber, pulp and paper, shake and shingle, veneer, and plywood. The majority of timber harvested in the CFD is also processed in the district, but only satisfies about 10% of timber demand by mills in the district. The remainder of demand is met by logs brought in primarily from the BC Interior forest districts (BC MOF, 1998).

Logging accounts for 0.56% of employment in the Chilliwack Forest District, while pulp and paper and wood manufacturing account for 4.45% of employment. Tables 2.1 and 2.2 provide a breakdown of direct, indirect, and non-basic employment and income by sector in the CFD. The proportion of employment from logging done within the CFD is even less than 0.56%. Many loggers live in the CFD but work outside of the district, so the number of logging jobs within the district is actually less than 1000 out of the total of over 6000 loggers residing within the district (BC MOF, 1998). Even though wood processing is still important to the economy in the CFD, only a very small proportion of the population in the CFD live in communities significantly reliant on logging for income. Communities most vulnerable to reductions in logging are: Hope, Yale, Spuzzum, and Boston Bar, where about 14% of the community's income comes from the forest sector (Horne, 2004).

Table 2.1

Employment, by Sector, in the Chilliwack Forest District (2001)

[8] Data gathered from the BC MOF Harvest Billing System in 2006

Employment	Direct	Indirect	Nonbasic[9]	Total	% of Total Employment
Logging	3,630	794	1,658	6,082	0.56%
Pulp and Paper	4,337	3,230	3,687	11,254	1.04%
Wood Manufacturing	20,421	5,872	10,585	36,878	3.41%
Mining	4,790	1,855	3,180	9,826	0.91%
Oil and Gas	782	1,395	974	3,152	0.29%
High Tech	51,926	4,210	26,960	83,097	7.69%
Fishing and Trapping	5,080	790	1,767	7,637	0.71%
Agriculture and Food	31,042	6,892	11,350	49,285	4.56%
Tourism	81,124	6,415	21,169	108,708	10.06%
Public Sector	251,700	31,692	112,122	395,515	36.61%
Construction	52,996	15,647	25,939	94,582	8.75%
Film and Sound Production	11,196	2,584	5,399	19,179	1.78%
Other	168,958	13,426	72,810	255,195	23.62%
Non-employment	0	0	121,406	121,406	
Total	687,983	94,804	419,008	1,201,795	100%

Source: 2001 Economic Dependency Tables for Forest Districts

Table 2.2

After Tax Income, by Sector, in the Chilliwack Forest District (2001)

After Tax Income (millions)	Direct	Indirect	Nonbasic	Total	% of Total Employment

[9] Nonbasic employment and income is an estimate of employment and income generated within the district by each sector

					Income
Logging	106.2	25.4	44.3	175.9	0.56%
Pulp and Paper	184.5	108.1	98.4	391	1.24%
Wood Manufacturing	652.9	187.1	282.5	1,122.50	3.56%
Mining	191.5	60.9	84.9	337.3	1.07%
Oil and Gas	32.1	45.2	26	103.3	0.33%
High Tech	1,992.90	146.6	719.7	2,859.10	9.06%
Fishing and Trapping	114.4	25.8	47.2	187.4	0.59%
Agriculture and Food	676.1	224.6	303	1,203.70	3.81%
Tourism	1,475.30	204.5	565.1	2,244.90	7.11%
Public Sector	7,905.10	992.3	2,992.90	11,890.20	37.67%
Construction	1,526.70	531.7	692.4	2,750.80	8.72%
Film and Sound Production	346	82.5	144.1	572.6	1.81%
Other	5,332.20	445.6	1,943.50	7,721.30	24.47%
Non-employment	9,634	0	3,240.70	12,874.70	
Total	30,169.70	3,080.30	11,184.60	44,434.60	100.00%

Source: 2001 Economic Dependency Tables for Forest Districts

3.0 Study Approach and Methods

The previous chapter reviewed several alternative approaches for carrying out the study and discussed empirical studies demonstrating these techniques. In this chapter we describe the methodology used, beginning with the basic cost-benefit analysis framework we adopted. We chose this approach because of its greater ability to make use of our data, together with its suitability for the task at hand. For example, while optimization modelling might provide greater academic rigor it is of less usefulness in assessing fixed production scenarios, as we do here. In addition, we adopted a total economic value (TEV) framework to organize the forest values at risk and adapted this to our study. Since we could not assess all possible values associated with the loss or preservation of old growth forest, the TEV approach enables readers to see our more limited analysis within a broader conceptual framework of values. Finally, we describe the SELES model used to generate timber harvest impacts from the fixed production scenarios we analyse. This model was used by the Spotted Owl Recovery Team (SORT) in developing spotted owl management recommendations, making it particularly suited to our needs. The chapter concludes with a brief discussion of the main data sources consulted in undertaking the study.

3.1 Cost-benefit Analysis: Basic Concepts

Economic analysis is an important element in the evaluation of potential forestry projects, whether these are concerned with creation of protected forest areas, natural forest management, logging or processing. Economists have developed a systematic approach for assessing whether such projects are worthwhile from a national standpoint using cost-benefit analysis. However, it is not the purpose here to review the economics of project assessment *per se,* but to consider the contribution economics can make in assessing the opportunity costs of protection of old growth forests. This is admittedly a more limited task than full project appraisal, but still requires coverage of some basic economic concepts.[10]

3.1.1 With/Without Criteria

In carrying out the assessment we want to measure the opportunity costs of the forest management situation which would have existed if preservation were not undertaken and compare this to the case with preservation. Economists use a *with/without criteria* to refer to the case with and without a given project. For the Fraser TSA, it seemed plausible to use a projected harvest management plan as the "without" situation and to construct or obtain scenarios of old growth withdrawals as the "with" situation. There are different ways to define the withdrawals scenarios: what to preserve could be defined by age class (age class 8 and 9, or 7, 8, and 9), and possibly further defined by elevation or species composition.[11] Instead, we were able to use fixed production scenarios analyzed by the Spotted Owl Recovery Team (SORT). Thus, explicit recognition can be given to alternative management regimes rather than simply assuming that all old growth timber is withdrawn from production.

3.1.2 Benefits and Costs in Different Time Periods (Discounting)

With the long gestation and productive life of many tree species, the issue of time and discounting is an important one in forest economics. When economists evaluate benefits and costs which extend over more than one time period they take this into account with a *discount rate*. The discount rate is used to weight benefits and costs occurring in different time periods, similarly to the use of an interest rate to calculate interest payable on bank accounts. Since we would prefer having a sum of money in the present to waiting until a later time period for it, we must place a greater emphasis (weight) on current values than on ones in distant periods. To accomplish this, we use a discount factor which incorporates the discount rate selected. Weighting a series of benefits or costs and summing these yields a *present value*. The challenge arises in selecting an appropriate discount rate. Economists generally consider two approaches, although there are several variations on this theme.

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[10] Economic analysis is concerned with whether forest management activities represent an efficient use of society's resources. This involves assessing the opportunity costs of forest management. Environmental impacts can be a very important consideration in an economic analysis since they constitute part of the opportunity costs of our actions. If we damage or destroy a forested area while logging it, then the lost possibilities for recreation in the forest, for example, represent an economic cost of that logging. In comparison to financial analysis, an economic analysis would consider: (a) market prices of production and harvesting inputs, adjusted for any taxes/subsidies that distort markets; (b) costs of replanting, maintenance and protection; (c) environmental costs of harvesting activities; and, (d) any depletion effects due to over harvesting of the growing stock.

[11] Age class 1 (1 – 20 years), age class 2 (21 – 40 years), age class 3 (41 – 60 years), age class 4 (61 – 80 years), age class 5 (81 – 100 years), age class 6 (101 – 120 years), age class 7 (121 – 140 years), age class 8 (141 – 250 years), age class 9 (251+ years)

In the first case, they must make allowance for the fact that individuals view more distant benefits and costs differently than more immediate ones. Generally, the pattern observed is that individuals prefer costs to be postponed and benefits to be received as soon as possible. This situation is referred to as time preference. To account for time preference in valuation and cost-benefit studies, economists use a form of discount rate referred to as a social time preference rate. A second approach looks at the opportunity cost of capital invested in an activity, which refers to the profits which could have been obtained by investing this capital in the next best possible opportunity. These foregone profits represent the cost of the capital employed in the project. The net benefits of a project must at least equal these foregone profits if it is to be considered viable. Thus, when weighting benefits and costs in different time periods, the opportunity cost of capital is used as the discount rate to reflect what the activity should be generating in terms of benefits, if it is to be an attractive investment. Discussion of the social discount rates selected for use in the current study is deferred to the next chapter.

3.1.3 Decision Criteria

In CBA, we calculate the present values of benefits and costs, and take the difference between the two, the *net present value (NPV)*, as an indicator of an action's viability in economic terms.[12] An NPV greater than zero implies the action returns positive net economic benefits. We can instead calculate the present values of benefits and costs and place these in a ratio, referred to as a *benefit-cost ratio (BCR)*. A BCR greater than one indicates that benefits exceed costs and that the action is considered, in balance, favourable. For this study, such approaches are not appropriate since we are not considering the full benefits from preservation and we have not defined a specific project proposal. Instead, the study represents a more limited analysis in the form of an assessment of the opportunity costs of preservation of old growth forests with adjustment for several of the potential benefits from preservation. Normally, for this type of analysis a switching value approach is more acceptable. However, this approach is only meaningful if the opportunity costs of preservation exceed the value of the benefits that can be quantified.

3.1.4 Should there be a Depletion Premium on BC Timber?

A final issue is whether harvesting of timber exceeds the natural regenerative capacity of the timber supply area. If so, then including an adjustment for overexploitation is needed. Recognition of the harmful effects of the depletion of natural capital in agricultural and forestry projects is a cornerstone of ecological economics (Knowler, 2005). This depletion is a form of

[12] CBA is concerned with the economic efficiency aspects of environmental changes stemming from some forest management activity. But analysts also must be aware of the distribution of the benefits and costs of forest management activities, and this may rely in part upon the underlying institutions such as property rights or rights of access to forest resources. These impacts are obviously important, or perhaps critical.

user cost, since it yields short-term gains but at the expense of future income. Leaving out this user cost can affect forestry analyses as it results in an overstatement of the net economic benefits of current forest harvests, if harvests deplete the natural capital. If such practices are compared to more sustainable rates of harvest, the evaluation is biased in favour of depletion. In this case, an adjustment should be made for user costs (El Serafy, 1989). To estimate the user cost formally requires specifying and solving a model that consists of mathematical functions describing the economic and ecological relationships of interest [see Knowler (2005) for details]. Undertaking such modelling is a challenge, given most project appraisal situations and is not feasible in the present study. Short cut techniques to calculate the user cost of a depleting natural resource exist, but are specific to the problem at hand.[13]

Depletion of natural capital may characterize the management of British Columbia's production forests. A review of recent projections of growing stock for BC indicates a gradual decline in BC's growing stock: from 4.1 billion m^3 at present to 3.1 billion m^3 by 2150 (National Forestry Database Program, 2005). This suggests depletion effects should be taken into account. However, wider forest management issues, such as the drawdown of pine beetle infested areas, and conversion of old growth to managed timber producing forests, also have implications for depletion management, making adjustment for depletion complex and not amenable to simple approaches.

Surprisingly little attention has been paid to quantifying user costs in the assessment of BC's timber economy. To our knowledge, only Green (2000) has grappled with this issue in a substantive and quantitative way. Developing a new methodology, the author demonstrates that a depletion premium of 22% was appropriate for BC forestry in the late 1990s, using the government's own estimates of forest growing stock, sustainable yield and harvest rate. However, Green shows that the depletion effect could be much higher if more stringent ecological criteria for sustaining forests are considered. There is a problem in replicating this type of analysis at the Fraser TSA scale and over a lengthy time period. For example, the management plan for the Fraser TSA shows the standing forest stock actually increasing over time, although controversially this occurs via conversion of old growth stands to managed forest. However, from a strictly timber production standpoint it may not be valid to argue for depletion at this scale. As for other benefits of the old growth forest (versus managed forest), it is much more complicated and largely captured by other parts of the analysis (e.g. recreation, carbon sequestration, etc.). Given the challenges and extensive additional research needed to capture depletion correctly, we did not adjust our results for depletion. Clearly though, further research

[13] Three commonly used approaches are the net price method (Repetto *et al.,* 1989), the shadow project approach (von Amsberg, 1993), and the marginal user cost method (Pearce and Markandya, 1989). The net price method is useful when the analysis calls for the deduction of user costs at the national level. The shadow project approach is more useful for the analysis of specific projects, as it accounts for depletion by adding the costs of replacing lost natural capital to project economic costs (e.g. artificial wetlands or reefs as substitutes for losses of natural wetlands or reefs). In contrast, the marginal user cost methodology is more appropriate for building up shadow prices of project outputs when user costs have been ignored. An example of an application of the marginal user cost method to forests in Nepal is provided by Knowler (2005).

on this topic is required.

3.2 Forest Values and Valuation

In constructing the alternative scenarios (with/without), the analyst needs a structure with which to organize and compare the economics values under each scenario. Also required are valuation techniques to convert physical information about changes in ecosystem goods and services into monetary values. We discuss these two considerations below.

3.2.1 Total Economic Value Framework

If researchers are to value non-marketed forest uses and decision-makers are to take these uses into account, then some sort of framework for distinguishing and grouping these values is required. The concept of *total economic value* (TEV) provides such a framework. Simply put, TEV makes a fundamental distinction between use values and non-use values, the former being somewhat self-explanatory and the latter referring to values associated with an environmental resource which rely merely on its continued existence and are unrelated to use. Use values are grouped according to whether they are direct or indirect values. Formerly, a separate category for option value and quasi-option value was used but now these are seen as aspects of use value that incorporate elements of risk or uncertainty and/or an *ex ante* perspective (Freeman, 1993). The main components of TEV are described in more detail below.

Direct use values

Direct uses refer to those uses which are most familiar: harvesting of timber and wildlife, collection of non-timber forest products, and use of the forest for recreation. Timber harvesting is often emphasized at the expense of other direct forest uses. In this context it is important to distinguish between direct uses, which may degrade a forest or convert it to an alternative use, and those that are consistent with conserving the forest. If logging practices lead to large standing forest losses without subsequent reforestation, or land is clear cut to allow cultivation, more benign forest uses will be precluded in the future. In contrast, the use values associated with ecotourism or collection of non-timber forest products can potentially be sustained indefinitely.

Indirect use values

Forests also perform ecological functions that support economic activity. These ecosystem services are referred to as indirect use values since it is not the functions themselves but their contribution to production that is valued. For example, forests prevent soil erosion and regulate floods. Loss of the forest results in damages to agricultural or other production downstream, and measuring these damages provides an indication of the indirect use value. Not all forest researchers agree on the validity of certain indirect use values. There is controversy over the effects of deforestation on rainfall patterns, for instance. In other cases, such as carbon storage values, the magnitude of loss associated with deforesting an area depends on how the land is subsequently used.

Non-use value

Non-use value is often thought of as coinciding with the concept of *existence* value. That is, individuals may be concerned about the continued existence of some environmental resource, such as a forest, even though they have no plans to visit it. Non-use values are typically not commercially expressed since they are unrelated to use and, like many indirect use values, have public good qualities. Forest biodiversity may be valued by persons living in distant countries, and because of its public good nature, the non-use value attributable to Europeans does not reduce the same values which may be held by Canadians, for example. Due to their nature, non-use values are very difficult to measure.

When the TEV framework is applied to forests, typically it is presented as shown in Table 3.1. Efficient resource allocation can only occur if all forms of value are included, even though it is difficult to quantify the many unobservable or uncertain values. Many values could be incorporated in an evaluation of old growth forests if data is available on forest structure (for carbon storage), hydrology (for water protection), soil structure (for control of soil erosion), non-timber use values (for option value of e.g. mushrooms, medicinal plants) and willingness to pay (for existence value). However, only a subset of these values will be considered because of resource and data limitations. In addition, there are other forest values not included that lie outside the realm of economic analysis. These values include cultural, spiritual and historical values, many of which are particularly important to First Nations. Thus, the economic analysis contained in this study is incomplete as it is limited to only those values of an explicitly economic nature.

In determining which economic values to include in our study, we reviewed relevant research from the Pacific Northwest of the US and Canada. Our criterion in making a selection was that there must be existing data on the value in question, since no resources were available for primary research. As a result, we selected the following components of TEV for the study:

Table 3.1

Sample Classification of Total Economic Value for Forests

USE VALUES a/		NON-USE VALUES (Existence Value)
Direct Use Values	**Indirect Use 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 - weather damage protection - groundwater recharge - greenhouse gas sink - ecosystem stability b/	- biodiversity b/ - culture, heritage

Source: adapted from Barbier (1991), Panayotou and Ashton (1992), Myers (1992) and Pearce and Warford (1993)

a/ Use values are now usually considered as encompassing option and quasi-option values.

b/ Biodiversity is essentially an attribute of the forest; hence, it may also serve important direct and indirect use values. For example, the diversity found in a forest may have direct use value for scientific research, education and as a source of genetic material. Similarly, biological diversity may have an indirect use value in assisting the ecological stability of the entire forest system.

Direct Use Values

- Timber products

- Non-timber forest products (e.g. mushrooms, salal, medicinal plants)
- Recreation and tourism

Indirect Use Values (Ecosystem Services)

- Carbon sequestration and storage

While limiting our analysis to these components of value for which data was available means some important values are ignored (e.g. watershed services), we believe these capture several of the most significant forest values. The authors are undertaking further primary research to address the missing values.

3.2.2 Economic Valuation Techniques

Economic values are reflected in our *willingness-to-pay* for something, less what it costs to supply it. Where an environmental resource simply exists and provides us with products and services at no cost, it is willingness-to-pay alone that describes the value of the resource, whether or not we actually make any payment. Measuring these values relies on a number of valuation techniques and there are a number of ways of classifying or grouping these techniques. A relatively simple approach is used here, one which accords with most classifications found in the technical literature. Valuation techniques can be divided into those that use market prices to directly measure the economic value of environmental impacts, and those that do not. The latter group constitute methods for non-market valuation, and these can be subdivided into a several groupings. Table 3.2 shows a summary of the valuation techniques available, and indicates which types of values they can be used to estimate. A selection of valuation techniques is used in this study, the details of which are provided in the next chapter. However, since most of these value estimates come from other sources, the process of applying them to our study is called *benefits transfer*. This approach makes sense when there is neither time nor resources to carry out primary research. Caution is required in making benefits transfers to ensure the sites and basis for valuation are as close as possible. We keep this principle in mind in undertaking the present study.

3.3 Modeling Approach

In this report we compare the value that forests provide as either managed stands or as protected habitat. The main sources of value that we are estimating are timber, recreation, non-timber forest products, and carbon storage and sequestration. The non-timber sources of value are not

Table 3.2

Selected Valuation Techniques for Assessing Old Growth Forest Values

USE VALUES		NON-USE VALUES
Direct Use Value	**Indirect Use Value**	**Existence/Bequest Value**
- market or shadow price analysis - changes in productivity - hedonic price method - travel cost method - production function approach - direct/indirect substitute approach [a/] - contingent valuation method - indirect opportunity cost [a/] - replacement costs [a/]	- changes in productivity - damage costs avoided - preventive expenditures - relocation costs [a/] - replacement costs [a/]	- contingent valuation method

Source: adapted from IIED (1994)
a/ signifies valuation technique to be used with caution

exclusive to either management option. While protected stands have a significant storage capacity for carbon, for example, managed stands have a significant role in the sequestration of carbon, and both protected and managed stands provide non-timber forest products and recreational opportunities. The net value provided by a forest stand that is cut is the value of the timber, minus harvesting costs and the opportunity costs of any benefits given up.

To assess the opportunity costs of preserving more spotted owl habitat we compare the total forest value provided by the Fraser Timber Supply Area under different scenarios: current management practices or increased habitat protection. We estimate the value of timber harvests for each of these management scenarios and then we add the values derived from recreation, carbon, and non-timber forest products in each scenario. We compare forest value for the Fraser TSA as a whole rather than solely for the areas excluded from the timber harvesting landbase in the increased habitat protection scenario. This is done partly because we were unable to obtain spatial data on exactly where the preserved areas are located, but also because the harvest schedule for the areas not protected adjusts forward in the increased habitat protection scenarios to lessen the negative impact on timber supply (see earlier critique of the Crane Study). All values are calculated in 2006 $CAN, and then discounted and summed to create a present value of the total forest value. This present value can be used to compare the different land use options.

3.3.1 The SELES Model

To estimate the opportunity costs of preserving more old growth forests in the Chilliwack Forest District, we use harvesting data forecasted for a one hundred year period with a timber harvest simulation model called the Spatially Explicit Landscape Event Simulator (SELES).

SELES (Fall and Fall 2001) is a modelling language that can be used to build spatio-temporal models of landscape dynamics and is currently used by the Chilliwack Forest District for the Fraser TSA timber supply analysis. The model used in this report was originally developed by Gowlland Technologies Ltd. for use with the Canadian Spotted Owl Recovery Team (CSORT) and Cortex Consultants Inc. in the production of their joint 2007 report, *A Framework to Support Landscape Analysis of Habitat Supply and Effects on Populations of Forest-dwelling Species: A Case Study Based on the Northern Spotted Owl* (Sutherland, et al. 2007). The model developed for their report uses recent forest inventory GIS data and a range of land management requirements to forecast and compare changes in timber inventories and spotted owl habitat availability. The SELES model developed for their report includes all known spotted owl habitat in British Columbia, which consists of areas in the Soo TSA, Lillooet TSA, Fraser TSA, and TFL 38. For our purposes this model was narrowed to include only the Fraser TSA.

SELES is both a high level declarative language and a simulation engine, which can be used to build a model to simulate spatio-temporal landscape dynamics. It uses raster layers of GIS data on variables that are both static, such as slope and elevation; and changeable, such as dominant tree species and stand age class. Landscape events, which could be grazing, fire, forest succession, or timber harvesting, define the model behavior. For the purposes of this report we used a model that is defined by forest succession, natural disturbance dynamics, and timber harvesting. A schematic of the SELES based model is provided in Appendix B.1, figure B-1.

The model divides the forest landscape into *analysis units*, which are characterized by leading tree species and site productivity. Site productivity is a function of elevation, aspect, slope, soil type, and moisture. The model tracks stand growth, which depends primarily on tree species and site productivity, estimates when stands will be available for harvest, and predicts which stands will be harvested according to specified land management rules. The model assumes replanting occurs within a year of harvest and also estimates the length of road construction required for harvesting.

The SELES based model creates output on a per decade basis, providing data on area and volume of stands in the timber harvesting land base. For each decade the model generates estimates of total area and volume by dominant tree species and age class for both stands left standing and stands harvested.

For further information on SELES readers can refer to Appendix 2 in Sutherland *et al.* (2007), as well as the SELES website.[14]

3.3.2 Description of the Scenarios

To estimate the opportunity costs of preserving more old growth habitat, we chose to compare three of the scenarios drafted for the report by Sutherland *et al.* (2007). The authors of that report defined a range of scenarios with varying degrees of protection for spotted owl habitat, and recalibrated the SELES based model to certain policy rules to predict the impact each scenario would have on future timber supply and habitat availability. A full description of these scenarios can be found in the above report.

Of the three scenarios we chose to evaluate, the first is based on the 1997 Spotted Owl Management Plan guidelines and is closely related to current management practices within the CFD. In this scenario, called **SOMPcurr**, some Spotted Owl habitat is preserved within long term activity centres (LTACs) within which harvesting is allowed as long as 67% of the productive forest within the LTAC remains at least 100 years old. The specific area preserved can change within the LTAC as long as a total of 67% is maintained as 100 years or older. The LTACs included in this scenario are the ones currently defined in the Fraser TSA. This scenario was created to reflect the current Timber Supply Review Analyses for the Fraser, Soo, and Lilloet TSAs as closely as possible. SOMPcurr was designed to be consistent with the Spotted Owl Management Plan as well, but may differ slightly from the most current Fraser Timber Supply Analysis. The scenario was designed this way because management practices may vary slightly with each subsequent timber supply analysis due to administrative changes, but the

[14] See http://www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr038.htm for a link to the report and the SELES information website http://www.seles.info/index.php/Main_Page.

Spotted Owl Management Plan will not.

The remaining two scenarios involve preserving nearly all remaining Spotted Owl habitat, although the two scenarios differ in how the habitat is distributed. In one scenario, called **Suit100**, 100% of stands that currently meet the minimum requirements for suitable Spotted Owl habitat are preserved, or removed from the timber harvesting landbase, regardless of how the stands are spatially related. The SELES model determines which stands qualify as currently suitable based on four variables: stand age, stand height, biogeoclimatic ecosystem classification (BEC) variant, and elevation. Suitable habitat is defined by a maximum elevation, and minimum stand age and height specific to each BEC variant. Requirements differ for nesting and foraging habitat, and whether the stand falls in the maritime, sub-maritime, or continental zone.

In the second preservation scenario, called **Terr100**, packed territories are defined to form contiguous areas of habitat and 100% of these territories are preserved. Not all the stands within the packed territories necessarily meet the minimum standards for Spotted Owl habitat currently, but do over time meet the age and structural requirements to become suitable for Spotted Owl habitat. These packed territories are defined using the current LTACs, so that 100% of the LTACs are protected.

The three scenarios are summarized in Table 3.3. In addition, Figure 3 shows the annual allowable cut (AAC) under each of the three scenarios. In SOMPcurr the AAC is constant at 1,435,500 m^3; in Suit100 the AAC is 961,700 m^3 for the first six decades, and then increases to 1,076,200 m^3; and in Terr100 the AAC remains constant at 961,700 m^3.

3.4 Data Sources

The following sections describe the data sources we used in our study. These are by no means exhaustive or detailed but provide a good idea of what was available to carry out the analysis.

3.4.1 Timber Products

For evaluating the potential value of old growth forests in terms of timber products, we combined the SELES output data on harvest volumes with price and cost estimates generated from a combination of sources. Price estimates were derived from Ministry of Forests Log Market Reports and Harvest Billing System. Cost estimates were gathered from three reports: *Analysis of Woodflow in the Coast Forest Region* (Pierce Lefebvre, et al., 2003), the Coast Forest Product

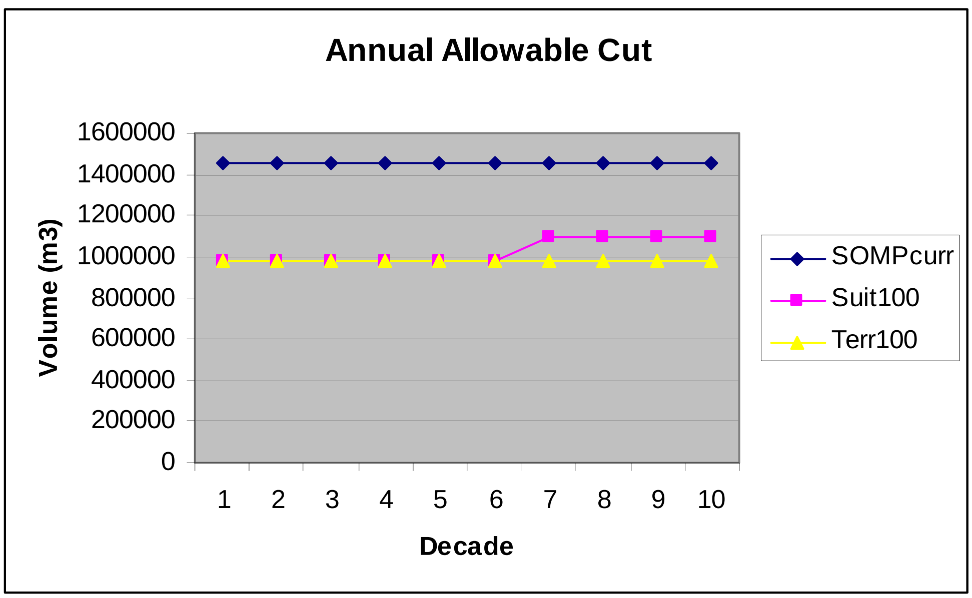
Table 3.3

Description of With/Without Forest Management Scenarios

Scenario	Description
SOMPcurr	67% of productive forests within LTACs are maintained as 100 years or older.
Suit100	100% of currently suitable Spotted Owl habitat is removed from the timber harvesting landbase.
Terr100	100% of packed territories are removed from the timber harvesting landbase regardless of whether or not the stands are currently suitable for Spotted Owl habitat.

Figure 3

Annual Allowable Cut under SOMPcurr, Suit100, and Terr100



Source: SELES output and Sutherland, et al. (2007)

Association's *Economic Impact of Five Coastal British Columbia Companies* (PriceWaterhouseCoopers, 2006), and the *2004 Coast Appraisal Manual* (Ministry of Forests

Revenue Branch, 2004). More details on how our estimates were derived will be discussed in the next chapter.

3.4.2 Other Forest Values

There is very little data on the value of tourism and recreation operators for the Fraser TSA specifically. The most recent recreation survey of provincial forests was the Ministry of Forests Recreation Branch *Outdoor Recreation Survey 1989/90*, which we use as the main basis of our estimates (Ministry of Forests, 1991). We combine this data with information from various recreation literature sources and reports on the impact of forest management practices on recreation values. While a slightly more recent 1996 survey exists, *The Importance of Nature to Canadians* (Environment Canada, 2000), this survey was not restricted to provincial forests, but instead covered all ‘natural areas’, which would include provincial parks and possibly private land. Since there may be a significant difference in recreation values between provincial parks and provincial forests, we believe the slightly older survey will provide us with more accurate estimates of recreation values in the areas we are analyzing in this report.

As with recreation and tourism, there is very little data available on the harvesting of non-timber forest products in BC, and data by forest district is all but non-existent. To make our estimates of the level of NTFP harvesting in the Fraser TSA we relied on a combination of literature, government reports, contacts at the Royal Roads Centre for Non-Timber Resources, and individuals in the industry such as mushroom buyers and recreational mushroom pickers.

To value the net change in carbon we used the SELES output data on standing and harvested timber volumes to estimate tonnes of carbon sequestered, and then applied different shadow prices derived from various literature sources. Our analysis of the pattern of carbon emissions from harvested timber is based on Forestry Canada’s *The Carbon Budget of the Canadian Forest Sector: Phase 1* (Kurz et al.1992). It is one of the best models available for the type of data we used and has been used in previous studies, such as a report by Model Forest Network (2000) and Kurz et al. (2002).

4.0 Assumptions and Parameters

In this chapter, the parameter assumptions used to make our estimates are presented in summary form. Concerning timber production, these chiefly involve timber pricing and harvesting costs. Since timber prices have been quite volatile in recent years, we carried out a detailed analysis in arriving at our final pricing assumptions. Fortunately, we were able to consult a recent study on harvest costs so that the cost assumptions are up-to-date. These parameters are expressed per cubic meter of wood harvested, since this coincides with the output from the SELES model. In contrast, the parameter estimates used to value selected use benefits (recreation and tourism, non-timber forest products and carbon sequestration) were expressed on the basis of a hectare of harvested timber land. While this approach may not be ideal in all circumstances it allowed us to use the output of the SELES model readily and to place valuation of these forest benefits on a similar footing with timber. Details concerning the parameter estimates are contained in Appendix B.

4.1 Timber Production

The economic value of the land as managed forests is defined as the producer surplus, or rent, that can be earned through timber harvesting. Producer surplus is defined as the difference between total revenues earned through sale of the logs and the total input costs of harvesting and delivering the logs to the market. We are basing our definition of producer surplus on the theory of Ricardian rent, which is a rent that can be captured when there are fixed factors of production, such as land and an annual allowable cut. The marginal productivity of variable inputs, such as labour, will be positive but diminishing, and firms will introduce variable inputs until the marginal cost of the input is no longer covered by the marginal value of the output it produces. Ricardian rent that can be derived from forests is defined as the value of forest outputs net of variable input costs and net of the value of the forest in its next highest valued use, or its transfer price. If forests have no value other than for harvesting the transfer price would be zero. However, if forests have value in terms of other uses, such as carbon storage and recreation, then the transfer price is positive (Grafton et al., 1998). In this section we focus only on timber values foregone with increased habitat preservation, and in the following sections we estimate the other non-timber values.

A good proportion of this producer surplus goes to the Government of British Columbia in the form of stumpage fees, and what remains goes to the logging companies as economic profits or perhaps may be captured by labour, in the form of higher than normal wages. We do not try to project stumpage revenues as a separate component of producer surplus. In this section we provide the pricing and cost assumptions used in our calculation of the economic rent from timber harvests.

4.1.1 Timber Prices

The SELES model generates harvest forecasts and provides estimates for volume cut in each analysis unit by decade.[15] To generate an estimate of revenue earned through harvest, we first estimated a grade-weighted average price per cubic metre for each species using data for the period of 1999 to 2005. To accomplish this we used a combination of the Coastal Log Market Reports, which report average prices per cubic metre of old growth logs by species and grade, and harvest data for the Chilliwack Forest District provided by the Harvest Billing System.[16] While only a minority of logs are bought and sold on the Vancouver Log Market, it is generally believed that the prices reported in the Log Market Reports accurately reflect the overall price level. The Harvest Billing System provides data on the volume per grade and per species harvested within the Chilliwack Forest District. We multiplied this volume by the grade and species specific prices for each particular year quoted in the Log Market Reports for the coastal region.

For each species we calculated a grade-weighted average old growth price by weighting the price for each grade by the proportion of the total harvest that grade makes up. We used an average of the seven annual price estimates from 1999 to 2005. Our estimated price of cedar is $135.83 per m^3, Douglas fir $104.10 per m^3, Hembal $61.72 per m^3, spruce $85.61 per m^3, and deciduous species $60 per m^3.

Second growth log prices are lower than that of old growth logs. Log market reports are not yet available for second growth logs since there is too small of a harvest to produce reliable estimates of average prices. Instead, we used the second growth price conversion parameters provided in Ministry of Forests Revenue Branch *Coast Log Prices* report for 2004, established

[15] An analysis unit is defined leading tree species and whether the stand is old growth or managed.
[16] The log market reports can be found at http://www.for.gov.bc.ca/hva/timberp/amv.htm, and data from the Harvest Billing System can be retrieved from http://www15.for.gov.bc.ca/hbs/.

by the Coast Appraisal Advisory Committee. The conversion table provides estimates of what second growth log prices would be in comparison to old growth prices for similar grades. Second growth log prices were obtained by multiplying the old growth prices from the Log Market Reports by the second growth conversion factors derived by the Coast Appraisal Advisory Committee (BC MOF, 2004).

A second growth grade H hembal log, for example, would be worth about 75% of a similar old growth grade H hembal log. A problem arises in applying these prices to timber harvest forecasts because SELES does not provide estimates of grade profiles. Instead we make an assumption that the grade profile will be similar between old growth and second growth harvests except for the proportion of higher grade logs. We assume that second growth harvests will only be of grades E and lower, but otherwise grade profiles are similar to past old growth harvests. We applied the conversion factors to the old growth price data and calculated grade weighted average prices for cedar, hemlock, Douglas fir, and spruce. The second growth prices are \$121.08 per m^3 for cedar, \$75.85 per m^3 for Douglas fir, \$54.05 per m^3 for hembal, and \$63.83 per m^3 for spruce.

Figure 4 shows the grade-weighted average prices for 1999 to 2005 in 2006 \$CAN for old growth and second growth of the three most common species in the CFD: cedar, hembal, and Douglas Fir. Since predicting future timber prices is highly speculative and sensitive to assumptions, we provide revenue estimates using three different assumptions about future price trends: prices remain constant, prices rise over time, and prices decline over time. Details concerning these assumptions can be found in Appendix B.

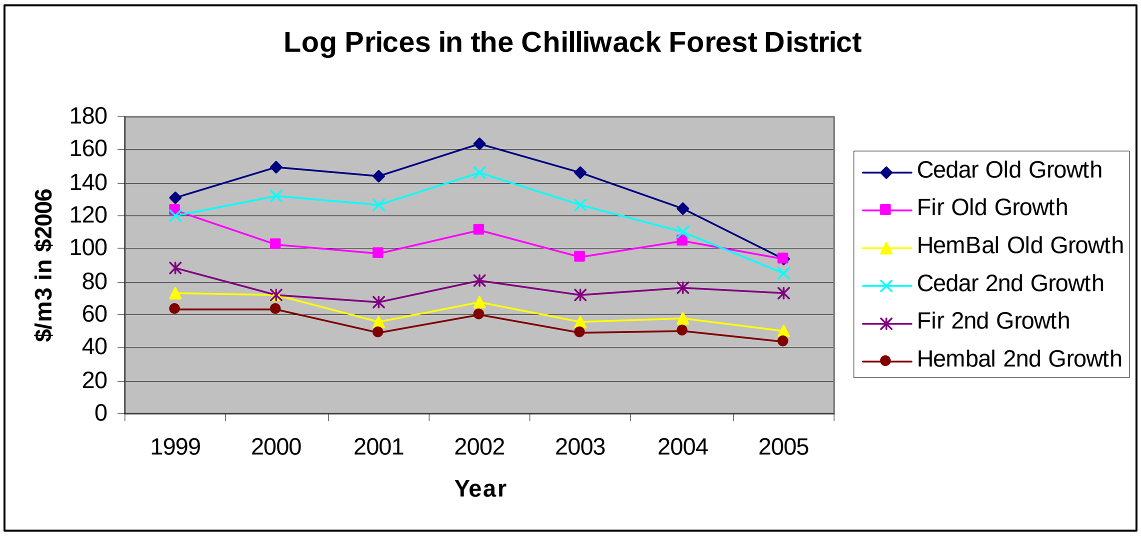
4.1.2 Harvesting Costs

In the short run, producer surplus is defined as the difference between the total revenues and total variable production costs, which do not include fixed costs of production such as capital equipment and overhead/administration. In the short run it is true that producer surplus should only consider variable costs because producers have no control over the costs of the fixed inputs. In the long run, however, all inputs are variable and we can assume firms maximize profits by producing at the level that provides the lowest long run average cost. For our study, we are estimating producer surplus over a one hundred year period, so it is appropriate to consider fixed and variable costs of timber harvesting rather than only the variable costs.

In the short run firms will continue operating as long as variable costs are covered, but in the long run firms will only continue operating if all costs are covered. Logging companies in British Columbia have experienced considerable losses within the past decade, but most have managed to survive. Table 4.1 provides variable and total harvesting cost estimates per cubic metre for the Coast Forest Region in 2006 \$CAN prices, which we derived from the *Analysis of Woodflow* report and the 2006 Coast Forest Products Association report, *Economic Impact of*

Figure 4

Average Log Prices in the CFD for Cedar, Hemlock, and Douglas Fir



Source: Harvest Billing System and Coast Log Market reports

Table 4.1

Variable and Total Harvesting Costs for the Coast Forest Region in 2006 $CAN

	1998	1999	2000	2001	2004	2005
Variable Costs	49.23	49.12	53.84	54.95	n.a.	n.a.
Total Costs	89.33	85.09	93.64	91.04	81.27	78.69

Source: *Analysis of Woodflow* and PriceWaterhouseCoopers (2006)

Five Coastal British Columbia Companies. The *Analysis of Woodflow* report has cost estimates for 1998 to 2001, while the Coast Forest Products Association has estimates for 2004 and 2005. These cost estimates include harvest costs, such as falling, yarding, loading, and delivery; head office and administrative costs, such as operational overhead and road building; as well as silviculture and replanting costs. The cost estimates do not include government administrative costs or stumpage and other royalties paid by harvesting firms to the government. We use an average of the two more recent estimates from the Coast Forest Products Association report, which is \$79.98 per m^3. These more recent cost estimates should more closely reflect the current harvesting costs.

Stumpage, which is the share of economic rent captured by the government, is not included in the cost estimates. Our goal is to estimate producer surplus derived from timber harvesting regardless of whether that producer surplus is captured by timber harvesting firms or the provincial government.

4.2 Recreation and Tourism

The Chilliwack Forest District encompasses the Fraser Timber Supply Area as well as numerous ecological reserves, recreation areas, and provincial parks. While these areas are popular outdoor recreation sites, there are substantial opportunities for outdoor recreation within the boundaries of the Fraser TSA. People hunt, fish, hike, camp, bike, canoe, river raft, rock climb, trail ride, ski, snow shoe, motorbike, ATV, and snowmobile within the forests of the Fraser TSA. Table 4.2 provides a sample of recreation locations within the Fraser TSA that are located on land which is held by a forest, timber, timber sale, or tree farm license.

4.2.1 Consumer Surplus from Outdoor Recreation

We measure the benefits to recreationists from the forests of the Fraser TSA as their consumer surplus (see Chapter 3). For recreation, consumer surplus is the difference between how much consumers value outdoor recreation and how much they spend on outdoor recreation. There are many different methods for estimating consumer surplus, the most common of which is the contingent valuation method. Consumers are asked how much they would be willing to pay in a hypothetical market for outdoor goods, such as wildlife habitat and provincial parks, over and above their expenditure on equipment, travel, and fees or licenses. There have not been any contingent valuation studies done for BC provincial forests in the last decade, so we use estimates from the *Outdoor Recreation Survey* 1989/90 to form an estimate of current willingness to pay. This survey covered recreation activities on provincial forests, which coincides with the area being analyzed in this report, the Fraser TSA.

Table 4.2

Recreation Locations in the Fraser TSA

Recreation Locations in the Fraser TSA		
Angling		
Allan Lake	Harrison Lake	Olive Lake
Alouette Lake	Hayward Lake (M)	Pierce Lake
Bear Lake	Hoover Lake	Salsbury Lake
Blinch Lake	Inkwathia Lake	Sayres Lake
Blue (Fishblue) Lake	Isabel Lake	Silvermere Lake
Campbell Lake	Jones Lake	Stollicum Lake
Chehalis Lake	Kawkawa Lake	Stacey Lake
Clerf Lake	Kenyon Lake	Stave Lake
Devil's Lake	Klahater Lake	Sunrie Lake
Eaton Lake	Lake Errock	Swanee Lake
Elbow/Echo Lakes	Lake of the Woods	Weaver Lake
Florence Lake	Ling Lake	Wilson Lake
Foley Lake	Lookout Lake	Wolf Lake
Francis Lake	Morgan Lake	Wood Lake
Grace Lake	Morris Lake	Wotten Lake
Forest Service Recreation Sites		
20 Mile Bay	Cogburn Beach	Rapids
Allison Pool	Eaton Creek	Riverside
Apocynum	Fir Flats	Scuzzy Creek
Bear Creek	Francis Lake	Skwellepil
Camp Foley	Grace Lake	Sunrise Lake
Cascade Peninsula	Hale Creek	Tamihi Creek
Chehalis Lake North	Log Greek	Thurston Meadows
Chehalis Lake South	Long Island Bay	Weaver Lake
Chehalis River	Nahatlatch River	Wolf Lake
Chipmunk Peninsula	Rainbow Falls	Wood Lake
Hiking Trails		
Campbell Lake	Ford Mountain	Rolley Falls
Denham	Harrison Lookout	Stave Falls
Devil's Lake	Hoover Lake	Sumas Mountain
Eaton Lake	Mount Cheam	Vedder Mountain
Elk Thurston	Mount Outram	Williams Peak
Other Multi-Use Trails		
Bear Lake Trail	Hope Mountain Trails	Pierce Lake Trail
Caswell Trail (Mission)	Ling Lake Trail	Pioneer (Bear Mt) Trail (M)
Centenial Trail	Lucky Four Mine Trail	UBC Research Forest
Clerf Lake Trail	Mount Crickmer Trail (M)	Wells Peak Loop Trail
Gate Mountain Trail	Mount Kaudt Trail	Williams Lake Trail
Ghost Pass Trail	Mount Slesse Memorial Trail	
Hayward Lake Trails (M)	Ogilvie Peak Trails	

Table 4.2, cont'd

River Paddling	**Lake Paddling**	**Skiing and Snow Shoeing**
Big Silver Creek	Chehalis Lake	Mount Cheam
Chehalis River	Harrison Lake	
Chilliwack River	Hayward Lake	
Cogburn Creek	Jones Lake	**Hot Springs**
Fraser River	Kawkawa Lake	Clear Creek Hot Springs
Harrison River	Pitt River	Pitt River Hot Springs
Nahatlatch River	Stave Lake	

Source: *Backroad Mapbook Road and Recreation Atlas Southwestern BC* and the CFD website

To adjust the 1989/90 willingness to pay estimates to a current equivalent, it is important to account for the factors that would have affected demand since 1989/90, such as population growth, income growth, and the income elasticity of demand for outdoor recreation. Details of how this was done are provided in Appendix B. Using the estimate of value per recreational user day (RUD) of $37.92 and the projected estimate of total RUDs of 44.4 million from Appendix C, we estimate the total use value placed on provincial forests by BC residents to be $1.68 billion. We also need to account for the fact that there is very little hunting activity within the borders of the CFD. Hunting values account for 10.2% of the $1.68 billion total use value, so we will subtract $171.7 million from the total and calculate a separate value for hunting activities specific to the CFD in the following section. The total use value for all provincial forests, excluding hunting, is therefore $1.51 billion.

The final step is to calculate a per hectare use value. This step assumes a constant use value over all provincial forest land but is necessary given the absence of spatial data. Use values for a given hectare of forest will depend on variables such as location, elevation, aesthetic qualities, views, wildlife diversity, and accessibility. We do not however, have this level of information and therefore use an average per hectare use value.

To calculate a per hectare recreation value, we estimate the total land base over which outdoor recreation takes place, keeping in mind that participation is not distributed evenly over the whole province. According to the *Outdoor Recreation Survey 1989/90*, 52% of the province's RUDs occur within the Vancouver Forest Region, which means the total use value placed on provincial forests within the Vancouver Forest Region by BC residents, excluding hunting, is about $785.7 million. Use values may be higher in the Fraser TSA and Soo TSA (Squamish Forest District) than in other TSAs within the Vancouver Forest Region because of higher population densities; however we do not have sufficient data to make a reliable adjustment, so we assume use values are even across the region.

The Vancouver Forest Region, the administrative unit at the time of the 1989/90 survey, contained all of the TSAs in the current Coast Forest Region except for the North Coast TSA. The total area of land managed by the BC Forest Service, including non-forest land, and area covered by tree farm licences for the Vancouver Forest Region, is 9.92 million hectares.[17] $785.7 million of use value spread over 9.92 million hectares translates into approximately $79.19 per hectare in recreational consumer surplus use value per year.

4.2.2 Hunting Values

Hunting data shows that only about 5.7% of BC's black bear harvest, 1.6% of the cougar harvest, 0.2% of the Elk harvest, and 7.1% of the Mule (black-tailed) deer harvest is from the Lower Mainland wildlife management region, which encompasses most of the CFD. There is no

[17] This includes the Fraser, Kingcome, Arrowsmith, Mid Coast, Queen Charlotte, Soo, Strathcona, and Sunshine Coast TSAs and TFLs 6, 10, 19, 25, 26, 37, 38, 39, 43, 44, 45, 46, 47, 54, and 57.

hunting of grizzly, mountain goat, mountain sheep, bison, caribou, moose, wolf, or white-tailed deer in the Lower Mainland region, and only 1.6% of the province's total hunter days by residents are within the Lower Mainland wildlife management region.[18] The wildlife management regions do not correspond with Forest District boundaries, so we estimate based on a map comparison that the CFD is approximately one third of the Lower Mainland wildlife management region. Assuming hunting activity is distributed evenly across the region, the CFD would account for about 0.5% of the total number of resident hunter days for BC. We make the assumption that if the CFD accounts for 0.5% of hunter days, then only 0.5% of the total provincial hunting recreation value can be attributed to the CFD. The exact proportion of the total provincial hunting value would depend also on the species being harvested within the CFD, since some species, like grizzly and black bears, are considered more valuable. The Lower Mainland region does not account for any of the grizzly harvest, but it does account for a disproportionately high portion of the black bear harvest, so we assume assigning 0.5% of the provincial value to be reasonably accurate.

As a result, the estimate for hunting value is $448,000 using the 1990 data for the *Outdoor Recreation Survey 1989/90*. Adjusting for the increase in disposable income, income elasticity of demand, and inflation, the total use value is $681,000 in 2006 prices. Since there are 890,000 hectares of land managed by the forest service in the CFD, the average value is $0.77 per hectare per year.

4.2.3 Consumer Welfare and Timber Harvesting

The recreational use value of a hectare of forest could alter drastically if that hectare is harvested. Different recreational activities will be affected in varying ways, depending on the relationship an activity has with the forest. Some activities benefit from the increase in clearings that logging creates, other activities are more dependent on maintaining a pristine forest condition, and therefore are negatively affected by logging, and almost all activities benefit from the extended road networks created for timber harvesting.

When modelling the effects of timber harvesting on recreation values we were limited by our lack of spatial data. Our data provides information on total area cut each year, but there is no information on where the areas are located. Species and age class of areas harvested can be determined, but there is no information on elevation, aspect, under story composition, proximity to popular recreation features, or any other variable that would affect the recreation use value of a particular hectare of forest. Since the per hectare use values derived in sections 4.2.1 and 4.2.2 are based on a survey that covered all provincial forest land, the estimates are an average over many forest types. The *Outdoor Recreation Survey 1989/90* did not distinguish between forests of different ages, different species compositions, different elevations and aspects, or different degrees of remoteness or proximity to key recreation features. As a result we cannot assign

[18] *Big Game Hunting Statistics for the 2002/03 Season*, Fish and Wildlife Recreation and Allocation Branch

hectare specific recreation values to the areas harvested in our timber harvest forecasts.

Another limitation of our study is that we do not attempt to model spatial shifts in recreation values due to timber harvesting. As discussed in the above section, timber harvesting will temporarily shift recreation activities. Some recreationists, such as hunters, may move onto newly harvested areas while others, such as hikers, may move away from harvested areas. This movement will have an effect on recreation values in other areas due to changes in participation rates and isolation benefits. If hikers, for example, move away from trails adjacent or adjoined to harvested areas, hiking activities will become more concentrated in areas away from logging. The increase in use of uncut areas will increase their per hectare recreation value; however, the increase in use will decrease isolation benefits and thus decrease their per hectare recreation value. In the absence of a spatially explicit recreation model, we make the simplifying assumption that the net effect of logging on recreation values in areas not being logged is zero.

To estimate how the value of a recreation day, calculated in the last section, changes with respect to forest harvest status, we divided recreation into three categories based on forest condition requirements: motor-powered land activities (snowmobiling, ATV), hunting, and water-based and human-powered activities. Then we estimated how the benefits in these three categories would be affected by timber harvesting.

To match the activity categories established in the *Outdoor Recreation Survey 1989/90*, which are listed in table 4.3, to our activity categories, we match ‘hunting’ to our hunting category; we use ‘motoring’ as our land-based motor-powered category; and combine ‘nature study’, ‘boating’, ‘fishing’, ‘camping/swimming’, ‘hiking/skiing’, and ‘all others’ into our water-based and human-powered category. We have already established that hunting generates annual use values of about $0.77 per hectare, and that all other activities generate $79.19 per hectare.

Motoring accounts for about 26% of all non-hunting use values, so we break the $79.19 down into $20.35 per hectare annually for motor-powered land activities and $58.84 per hectare annually for water-based and human-powered activities. We then create an approximation of the progression of these use values as forest age and structure change. Details concerning these assumptions are contained in Appendix B.

In addition, we added government revenues back into the estimates of consumer surplus. The BC government collects revenues from fees, permits, and licenses required by recreationists and recreation operators.[19] The average value of government revenues from hunting licenses and fees

[19] Fees and licenses are considered a cost by individuals and businesses, but from a social perspective fees and licenses are a wealth transfer, not a cost. When the *Outdoor Recreation Survey 1989/90* was conducted, respondents were asked what their willingness to pay would be over and above personal costs, which would have included fees and licenses. As a result, these costs are not accounted for in the estimates of consumer surplus and must be added in separately.

Table 4.3

Recreation Activities Included in the *OutdoorRecreation Survey 1989/90*

Nature Study	**Motoring**	**Hiking/Skiing**
Scenic Viewing	Vehicle touring	Hiking
Wildlife Viewing	Four-wheeling	Mountaineering/ Rock Climbing
Drawing/Painting/Photography	Trail Biking	Hang Gliding
Gathering/Collecting	ATV Use	Orienteering
	Snowmobiling	Horseback Riding
Boating		Snowshoeing
Motor Cruising	**Camping/Swimming**	Downhill/Cross Country Skiing
Sailing	Camping	Caving
Wildsurfing	Picnicing	Mountain Biking
Kayaking	Swimming	Bike Touring
Rafting	Beach Activities	
Canoeing	Diving	**Fishing**
Water Skiing	Surfing	**Hunting**
Other Boating		**All Others**

between 2000 and 2002 is $9.22 million in 2006 $CAN. Since this is part of social welfare, we will also attribute 0.5% of this, or $46,100, to the economic value of forests within the CFD.

Over the 890,000 hectares of land managed by the forest service in the CFD, that total value is about $0.05 per hectare, which we add to the $0.77 per hectare of consumer surplus for hunting activities for a total of $0.82 per hectare.

In 2000 government revenues from angling, including basic licenses, conservation surcharges, and classified waters fees, was $10.85 million, while guide and assistant guide fees raised $313,000 in revenues.[20] In 2006 $CAN, that would be a total of $12.62 million. 18.2% of provincial angler days occurred in the Lower Mainland Region, so we assign 18.2% of the $12.62 million in revenues, or $2.30 million. Assuming again that the CFD accounts for about one third of the Lower Mainland wildlife management region, and that angling activity is distributed roughly evenly across the region, we assign one third of the $2.30 million, or $766,000 to the CFD. Over 890,000 hectares, the value is about $0.86 per hectare which we add to the consumer surplus estimate of $58.84 for water-based and human-powered activities for a total of $59.70 per hectare. There was no data available for campground fees collected in the Forest Service recreation sites.

4.2.4 Effects of Timber Harvesting on Tourism/Recreation Producer Surplus

Producer welfare can be affected by timber harvesting in a number of ways, depending on how a recreation business benefits from a forest. For some producers, surplus is derived from being able to supply their product in an aesthetically pleasing, natural environment; for others surplus is derived from being able to use existing logging roads to access wilderness areas. Guide outfitters, fishing guides, and nature viewing guides derive welfare from the availability and diversity of wildlife. An estimate of the producer surplus from commercial recreation in the Fraser TSA is contained in Appendix B.

There has been very little study of the effects of timber harvesting on producer welfare. Hunt et al. (2005) used a hedonic method to estimate the effect of forest management practices on prices of sport fishing tours in Ontario. They find that logging negatively affects prices for fly-in fishing lodges, but not road- or boat accessible lodges. Although the effect on prices for fly-in fishing lodges is small, the authors point out that only currently operating lodges were surveyed and that there was anecdotal evidence of tourism operators closing due to the effects of logging.

The Ministry of Forests conducted a survey in Nimmo Bay (BC MOF, 2003) to analyze how guests would react to different levels of logging. The results suggest that of the guests who would return to the lodge if there were no visual effects of logging, 23% would not return if there was 1% or less visual alteration in the landscape, 29% would not return if there was 5% visual alteration, and 65% would not return if there was 22% or more alteration due to logging. At the Nimmo Bay Lodge, where 72% of the guests are repeat customers, timber harvesting

[20] *Fresh Water Angling in BC – an Economic Profile (2003) and Freshwater Guiding and Lodges in BC – an Economic Profile (2003)*

could have significant impact on revenues; and since revenues would likely fall faster than variable costs, timber harvesting could have a serious impact on producer surplus in the short run. The Nimmo Bay report assumes that if the revenues fall by 25%, total costs would only fall by about 15%.

To get a better idea of the relationship between forests and wilderness tourism operators in the CFD, we surveyed a sample of local operators. As discussed above, the effects of timber harvesting will vary according to the activity. Businesses can be affected directly or indirectly, and positively or negatively. Businesses that rely on scenic beauty could, like the Nimmo Bay Resort, be negatively affected if the visual damage from logging reduces the number of clients. Guide outfitters, on the other hand, could be positively affected by logging because clear cuts and very young forests provide ideal habitat for game animals. Fishing tour operators can be negatively affected if logging damages spawning grounds and watersheds.

Two of the businesses that answered our survey offered wildlife viewing/ water sport touring along the Fraser River. They emphasized the importance to their business of the visual aesthetics of forests along the Fraser, stating that the scenic beauty was a large part of the experience for their clients. Both respondents felt, however, that there would have to be very significant visual damage from timber harvesting before they would lose clientele.

Two respondents who were in the guided freshwater fishing industry expressed concern over the effects of timber harvesting on watersheds and spawning grounds. Although neither felt that logging had hurt their business, they had both witnessed first hand the damage to lakes and creeks that is caused by soil erosion when logging occurs too close to waterways. They had observed a significant reduction in fish supply and diversity over the past few decades due to various forms of pollution.

No guide outfitters answered our survey, but one of the other respondents participated in hunting activities and gave anecdotal evidence of the positive effects of logging on hunting. Ample herb and shrub growth after a forest has been cleared provides ground cover and an excellent food supply. This respondent believed there were very healthy populations of cougar, black bear, and black tailed deer in the CFD. The respondent also indicated that most hunters rely heavily on logging roads to access hunting areas.

Because neither our survey nor the few studies done in this area provide clear evidence of a significant effect of timber harvesting on producer surplus, we conclude that there is not enough evidence to support an argument for a significant difference in producer surplus between each of the three management scenarios. This is an area in which further research is needed.

4.3 Non-timber Forest Products

British Columbia's forests not only provide benefits through the logging industry, but also through the harvest of non-timber forest products (NTFPs). NTFPs include a wide variety of goods produced within forests, the most common of which are mushrooms and floral greenery.[21] Different mushroom species that can be harvested within the Chilliwack Forest District are listed in table 4.4. In this report we will discuss values derived from the commercial harvest of pine mushrooms, chanterelles, and salal, as well as the recreational mushroom hunting of a variety of mushroom species.

Like timber, non-timber forest products are a common resource in BC. Unlike timber, however, the harvest of NTFPs is not currently regulated on public land. For salal, other floral greenery, and wildcrafted herbs, the lack of regulation means a possibility that harvests exceed sustainable levels. Mushrooms, on the other hand, do not appear to face the risk of over-harvesting because of their physiology: mushrooms are the fruit of mychorrhizal plants which can live underground for decades or even centuries (Redhead, undated). As long as mushrooms are harvested correctly, the picking of mushrooms does not seem to affect the annual production of mushrooms by the plant (Norvell, 1995, and Egli et al., 1990).[22] In terms of producer surplus, this means that salal harvesters face the risk of resource depletion while mushroom harvesters do not.

4.3.1 Producer Surplus from Commercial Mushroom Collection

Edible mushrooms, such as pine and chanterelle mushrooms, tend to grow neither in really young forests nor in really old forests. Most mushrooms do not grow in cut or very young forests because they require a symbiotic relationship with tree roots. Timber harvesting removes the food source for the mycorrhiza and also damages the mycorrhiza through soil disturbance and subsequent decreases in soil moisture content.[23] As a forest ages, there is a change in the composition of mushroom species. Pines and chanterelles are most common in forest in age classes 3 to 7, after which time other species take over (Trowbridge et al. 1999).[24] Some edible species may exist in very old forests (age class 9), but according to local mycologist Paul Kroeger, it would not be a significant amount.[25] The species that exist in very old growth forests are an important component, however, of these ecosystems. Truffles are one edible species that grow in old growth spotted owl habitat and are an important food source for flying squirrels, which in turn are the main food source for spotted owls. Although commonly harvested in Oregon and Washington, there is little to no harvesting of truffles in British Columbia.

Table 4.4

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[21] See the Centre for Non-Timber Resources' *Buy BCwild 2006* for a list of products and suppliers.
[22]Also personal communications with local pickers.
[23] From http://bcmushrooms.forrex.org/
[24] Also see http://bcmushrooms.forrex.org/
[25] Personal communication 11/01/06

Fungal Species found within the CFD

Edible Fungi		
Common Name	**Latin Name**	**Comments**
Angel Wings	*Pleurotus porrigens*	Mostly picked recreationally
Belly Button	*Hydnum umbilicatum*	Mostly picked recreationally
Blewit	*Clitocybe nuda*	Mostly picked recreationally
Blue Chanterelle	*Polyozellus multiplex*	Mostly picked recreationally
Cauliflower	*Sparassis crispa*	Mostly picked recreationally
Chicken-of-the-woods	*Laetiporus sulphureus*	Mostly picked recreationally
Fried Chicken Mushroom	*Lyophyllum decastes*	Mostly picked recreationally
Hedgehog	*Hydnum repandum*	Mostly picked recreationally
Honey	*Armillaria mellea* complex	Mostly picked recreationally
King Boletes	*Boletus edulis*	Mostly picked recreationally
Lobster	*Hypomyces lactifluorum*	Mostly picked recreationally
Orange Peel	*Aleuria aurantia*	Mostly picked recreationally
Oyster	*Pleurotus ostreatus*	Mostly picked recreationally
Pacific Golden Chanterelle	*Cantharellus formosus*	Picked commercially
Pine	*Tricholoma magnivelare*	Picked commercially
Shaggy Mane	*Coprinus comatus*	Mostly picked recreationally
Truffles	*Gautieria monticola*	Mostly picked recreationally
Turkey Tail	*Trametes versicolor*	anti-cancer properties
Winter Chanterelle	*Craterellus tubaeformis*	Mostly picked recreationally

Production of pine mushrooms in the Chilliwack Forest District is mainly in the Boston Bar area, where pines grow in the IDFww (Interior Douglas Fir wet warm), CWHds (Coastal Westerm

Hemlock dry submaritime), and CWHms1 (Coastal Westerm Hemlock moist submaritime) biogeoclimatic zones (Freeman, 1997). Outside of the CFD, pine mushrooms also grow in ICH (Interior Cedar Hemlock), SBPS (sub-boreal pine spruce), ESSF (Engelmann Spruce-subalpine fir), IDF (interior Douglas fir), CWH (coastal western Hemlock).[26] Maps of pine mushroom and chanterelle habitat can be found on the BC Non-Timber Forest Products website.[27] To determine the productive potential of commercially harvested pine and chanterelle mushrooms in the CFD we gathered estimates from several sources. We talked to local buyers, looked at studies of biological productivity, and looked at data gathered by Royal Roads University's Centre for Non-Timber Resources.

Commercial mushroom harvesting is not a very stable source of income for two reasons: first, because mushroom harvesting is tied closely to local weather conditions; and second, because international demand for mushrooms is subject to changing preferences and availability of substitutes. In the 1990s, BC was a very important supplier of pine mushrooms to Japan, but now Japan is importing pines from other countries such as China and South Korea. Demand for chanterelles is affected by supply from other countries, namely in Eastern Europe. A good crop of pine mushrooms and chanterelles requires adequate precipitation in the late summer and early fall, and, as evident from the data collected by Wills and Lipsey (1999) reported in Appendix C, production can vary dramatically. International demand for BC chanterelles depends greatly on whether or not BC chanterelles can hit the international market ahead of European chanterelles.

Commercial pickers are generally independent workers, often local to the area, who sell their harvests on a daily basis to mushroom buyers set up near the harvesting area. Local buyers, such as Ponderosa Mushrooms in Port Coquitlam and Emperor Specialty Foods in Richmond, will set up buying stations during the mushroom season. These buyers in turn sell to local stores and restaurants and export internationally. There may be some mushrooms sold directly by pickers to local restaurants, but according to a buyer at Pacific Rim Mushrooms in Vancouver, this is either not likely or would not represent a significant amount since the time required to distribute does not make it worthwhile. Pricing and collection rate assumptions are contained in Appendix B.

Our assumptions indicate that the average daily revenue for pickers is $111.16 for chanterelles and $148.82 for pine mushrooms. To estimate costs, we assume an average agricultural labourer wage of $10 per hour for the opportunity cost of pickers' time, and an average daily costs for transportation and materials of $30 per day.[28] Total production costs are therefore $67 in wages and $30 in other costs, or $97 per day. The producer surplus for chanterelle pickers is therefore approximately $14.16 per day, or $1.00/kg; and the producer surplus for pine mushrooms pickers is approximately $51.82 per day, or $19.19/kg.

[26] From http://bcmushrooms.forrex.org/ntfp/index.html
[27] http://bcmushrooms.forrex.org/
[28] Wage figure from Service Canada for 'Harvesting labourers' in the Lower Mainland (http://www.labourmarketinformation.ca/standard.asp?ppid=43&lcode=E) and production cost estimates from CNTR (2006) Mushroom Harvesters Survey

In order to express these producer surplus estimates on a per hectare basis, we first calculate total producer surplus possible for the CFD and then divide by the total area of potential pine mushroom habitat at the start of the simulations. According to the SELES model, at the beginning of each scenario there are 267,000 hectares of non-Cedar dominated forests in age classes 3 to 7. If 14,700 kg of pine mushrooms are harvested annually in the CFD, then there is about $282,000 of producer surplus available for pine mushrooms; and if 17,000 kg of chanterelles are harvested there is about $17,000 of producer surplus available for chanterelles. Spread over 267,000 hectares that is approximately $1.12 per hectare of producer surplus for chanterelles and pine mushrooms.

If we assume that pickers personally consume about 2% of their harvest, or about 300kg of pine mushrooms and 340kg of chanterelles, this volume should be valued at the market prices and added to total surplus from harvesting mushrooms. At an approximate market price of $30/kg for pine mushrooms and $10/kg for chanterelles, over 267,000 hectares, personal consumption had a value of about $0.05 per hectare. Total surplus per hectare from the harvest of pine mushrooms and chanterelles is therefore $1.17 per hectare.

There may be a significant volume of mushrooms picked and sold locally that will not have been captured by the studies that have been completed. There are other mushroom species picked and as traded to local stores and restaurants. Mushroom species such as King Boletes, Winter chanterelles, blue chanterelles, lobster, cauliflower, and hedgehog can be found within the CFD. Wills and Lipsey (1999) estimate that BC can produce a harvest of up to 100,000kg of boletes, and 50,000kg together of the less common species such as lobster, cauliflower, and hedgehog. To account for these other species and the volume sold locally, we add an additional 10% to the producer surplus calculated per ha for pine mushrooms, or $0.11.

4.3.2 Recreational Collection of Mushrooms

There are many people within the Chilliwack Forest District for whom mushrooms are a hobby. These people not only enjoy eating mushrooms, but they also hunt for their own mushrooms in the local area. Recreational pickers differ from commercial pickers in that they consider the time they spend picking to be a benefit rather than a cost of harvesting.

Members of the Fraser Valley Mushroom Club and the Vancouver Mycological Society were surveyed in order to estimate the value of recreational picking in terms of mushrooms and time. Members were asked whether they considered the time they spent picking mushrooms to be recreational or a necessity to obtain mushrooms, how many days per year they picked, and what volume of mushrooms they picked in an average year within the CFD. Of the approximate total of 250 members between the two clubs, 38 members completed the survey. Thirty-five of the 38 considered the time spent looking for mushrooms to be recreational, while the remaining three considered the time both recreational and a necessity. Members who completed the survey spent an average of 12.2 days per year picking, and picked an average of 13.4 lbs or 6kg per year. The average harvest consisted of 51% Pacific Golden chanterelles, 11% boletes (various kinds), 5% oyster mushrooms, and 33% other varieties, including shaggy mane, angel wings, lobster, cauliflower, pine, morel, and honey. There is a possibility that members of the clubs who did not complete the survey are not as active mushroom pickers as the members who did complete the survey; however, it is also quite likely that there are many recreational mushroom pickers in the Chilliwack Forest District who are not members of either club. We therefore believe extending the survey results to all members of the clubs provides a reasonable and conservative estimate of recreational mushroom picking activity in the CFD.

To calculate a value for recreation time we use the consumer surplus estimate derived in the recreation section of this report of $37.92 per day. If the average picker spends 12.2 days per year picking, he or she is deriving $463 per year in benefits from time spent picking. To value the mushrooms harvest of recreational pickers we apply an average market price to the volume harvested. Using market prices gathered from local suppliers, we use an average price of $10.00/pound, or $22.00/kg. The average mushroom picker therefore harvests about $134 worth of mushrooms per year.

Total benefit from recreational mushroom picking is estimated as the consumer surplus from hiking plus the market value of the mushrooms picked. The total of $597 is multiplied by the total membership between the two clubs of approximately 200, to get a total annual value of $119,400. Over the total area 267,000 hectares of non-cedar dominated forest in age classes 3-7 (mushroom picking is not allowed in provincial parks), that means each hectare produces approximately $0.45 per year in recreational mushroom picking values.

4.3.3 Floral Greenery and Other Non-Timber Forest Products

There are many other non-timber forest products that could potentially be harvested within the Chilliwack Forest District. Salal is one of the most economically important forest greenery products in British Columbia, but there are many other species of plants harvested for floral greenery, nurseries, wildcrafting, and artisan work. Medicinal mushrooms are also picked for personal consumption or for retail. Because the harvest of these products is not regulated at all, data is even more difficult to gather than for pine mushrooms and chanterelles. It is not believed, however, that there are economically significant harvest levels of any species other than pine mushrooms and chanterelles in the CFD (Crane Management, 1995). As well, the harvest of salal is not believed to generate positive producer surplus. Salal pickers on Vancouver Island, for example, are often people at the margins of the labour force who earn very little above the operating costs, or not enough to earn a minimum wage (Cocksedge, 2003). Since the economy of the CFD is so much larger than for Vancouver Island, and there are many other economic opportunities that would be provide higher returns than harvesting greenery or other NTFPs, we believe it is reasonable to assume there is no significant producer surplus being derived from the commercial harvest of other NTFPs.

4.4 Carbon Sequestration and Storage

One of the most important ecosystem services provided by forests is the storage and sequestration of carbon from the atmosphere. Atmospheric carbon is widely recognized as a key contributor to global warming, and economists have long been attempting to estimate the value of carbon, either in terms of the cost of emissions, or in terms of the benefits of storage and sequestration. In our comparison of forest management scenarios, there are two main carbon flows: one is the sequestration of carbon through net forest growth and the second is carbon emissions from the decay of timber products. Timber harvesting also involves significant changes in carbon content in soil and under story biomass, as well as carbon emissions during the harvesting process. Motorized recreation activities may also be a significant source of carbon emissions. While these sources of carbon emissions are important, they are difficult to quantify and we have therefore narrowed our analysis to carbon changes due only to changes in forest volume.

4.4.1 Carbon Sequestration Assumptions

In all three scenarios the volume of total growing stock increases annually because the total growing stock is growing faster than it is being harvested (Figure 5a). The volume on the timber harvesting landbase, a subset of the total growing stock, decreases over most of the 100 year period for two of the scenarios, SOMPcurr and Terr100 (see Figure 5b); however, growth in other areas of the total growing stock more than compensates for this loss.

To estimate how much carbon is lost due to decay in harvested timber, we first determine what type of products the timber becomes. Wood that becomes construction lumber, for example, will not decay as fast as wood that becomes paper. Using the 2003 breakdown of fiber flow in the Lower Mainland in the *Analysis of Woodflow* report, and assuming that fiber flow in the Fraser TSA follows the same pattern as the Lower Mainland region as a whole, we estimate that 38% of the volume of harvested timber becomes construction lumber, 16.3% becomes other types of lumber, and 45.7% becomes chips. More than 54.3% of harvested logs go to mills to become construction and other lumber, but much of the volume is lost in processing. All volume lost in the mill production of construction and other lumber is assumed to join the chip flow, as illustrated in the *Analysis of Woodflow*.

Figure 5a

Annual Forest Volume in Total Growing Stock

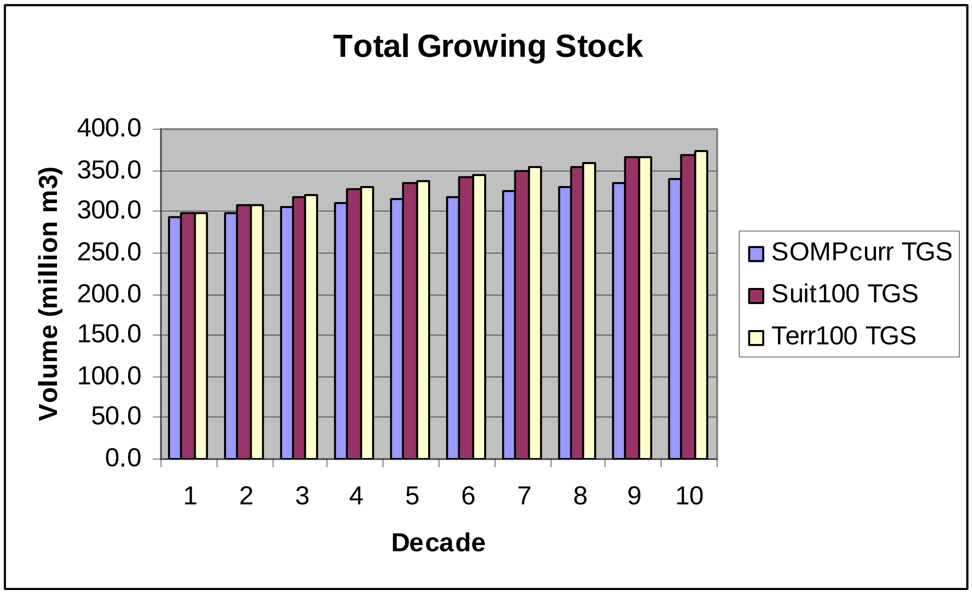
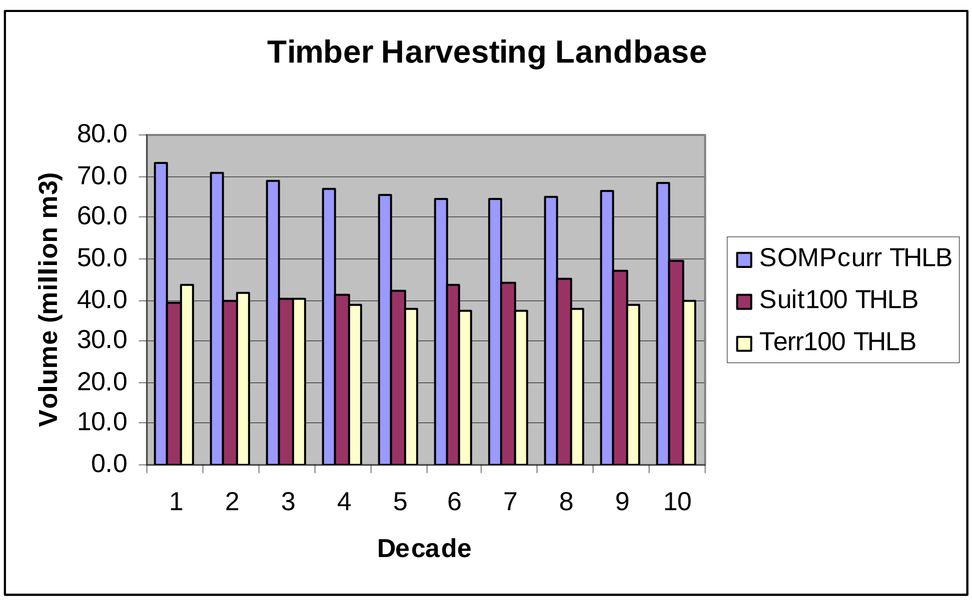


Figure 5b

Annual Forest Volume in Timber Harvesting Landbase



Using the carbon retention patterns found in Kurz et al. (1992),[29] we assume four different patterns of decay for construction lumber, other lumber, chips, and wood that goes to landfills. As illustrated in Figure 6, construction lumber is assumed to initially lose 5% of its original volume in construction scraps, then about 0.8% of its original volume per year for the next 60 years (through renovations for example), and finally lose 1.1% of its original volume per year for the remaining 40 years. Timber classified as other lumber, such as panel board, packaging, and trim, is assumed to lose more of its volume the first year and to lose volume at a faster rate thereafter compared to construction lumber. During the first year it is assumed to lose 40% of its volume due to use in short-lived, non-reusable products such as packaging and palettes. After the first year there is a 1% per year decrease of the original volume until year 50, and thereafter the volume decreases by about 0.1% per year. Timber that becomes chips loses volume the fastest. In the first year, 50% of chip volume is assumed to be lost, after which about 9% of the original volume is per year for the first five years, 1% per year for the next five years, and then 0.1% per year for the remaining years. Of the volume of lumber and chips leaving its primary use, including the loss in the first year and each annual loss, 87.5% is assumed to enter a landfill, 7.5% is assumed emitted through burning or decomposition, and 5% is assumed to be recycled back into primary use. At a landfill, wood decays at a rate of about 1% per year until year 80, at which point the rate of decay drops to zero.

4.4.2 Valuing the Benefit of Carbon Sequestration

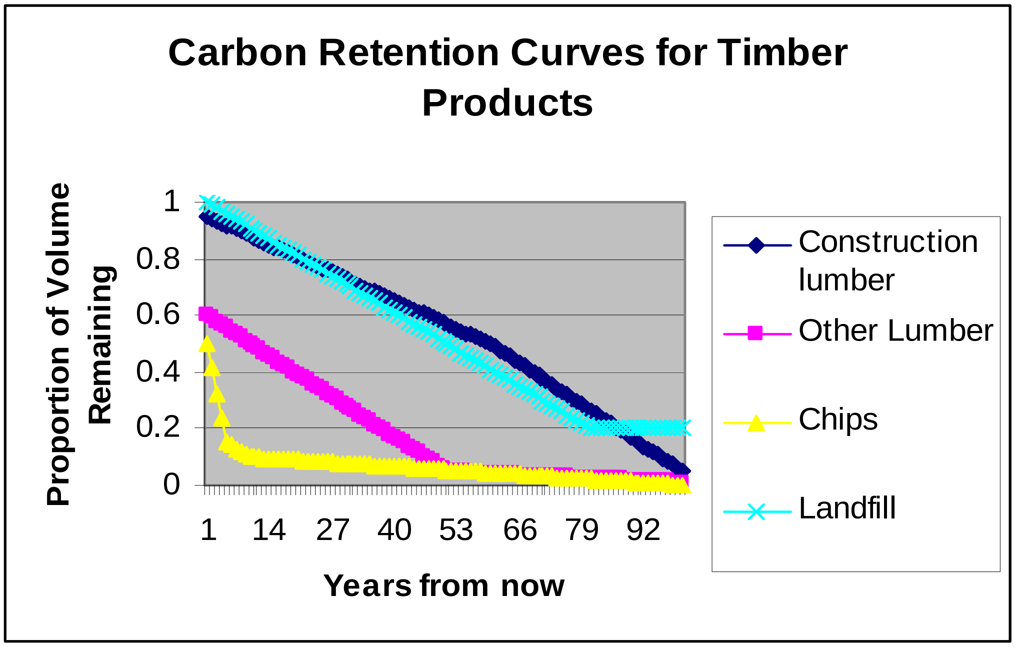
Economists have used many different approaches to estimating the value of carbon. In a study of the value of carbon sequestration in protected areas in Canada, Kulshreshtha et al. (2000) summarize common approaches and recent estimates of the value, or price, per metric tonne of carbon. Some of these common approaches involve estimating the cost of recapturing carbon (through, for example, afforestation), the cost of mitigating carbon emissions (for example, by reducing vehicle emissions or forgoing timber harvests), or using the price established in emerging carbon emission credit markets.

Estimates based on alternative technology, retrofitting, and recapturing range from $16.96 (Building Issue Table, 1999) to $746.00 per tonne in 2006 dollars (Bergman et al., 1997). Replacement cost estimates for methods such as reforestation, afforestation, and other silviculture practices yield estimates that range from as low as $3.75 per tonne (Sinks Issue Table, 1999) to $121.60 per tonne (Dixon et al., 1994) in 2006 dollars. European Trading Scheme prices have ranged from $29 to $129 per tonne in 2006 dollars (Nordhaus, 2005).[30] The *Stern Review on the Economics of Climate Change* (2006) estimates that the social cost of carbon should be $353 per tonne. Based on the range of estimates described, we chose three price assumptions: $20, $75, and $150 per tonne of carbon, but consider a more pessimistic option of $350 in the sensitivity analyses.

[29] See also for other applications of this carbon model: Model Forest Network (2000) and Kurz, et al. (2002)
[30] Converted at a 2005 Canada-US exchange rate of $1.21 and adjusted for inflation

Figure 6

Carbon Retention Curves



Source: Kurz et al. (1992)

4.4.3 Carbon Sequestration Benefits under Different Forest Management Scenarios

To compare the three forest management scenarios in terms of their contribution to carbon sequestration and emissions, we estimated the present value of net carbon flows for each scenario. We did not include the value of carbon stored in forests at the beginning of each scenario, as the starting volume for each scenario is identical. Instead we estimated the value of carbon sequestered through net forest volume increases and the value of carbon emitted through the decay of harvested timber.

For each year, we calculated the change in volume of the total growing stock and the volume of timber harvested using the SELES output. The volume of timber harvested was divided into four flows which decayed according to the patterns described in section 1.3: construction lumber, other lumber, chips, or landfill. Assuming an average carbon density of 0.1824 tonnes carbon per cubic metre of timber, we then converted the annual change in timber volume to an annual change in carbon volume (van Kooten et al., 1999). Using a range of shadow prices per tonne of carbon, we calculated the value of carbon sequestered and lost for each year, and then discounted and summed those values to get a net present value of carbon sequestered and lost over the next 100 years.

4.5 Other Parameters

Two additional parameters were required for the analysis, a social discount rate and a time horizon for the modeling. The choice of a discount rate is a controversial matter, and depends on whether a time preference or an opportunity cost of capital approach is appropriate, as discussed in Chapter 3. In addition, some researchers argue the discount rate should be set high, since many forestry management activities impose damage on the environment and should be penalized, while others argue no discount rate should be used at all, to incorporate sustainability considerations and the interests of future generations. Some forestry projects have positive environmental impacts, in contrast, suggesting a low discount rate might be appropriate, to encourage such activities. In reality, the impacts of forestry activities on the environment range widely, suggesting that the appropriate discount rate might vary with the circumstances.

It is generally preferable to use a single rate for all projects evaluated to ensure consistency and to allow for comparisons amongst different projects. But if a single discount rate is to be used, then to accommodate environmental concerns we must decide whether the rate should be high, low or zero. Interestingly enough, the overall impact on the environment of a high or low discount rate applied to all projects is ambiguous.[31] As a result, there is an emerging consensus

[31] For example, a high discount rate discourages environmentally damaging activities and reduces the overall level of investment; therefore, the rate of natural resource use declines. But this result comes at the expense of emphasizing the interests of the current generation over those of future generations, since net benefits far in the future are heavily

that no adjustment be made to the standard, economy-wide discount rate when evaluating environmental values, and instead other techniques be used to adjust for any special conditions associated with environmental benefits and costs. This is the approach that was taken in this study.

We selected a social discount rate of 4% for two reasons. First, this is the social discount rate estimated by Heaps and Pratt (1989) for the social opportunity cost of capital in the BC forest sector; and second, because most previous reports on opportunity costs in the BC forest sector have used the Heaps and Pratt (1989) estimate. The Crane Management study (Crane Management, 1995), van Kooten and Bulte (1999), and Stone and Reid (1997) all use 4% as a base case discount rate, so using 4% in our report enables a comparison of our results to the earlier studies. For a sensitivity analysis we also include results using a 1% and a 7% discount rate.

We chose a time horizon of a 100 year period. We do not consider a longer time period partly because benefits and costs beyond 100 years are very small when discounted, and therefore would not significantly affect our results; and partly because the accuracy of our parameter assumption decreases the further into the future we try to predict. Even at 100 years there is huge uncertainty but given the usual forest rotation cycle of 70 to 80 years, any shorter period would be inappropriate.

Table 4.5 summarizes all of our parameter assumptions used in the final modeling of forest values.

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discounted. A high discount rate can discourage more environmentally-friendly forest management practices, or investments in ecosystem restoration.

Table 4.5

Summary of Parameter Assumptions

Parameter	Units	Value
Old Growth Log Prices		
Cedar	$/m³	135.83
Douglas fir	$/m³	104.10
HemBal	$/m³	61.72
Pine/larch	$/m³	43.83
Spruce	$/m³	85.61
Deciduous	$/m³	60.00
Second Growth Log Prices		
Cedar	$/m³	121.08
Douglas fir	$/m³	75.85
HemBal	$/m³	54.05
Spruce	$/m³	63.83
Harvesting Costs	$/m³	79.98
Average per hectare Recreation Values		
Hunting	$/ha	0.82
Water-based and human-powered	$/ha	59.70
Non-Timber Forest Products		
Commercial harvesting	$/ha	1.27
Recreational harvesting	$/ha	0.45
Shadow Price of Carbon[32]	$/tonne	20, 75, 150
Discount Rate	%	1, 4, 7
Time Horizon for Modeling	years	100

[32] The *shadow price* of carbon is the social value per tonne of carbon stored, emitted, or sequestered.

5.0 Results and Discussion

In this chapter we present the results of our estimation of the opportunity costs of an increase in old growth forest protection in the Fraser TSA. In the next section we consider the results in terms of lost producer surplus or rent from timber alone. Then in the subsequent section we expand the scope to incorporate the other forest values we considered into our estimates of the opportunity costs (these were recreation, non-timber forest products and carbon sequestration/emissions). The chapter concludes with a brief discussion of the implications of our results. While summaries of the calculations are provided in several tables in the main text, detailed tables are contained in Appendix C.

5.1 Opportunity Cost of Forest Protection in Terms of Foregone Timber Values

Net timber values were estimated for all three scenarios: SOMPcurr, Suit100, and Terr100 (see Appendix C for detailed tables). We then calculated the opportunity cost of adopting either Suit100 or Terr100, which is simply the difference between the net forest value for each of these "*with protection*" scenarios and the "*without protection*" scenario (SOMPcurr). The opportunity cost can be positive, indicating that there is a net loss to society associated with implementing Suit100 or Terr100, as opposed to maintaining the base case situation (SOMPcurr). If the opportunity costs are negative, then there would be a net benefit associated with implementation of either Suit100 or Terr100. All values are in 2006 prices and are net present values calculated over a 100 year time horizon with discount rates of 1%, 4%, and 7%, and rising, constant, and falling log prices.

Most of the constant and rising timber price and alternative discount rate combinations generate positive economic rents from timber harvesting in the Fraser TSA, when forest management scenarios are viewed in isolation (see Appendix C, table C-1). Thus, timber harvesting appears to be viable under these assumptions and across all management scenarios. However, the opposite is true for an assumption of falling timber prices. Next, we assessed the forgone economic rent when our "*with protecion*" scenarios are compared to the *"without protection"* scenario. Estimates of the opportunity costs in terms of timber values for Suit100 and Terr100 versus SOMPcurr are presented in Table 5.1. For all three price trends and discount rates, there is a positive opportunity cost associated with implementing either Suit100 or Terr100, in terms of producer surplus from timber. This indicates that there is foregone timber rent when old growth areas are removed from the timber base. How substantial is this opportunity cost? Using a constant timber price and 4% discount rate, the opportunity cost is about 60% of the timber surplus under SOMPcurr, but only about 3% of the revenue generated from that same scenario (see table C-1 for revenue estimates).

A lower discount rate generates a higher opportunity cost in all instances except in the case of falling log prices using a 1% discount rate. This exception is likely because the producer surplus from timber under Terr100 is lower at the beginning than at the end of the 100 year period. The lower discount rate would weight the future producer surplus estimates more heavily than the higher discount rates.

5.2 Including Selected Use Benefits from Protection

In this section we first present the net present value of the selected use benefits associated with each forest management scenario (recreation, non-timber forest products and carbon sequestration/emissions). These estimates were added to the timber harvesting values presented in Section 5.1 to obtain a net forest value. This net forest value is the net benefit the Fraser TSA could provide in terms of timber harvesting, recreation, non-timber forest products and net carbon sequestration under the three scenarios we examine. Once the net forest value estimates were obtained, we calculated the opportunity cost of adopting the Suit100 and Terr100 scenarios using the net forest value calculation as a basis. In Section 5.1 the opportunity cost estimates used only the producer surplus from timber harvesting, but in this section the opportunity cost estimates add in recreation, non-timber forest products and net carbon sequestration to provide a more complete (but still partial) estimate.

As a first step, we estimated net present values for hunting, water-based and human-powered recreation activities, and non-timber forest products (see Appendix C, table C-2). For all categories of forest values, the lower the discount rate the higher the net present value. Our results indicate that SOMPcurr provides the highest net present value for hunting, except when a

Table 5.1

The Opportunity Cost of the Suit100 and Terr100 Scenarios in Terms of Timber Benefits with Rising, Constant, and Falling Log Prices and 1%, 4%, and 7% Discount Rates (in $millions)

	Discount Rate	SOMPcurr-Suit100	SOMPcurr-Terr100
Rising log prices			
	1%	390.5	420.3
	4%	126.8	154.5
	7%	57.0	84.3
Constant log prices			
	1%	224.4	229.8
	4%	85.0	110.0
	7%	40.6	67.4
Falling log prices			
	1%	56.3	42.3
	4%	42.0	65.3
	7%	23.7	50.1

7% discount rate is used. For water-based and human-powered recreation activities, Terr100 provides the highest net present value, followed by Suit100. For non-timber forest products, SOMPcurr and Terr100 provide roughly the same net present values.

We also estimated net carbon change for each management scenario as the annual value of carbon sequestration minus the annual value of carbon emissions, using shadow prices for carbon of $20, $75, and $150 (see Appendix C, table C-3). For all three shadow prices, the estimated net value for carbon sequestered were highest for Terr100 and lowest for SOMPcurr, and the lower the discount rate the higher the value. In contrast, we obtained negative present values for SOMPcurr using a shadow prices of $20 and $75 with a 7% discount rate. These negative results indicate that with the SOMPcurr management plan the present value of carbon emitted exceeds the present value of carbon sequestered over the 100 year time period.

Once the net present values were determined for the additional forest benefits we used these values to estimate *net forest value.*[33] We then considered the opportunity costs of adopting the two preservation scenarios (Suit100 and Terr100). Again, this opportunity cost was calculated as the difference in net forest value between each of the preservation scenarios and our baseline scenario (SOMPcurr). Summarized results are presented in table 5.2, while detailed estimates ar presented in Appendix C.

Our analysis generated a range of estimates for the opportunity costs of preserving old growth forests under the two forest preservation scenarios. For example, the opportunity costs of adopting Suit100 range from $167.5million to -$653.3million and the estimates from adopting Terr100 range from $144.7million to -$817.9million. For both forest preservation scenarios the highest opportunity cost was produced using a $20 shadow price for carbon, rising log prices and a 1% discount rate. In contrast, the lowest (most negative) estimate was produced using a $150 shadow price for carbon, falling timber prices and a 1% discount rate.

In summary, the opportunity cost estimates are negative under most sets of assumptions, and are only positive when we assume rising or constant log prices and a $20 shadow price of carbon. This suggests that <u>over most of the range of assumptions there would be a net benefit to implementing either Suit100 or Terr100</u> in place of SOMPcurr. This result is of particular interesting because we have only included a selected number of the potential benefits of preservation. Obviously, including more benefits from the preservation old growth, such as the value of several important ecosystem services that were excluded, would only strengthen the results. Which scenario would provide the largest net benefits, Suit100 or Terr100? The answer to this question differs with the choice of discount rate and shadow price for carbon.

Table 5.2

[33] *Net forest value* is the sum of timber and other forest benefits for each management scenario.

Net Present Value (NPV) of the Opportunity Cost of Old Growth Forest Withdrawals for Two Scenarios (Suit100, Terr100) Compared to the Baseline Scenario (SOMPcurr), using a 100 Year Time Horizon (in $millions)

Shadow Price of carbon	Discount Rate	SOMPcurr-Suit100	SOMPcurr-Terr100
Rising log prices			
$20	1%	167.5	144.7
	4%	38.4	50.1
	7%	5.4	24.7
$75	1%	-38.4	-102.6
	4%	-65.4	-70.4
	7%	-62.7	-52.2
$150	1%	-319.2	-439.9
	4%	-207.1	-234.6
	7%	-155.4	-157.0
Constant log prices			
$20	1%	1.4	-45.8
	4%	-3.4	5.6
	7%	-11.1	7.7
$75	1%	-204.5	-293.2
	4%	-107.2	-114.8
	7%	-79.1	-69.1
$150	1%	-485.3	-630.4
	4%	-248.9	-279.0
	7%	-171.9	-174.0
Falling log prices			
$20	1%	-166.7	-233.3
	4%	-46.4	-39.2
	7%	-28.0	-9.5
$75	1%	-372.6	-480.6
	4%	-150.2	-159.6
	7%	-96.0	-86.4
$150	1%	-653.3	-817.9
	4%	-291.9	-323.8
	7%	-188.8	-191.3

Note: positive values represent a positive opportunity cost of forest withdrawal and, therefore, there is a positive cost to society of removing these areas from the timber harvesting land base.

5.3 Discussion

The purpose of this study was to estimate the opportunity cost of preserving more spotted owl habitat in BC, not only in terms of the value of foregone timber harvest, but including possible gains in other forest benefits such as recreation opportunities, non-timber forest products and carbon sequestration. Ultimately, the question is whether or not it is worthwhile, from a social perspective, to preserve more old growth forest, since it is the location of spotted owl habitat. There will be losses in terms of economic rent in the logging industry, but those costs could be offset, or more than offset, by gains in other forest values. Our results suggest that the latter situation (preservation benefits exceed opportunity costs) would prevail if either of the two management options for old growth forest preservation that we examined were adopted. Adding in additional benefits from preservation of old growth, such as ecosystem services other than carbon sequestration (e.g. watershed protection values) and non-use values such as existence cultural, spiritual and historical values, would only strengthen this finding and not change the essential results presented here.

Nonetheless, our results indicate that there could be a significant loss of producer surplus from timber harvests with implementation of either Suit100 or Terr100. The net present value of the loss in producer surplus is as high as $420.3 million with implementation of Terr100, assuming rising log prices and 1% discount rate. Revenues would fall by 35% with implementation of Terr100 and costs would fall by only 33%, which means implementation of Terr100 would result in almost a 60% loss of producer surplus compared to SOMPcurr (see Appendix C, Table C-1). A possible reason that profitability declines so much is that the areas set aside for preservation in Suit100 and Terr100 are some of the more valuable timber areas because they contain higher valued old growth logs. The harvest schedules under Suit100 and Terr100 would involve cutting more second growth timber and cutting it sooner than under SOMPcurr. Since second growth logs receive a lower price than old growth logs, total revenue would fall more than proportionally with a decrease in annual allowable cut.

In contrast, when the other selected forest values are added into the net forest value, most sets of assumptions result in a higher discounted net forest value for Suit100 and Terr100 than for SOMPcurr. So even though there is a positive opportunity cost in terms of the producer surplus from timber harvesting, many sets of assumptions lead to a negative opportunity cost when the other forest values are included; in other words, adding other forest benefits turns the loss to society from forest withdrawals into a gain. Of the other forest benefits, the value of net carbon change seems to be the most significant. There is relatively little difference between SOMPcurr, Suit100, and Terr100 in terms of recreation and non-timber forest products. The net present value of hunting, water-based and human powered recreation activities and non-timber forest products combined is only about 5% higher for Suit100/Terr100 than for SOMPcurr. With carbon, however, the net present value for Suit100/Terr100 is at least twice that for SOMPcurr, for most sets of assumptions.

As a result, there may be a net benefit to society from implementation of either Suit100 or Terr100, instead of SOMPcurr. Although we use a different approach and set of assumptions, this finding can be compared with the findings of earlier studies by van Kooten and Bulte (1999) and Stone and Reid (1997), which we reviewed in Chapter 2. Van Kooten and Bulte concluded that using average values for old growth benefits and costs that the opportunity costs of preservation were negative; that is, that no economic argument could be made for conserving old growth forests. However, using a more appropriate marginal analysis (considering ranges in site quality), it would be optimal for British Columbia to retain between 25% and 60% of its primary coastal temperate rainforest. Methodologically, our analysis falls somewhere in between the average and marginal value approaches, since we apply average values for some benefits and costs but on a very site specific basis, considering only a single forest region. Broadly, we would appear to be somewhat more optimistic about the net benefits of old growth conservation than can Kooten and Bulte, but not dramatically inconsistent.

Stone and Reid estimated the opportunity costs of old growth preservation for management options that included scenarios roughly similar to Suit100 or Terr100. However, they only estimated the opportunity costs in terms of producer surplus from timber harvesting. Their estimate of the opportunity costs, in 2006 prices, were over $1 billion, using a 4% discount rate and a 400 year time period. Their values were based on the full range of spotted owl habitat in BC. Our results for the opportunity costs of foregone timber producer surplus using a 4% discount rate are $42million to $155million, which are much lower for two reasons. First, our analysis covers a smaller area and a shorter time period; and second, since the time of their study log prices have fallen and timber harvesting costs have increased, reducing industry profits.

There were many sources of uncertainty when estimating net forest values for this study. Timber is one of the only forest values for which there is an established market and producer surplus can be estimated using market price and cost data. Other values, such as the value of carbon sequestration and emissions, must be estimated without the help of markets. However, even though current and historical data for log prices and harvesting costs are available, future trends in prices and costs are highly uncertain. Another source of uncertainty is the choice of discount rate. A high discount rate will put less weight on values in the distant future relative to values in the near future than will a low discount rate. Because of these uncertainties we chose to use a range of values for three of the most subjective parameters: the social discount rate, shadow price of carbon and future prices for logs.

Nonetheless, significant uncertainty remains and for this reason we carried out further sensitivity analyses of our results, allowing for additional adjustments in various parameters. We (a) use a higher shadow price for carbon of $350, (b) allow for increasing recreation values, (c) allow for rent capture by labour, (d) account for government forest management costs, and (e) allow for higher harvesting costs. Discussion of these sensitivity analyses follows, and results can be found in Table 5.3. For all cases except (e) we use a 4% discount rate and constant log prices, and for (e) we use rising log prices and a 4% discount rate.

Table 5.3

Sensitivity Analyses for Net Present Value (NPV) of the Opportunity Cost of Old Growth Forest Withdrawals, Assuming Constant Log Prices and a 4% DiscountRrate, in $millions

	Shadow price of carbon	SOMPcurr-Suit100	SOMPcurr-Terr100
Constant log prices & 4% discount rate			
Higher C shadow price	350	-626.6	-717.0
Recreation values increasing 0.5%/yr	20	-9.5	-2.1
	75	-113.3	-122.5
	150	-255	-286.7
Add labour rent $2.83/m³ (harvesting cost $77.15/m³)	20	30.2	39.8
	75	-73.7	-80.7
	150	-215.3	-244.9
Add government costs $6.53/m³ (harvesting costs $86.51/m³)	20	-80.8	-73.3
	75	-184.6	-193.8
	150	-326.3	-357.9
Rising log prices and 4% discount rate			
Higher harvesting costs ($89.78/m³)	20	-77.2	-68.0
	75	-181.1	-188.4
	150	-322.7	-352.6

5.3.1 Higher Shadow Price of Carbon

As discussed in Chapter 4, the *Stern Review on the Economics of Climate Change* (2006) estimates that the social cost of carbon should be about $350/tonne. This estimate has been widely criticized, so we did not include it in the main analysis.[34] Allowing for a shadow price of $350 significantly increases the net gains associated with implementing Suit100 or Terr100, compared to shadow prices of $20, $75, or $150. The opportunity cost estimates are more than twice as negative as the estimates are using a shadow price of $150.

5.3.2 Increasing Recreation Values over Time

It can be argued that recreation values will increase in the future because of various factors, such as population growth, increasing income, and increasing preferences for environmental goods. We allowed for a 0.5% annual increase in recreation values, which marginally increases the net gain associated with Suit100 or Terr100 compared to constant recreation values. The net gains from adopting Suit100 or Terr100 are about $10million when recreation values increase over time. Since recreation values do not differ dramatically between scenarios the impact on opportunity costs is comparatively small.

5.3.3 Rent Capture in Labor Wages

Several authors have raised the possibility that wages in the logging industry are higher than they would be if labor markets in BC, and in the logging industry in particular, operated normally (van Kooten and Bulte 1999). It is argued that the labor market is distorted by labor's ability to command higher wages than needed to attract sufficient labor to the industry.[35] In order to test whether labor capture of economic rent would have much impact on our calculations, we tested a model that incorporated this possibility. Perhaps the most important attempt previously to recognize labor market distortions and their impacts on estimation of economic rent was the study, *Natural Resources and Regional Disparities* (Copithorne 1979).

While very complex methodologies are needed to precisely measure the size of the captured rent, Copithorne used a relatively simple proxy measure that we adopt here. He assumed that wages in manufacturing represented a benchmark or reference point from which to assess unexpected gains in wages in the forest industry.[36] He used the Statistics Canada series for average weekly earnings (including overtime) by industry and province to make his adjustment. We carried out

[34] See, for example, "The *Stern Review* on the Economics of Climate Change" by William Nordhaus (2006) at http://www.econ.yale.edu/~nordhaus/homepage/SternReviewD2.pdf

[35] Several rationales have been advanced for why this might be so. One argument is that the stumpage formula has at times provided no penalty to industry profits when wages increase: the increase has simply been passed through as a reduction in the stumpage revenue earned by government. Thus, industry has not resisted wage demands as vociferously as it might if the impact on profits was more substantial.

[36] Indeed, a review of recent national data for average week earnings indicates that the wages in manufacturing are slightly lower than in logging, possibly due to the effects of higher logging wages for BC. Since BC dominates logging on a national scale, this would disproportionately boost the average in comparison to manufacturing (even if the latter includes relatively less important BC processing).

the same adjustment using equivalent Statistics Canada data for 2004 and 2005 (to match our harvest cost data).[37] We calculated a value of $2.83 per m^3 as a proxy for the rent captured from the harvest of logs in each scenario and added it back into the calculated rent (or, in other words, reduced harvest costs per cubic meter by this amount).

Including an adjustment for rent capture by labor results in an opportunity cost of adopting Suit100 or Terr100 that is higher than in our initial estimates where no allowance was made for rent capture. The opportunity costs are about $30 million higher in net present value terms when labor rent capture is incorporated, regardless of the carbon shadow price. However, using carbon shadow prices of $75 or $150 still results in opportunity costs that imply a net gain from adoption of Suit100 or Terr100, but a carbon shadow price of $20 implies a positive opportunity cost (net loss) from adopting the preservation scenarios.

5.3.4 Government Forest Management Costs

Government administrative costs are borne by the Ministry of Forests and Range for services such as fire and pest protection, forest stewardship, enforcement, and forest investments. Government costs should be included as harvesting costs because these costs are part of the total cost of forest management. Schwindt et al. (2000) estimate the net benefits of the Canadian salmon fishery, including government costs, and show that net benefits are actually negative once government costs have been included. The authors point out, however, that estimating government costs can be challenging because of the numerous public agencies involved and the fact that ministry services may overlap. The forest industry in BC is administered primarily by the Ministry of Forests and Range; however, services performed by other ministries may either enhance timber harvesting profitability (the Ministry of Transportation and Highways, for example, provides roadways adequate for large trucks) or resolve some of the problems possibly caused by the forest industry (the Ministry of Environment, for example, may incur costs due to soil erosion). Gale et al. (1999) estimate the share of government expenses that support unsustainable timber harvesting practices in BC by attributing a portion of the Ministry of Forests budget to timber harvest administration.[38] The authors use possible proportions of 20%, 40%, and 80% of the Ministry's budget.

For our analysis we want to estimate the costs borne by the Ministry of Forests and Range for the management of the total growing stock in the Fraser TSA. To estimate a government management cost we used the Ministry of Forests and Range *Service Plans* for 2003/04, 2004/05, and 2005/06, which outline the Ministry's budget. We included operating expenses in

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[37] Weekly earnings in BC for these two years averaged $868.38 per week in manufacturing and $978.29 per week in forestry and logging. Using Copithorne's approach, the difference of $109.91 per week would be attributable to rent capture by labor. According to the Coast Forest Products Association's *Economic Impacts* study, it took 0.515 person years of employment to produce a log harvest of 1000 cubic meters. Assuming 50 weeks of paid employment per year then the rent capture per cubic meter of harvest is $109.91 x 50 weeks x 0.515/1000, or $2.83 per m^3.
[38] The Ministry of Forests is now called the Ministry of Forests and Range

the following areas: protection against fire and pests, forest stewardship, compliance and enforcement, forest investment, timber pricing and selling, and BC Timber Sales. An average total operating expenditure was calculated in 2006 prices, based on the three budget reports. The average annual Ministry costs are $542 million, and with an annual provincial harvest of about 90 million m^3 government costs are about $6.03 per m^3. We added an additional $0.50 per m^3 to allow for capital depreciation and investment. Our estimate of government costs per cubic meter, therefore, is $6.53 per m^3, which is very close to a figure cited in the *Wilderness Committee Education Report* of $5.99 per m^3 in 2002 prices for the Lillooet Forest District (WCWC, 2002). Including government costs makes the opportunity costs more negative by about $80 million, meaning the net gain associated with implementing either Suit100 or Terr100 is substantially higher when government costs are considered.

5.3.5 Higher Harvesting Costs and Rising Log Prices

Finally, we allow for higher harvesting costs. In our earlier analysis, we used the more recent 2004 and 2005 harvesting costs estimates from the Coast Forest Products Association's *Economic Impact Report*, which were about $10 per m^3 less than older estimates using the same cost survey (1998 to 2001). While the more recent cost estimates may reflect advances in technology, lower harvesting costs could also be an industry response to lower log prices. When log prices are lower, logging companies may restrict their operations to areas where harvesting costs are lower as well. If log prices rise in the future, logging companies may find it economical to operate in areas where harvesting costs are higher. Therefore, we considered harvesting costs of $89.78 per m^3 using the older cost estimates, along with rising log prices and a discount rate of 4%. The opportunity costs are more negative by about $120 million with higher harvesting cost, so the net gain to society if Suit100 or Terr100 were implemented would be higher as well.

More importantly, the higher harvesting costs turn the opportunity costs of preservation from a positive to a negative value. Thus, if a rising price scenario is associated with higher harvesting costs (as seen historically) then the apparent net losses from adopting the two preservation scenarios are illusory (Table 5.3 versus Table 5.2). Instead, under higher harvesting costs, there may be significant net gains to society from implementation of either Suit100 or Terr100.

6.0 Conclusions

This study was concerned with valuing old growth forest habitat of the Northern Spotted Owl in BC, as part of an attempt to consider the desirability of protecting these forests from timber harvesting. We estimated the net forest value; consisting of economic rents from harvesting of timber and non-timber forest products, consumer surplus from recreation and damages avoided via carbon sequestration; under three forest management scenarios originally developed by the Spotted Owl Recovery Team (SORT). The study modeled several management scenarios using the simulation model (SELES) that was used to model outcomes for SORT, and which has been used extensively for projecting timber supply by the BC government. We considered only a single timber supply area, the Fraser TSA, located in the coastal forest zone of southwestern BC. The three management scenarios comprised a baseline scenario that corresponded to current management (SOMPcurr) and two "*with protection*" scenarios, one that sets aside all currently suitable old growth habitat (Suit100), and another that protects nesting territories even where these include immature forest at present (Terr100). As a measure of the extent of protection, Suit100 and Terr100 result in about a one third reduction in harvest in comparison to the baseline scenario. Thus, the impact of protection on timber harvests would be substantial in terms of the Fraser TSA, although amounting to less than one percent of the total provincial timber harvest.

The analysis is only partial since several important ecosystem values, such as watersheds, nutrient cycling, and control of soil erosion, were not included because of a lack of information on these values. New primary research will be needed to obtain these values. Nonetheless, this study provides a reasonably clear indication of the net economic benefits of protecting old growth forest in a representative timber supply area. Initially we considered the economic rents from timber harvests alone, ignoring other forest values. Most of the combinations of constant and rising timber prices and alternative discount rates generate positive economic rents from timber harvesting in the Fraser TSA. Thus, timber harvesting appears to be viable under these assumptions for all management scenarios. However, the opposite is true for an assumption of falling timber prices. Next, we assessed the foregone economic rent when our "*with protection*" scenarios are compared to the "*without protection*" scenario. For all three price trends and discount rates, <u>there is a positive opportunity cost associated with implementing either Suit100 or Terr100</u>, in terms of the producer surplus from timber. This indicates that there is foregone timber rent when old growth areas are removed from the timber base.

Once other forest values are factored into the analysis, and a comparison is made of the net forest value under each scenario, the results are different. The opportunity costs of shifting to forest protection turn negative under most sets of assumptions, and are only positive when we assume rising or constant log prices and a very low ($20 per tonne) shadow price of carbon. In other words, adding in other forest values under each scenario causes the two protection scenarios to yield higher net economic benefits than current management. This suggests that over most of the range of assumptions there would be a net benefit from implementing either Suit100 or Terr100 in place of SOMPcurr. This result is suggestive since we have included a selected number of the potential benefits of preservation and not all possible benefits. Including more benefits from the preservation of old growth, such as the value of several important ecosystem services that were excluded, would strengthen this result. Which scenario would provide the largest net benefits, Suit100 or Terr100, differs with the choice of discount rate and shadow price for carbon. In summary, there are very few, if any, combinations of pricing and discount rate assumptions that result in a positive opportunity cost from preserving old growth forest.

Our results show that old growth forests may have an alternative use in preservation, at least in selected areas. Removing these forest areas from the timber supply base leads to reduced economic rents from timber harvesting, since these tend to be higher valued forest stands, but this is more than offset by the gains from non-timber activities. Nonetheless, several shortcomings of the research cause us to advise caution in interpreting our research results. Since we could not use spatially explicit data describing the timber areas that would be withdrawn from the timber supply base, we applied average site values (per hectare) for non-timber activities. Sometimes these values were calibrated on a forest age class basis, using data from the SELES simulation, and values for carbon sequestration were based on predicted standing forest and harvest from the model as well. Despite some concerns about our inability to pinpoint precise values, we are confident that the use of a timber supply simulation model makes our estimates quite credible.

It is important that research on the values of old growth forests continue, as the state of our knowledge is poor, given the many outdated values or missing values for ecosystem services, such as nutrient cycling and soil erosion control, and biodiversity or cultural values. A key need is updated research on recreation values that can link these to specific forest age classes and site values. Coupled with more spatially explicit outputs from the SELES model, there is good potential for improved value estimates related to recreation. Further, the valuation of ecosystem services (except carbon sequestration) is in its infancy in BC and much more primary research is needed. A new study initiated by the authors will hope to fill this gap and provide a more complete set of forest values for the Fraser TSA and perhaps other areas as well.

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Appendix A: Methodological Review

As part of the initial development of the study we reviewed a large amount of literature dealing with methodological approaches. Economic analysis of land use options or tradeoffs involving forest or species protection has been subjected to a range of analytical techniques, from fairly simple cost-benefit calculations to sophisticated optimization and programming models. Thus, it was critical to consider a wide range of possibilities in devising our own approach. While some of these options were discussed in Chapters 2 and 3, this appendix presents a discussion of several other methodological approaches with relevance to the study. While of interest, these methodologies differ in intent from our ultimate objective, which was to assess the opportunity costs of setting aside old growth habitat. Therefore, they were rejected for use in this study.

A.1 Krutilla-Fisher Model

The Krutilla-Fisher model is a form of modified cost-benefit analysis but is treated separately here because it explicitly accounts for changes in benefits and costs over time in a manner that is relevant to endangered species and old growth conservation. Perman et al (1999) use this approach and assume the value of preserved wilderness will increase faster than the input and output prices for a development project. This assumption is based on availability of substitutes for the development products, changes in technology, and a high income elasticity of demand for wilderness. In the case of timber harvesting, the availability of building material substitutes will increase elasticity of demand for wood products, while the absence of substitutes for Spotted Owls and old growth forests may mean a low elasticity of demand for wilderness. Based on this reasoning, the model assumes the value of wilderness will grow relative to the value of a development project, and this decreases the net present value of a project. This consideration may be important in dealing with harvesting versus preservation of old growth forests. Perman emphasizes the importance of choosing an appropriate discount rate. It may be possible to use a different discount rate for the value of timber harvesting and the value of wilderness preservation but not all analysts agree, and there is some consensus that a single rate be used.

In another paper, Porter (1982) models the flow of commercial benefits, diminishing at rate δ, and weighted against a social discount rate and a flow of preservation benefits, growing at rate ρ. Growth of demand, ρ, is thought to be a result of the high income elasticity of demand for outdoor recreation, continued growth of national income, and continued reduction in the supply of wilderness areas. The author determines that projects will be unprofitable with social discount rates that are below or above a certain threshold. This model illustrates how even if $(\delta+\rho)$ is as small as 0.01, the net present value of the development project, D, must be at least 1.5 times as large as the net present value of preservation, P, to make a development project worthwhile. The larger is $(\delta+\rho)$, the larger D must be in proportion to P. However, these results are contingent on the assumption that δ is negative and ρ is positive. While the assumption that ρ is positive may hold in the case of spotted owls, the assumption that δ is negative will only hold if timber plantations exhibit diminishing productivity. The model may have similar implications if δ is positive but smaller than ρ.

Porter also shows that if a development project with a currently positive net present value is going to be delayed for a period of time, its net present value may become negative as the length of the delay increases. This model also differentiates between the resource flows from the project that stem from changes in investment versus consumption. If they reflect changes in investment, then the discount rate should be a social rate of return on investment, *r*, rather than a social rate of discount (time preference), *i*. Because of taxation, *r* is thought to be greater than *i*, and, if treated as such, will decrease the present value of a project.

A.2 Safe Minimum Standard (SMS)

The safe minimum standard approach preserves a minimum level of a natural resource unless the opportunity cost is too high. This minimum level for the spotted owl case would be defined as the threshold below which extirpation of the spotted owl in BC would be highly probable (e.g. minimum viable population). This model was developed as a "better safe than sorry" approach to situations where costs and benefits include high levels of uncertainty. Preservation of endangered species and old-growth forests may likely yield a substantial payoff in the future from unforeseen benefits of genetic diversity, climate stabilization, etc. Setting a safe minimum standard is a way of insuring against the loss of this potential. The main drawback of this method is the arbitrariness of the decision criterion. Defining the level at which the opportunity cost is "too high" is left to social and political processes rather than theoretical evaluation. The main contribution of this method is the incorporation of a precautionary principle that would help retain the possibility for future generations to make decisions about resource use.

In Berrens et al. (1998), the SMS approach is used as a collective choice rule for situations with high levels of uncertainty and potential for irreversible damages, but limited knowledge about the parameters surrounding the potential for damages. The case studies in this paper apply a general equilibrium model to assess the direct and indirect economic consequences of habitat preservation for endangered species. Measuring the economic impacts requires a regional economic model, either an input-output or a general equilibrium model that identifies both net and distributional effects. A general equilibrium model assesses the full effect of economic impacts on all areas of the economy. In this paper, the authors estimate the regional and sub-regional impacts on output and employment. In both case studies, while the impacts were not evenly distributed, the impacts were judged to be not "too high".

Crowards (1998) proposes that the SMS model overestimates the opportunity cost of preservation because the benefits of preservation are not subtracted from the opportunity costs. The benefits of preservation include expected benefits as well as unquantifiable unanticipated benefits. Acknowledging these unknown benefits means a development project should therefore only go ahead if the net expected benefits are considerably greater than zero, or if the benefit cost ratio is high rather than simply greater than one. The author advocates adoption of some level of a SMS to insure against species extinction that could possibly lead to further large but very uncertain losses, following Ciriacy-Wantrup's idea of "minimizing maximum possible losses".

Application of this model to the Spotted Owl study would require determining the minimum critical habitat area for species survival. This requires considering space; availability of food, water, and other physiological necessities; sites for shelter, reproduction, and breeding; and appropriateness of other habitat features based on similarity to historical habitat. Determining the economic impacts of reducing timber harvest to satisfy this SMS would require a comparison between meeting and not meeting the SMS. Furthermore, applying this method to analysis of the Spotted Owl case would require a definition of "unacceptable" social costs. Seidl and Tisdell (2001) discuss the application of a cost minimization strategy to an institutionally defined SMS. For the spotted owl case, the SMS may be survival of the species in B.C.; a SMS approach would involve defining a minimum probability of survival and finding a strategy to reach that goal with a minimum opportunity cost.

A.3 Marginal Opportunity Cost

Pearce and Markandya (1989) discuss how estimating the marginal cost and marginal benefit of timber harvesting at the current level can indicate whether forests are being over- or under-exploited. The marginal opportunity cost consists of a direct cost, or the opportunity cost of resources used in the resource extraction; an external cost, or the opportunity cost of other resources negatively affected by the resource extraction; and a user cost, or the opportunity cost of having to use substitutes when the resource becomes exhausted in the future. The last component is only positive when the resource is being extracted at an unsustainable rate. However, there is no consideration of benefits as the approach is strictly concerned with determining the full social costs of production activities.

A.4 Trade-off Curves

Ward (2006) uses trade-off analysis to model how much of one input must be sacrificed, e.g. timber, to gain more of another output, e.g. endangered species survival. This type of analysis addresses two questions: first, what is the change in quantity of outputs X_1, X_2, …X_N caused by a policy to supply more units of output Y; and second, how does the monetary value of lost units of outputs X compare to the value of the gain in output Y. The trade-off between the net present value of timber harvest and number of spotted owl pairs is described by a production possibilities curve that is concave to the origin, the slope of which is the rate at which the net present value of timber harvest would be traded for spotted owls. This implies an assumption that the land most valuable for timber is the land least suitable for spotted owls. There is some debate about whether the production possibilities curve should be concave or convex to the origin.

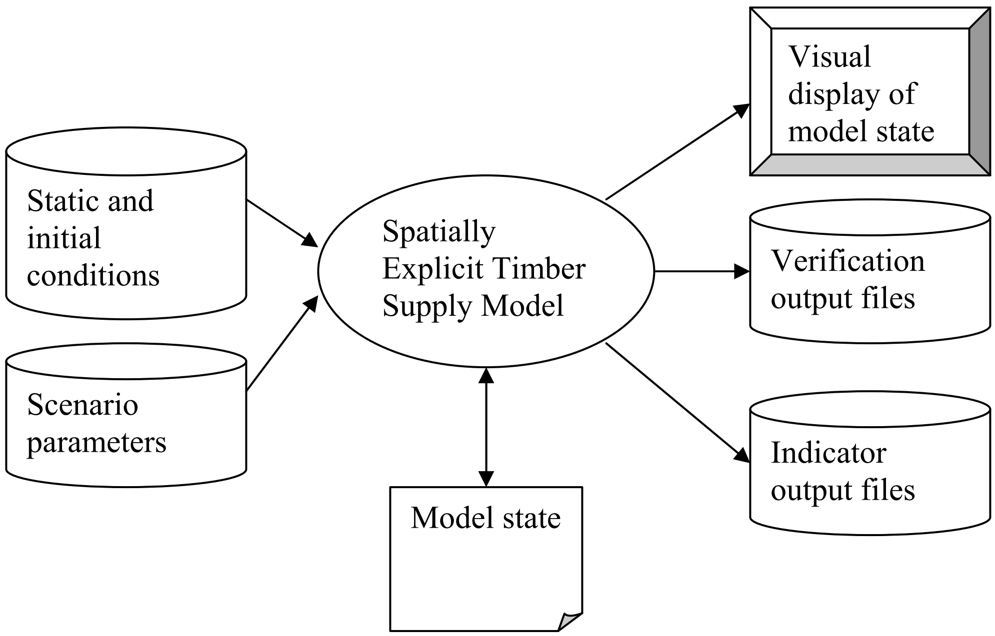
Appendix B: Detailed Parameter Assumptions

This appendix details the assumptions supporting the parameter estimates presented in Chapter 4.

B.1 SELES and Timber Supply Data Generation

Figure B-1

Schematic of the Spatially Explicit Timber Supply Model



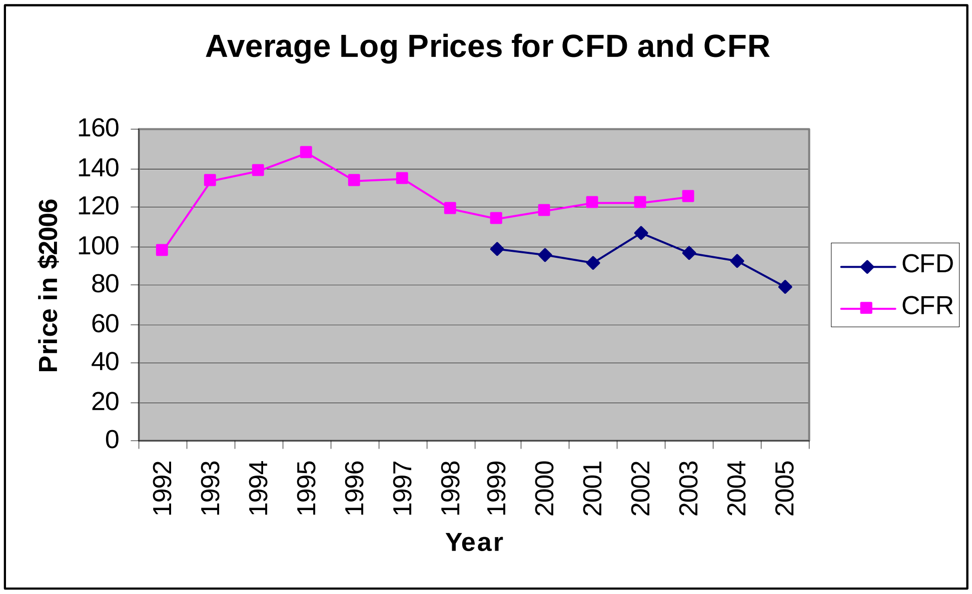
Source: reproduction of figure 5 in Sutherland et al. (2007). The Spatially Explicit Timber Supply Model is the component of the Spatially Explicit Landscape Event Simulator (SELES) that generates timber supply data under different management scenarios.

B.2 Assumptions about Timber Price Changes over Time

Figure B-1 shows average log prices (old growth) for the Coast Forest Region and the CFD between 1992 and 2005. Log prices within the CFD are slightly lower than for the Coast Forest Region as a whole, likely because there is less cedar in the CFD compared to other forest districts. There is a significant difference in log prices between the 1993 to 1997 period and the 1998 to 2003 period for the Coast Forest Region. Between 1993 and 1997 the average price in \$2006 was \$137 per m^3, and between 1998 and 2003 the average price was \$120 per m^3.

Figure B-2

Average Log Prices for the Chilliwack Forest District and the Coast Forest Region



Source for CFR data: *Analysis of Woodflow in the Coast Forest Region*, and for CFD data from the Harvest Billing System and Coast Log Market Reports.

It is feasible that log prices could recover to the 1993-1997 level, which was about 14.5% higher than the more recent price trend. Also, according to a 1993 Forest Resource Development

(FRDA) report (Simons et al., 1993), log prices rose by about 0.3% per year in real terms between 1965 and 1991, although price trends differed by species. Cedar prices tended to rise by about 1.2% per year, for example, while hemlock prices fell by about 0.3% per year. The authors predict an average price increase through the first half of the 21st Century of about 0.2% per year.
Log prices are sensitive to many factors, including changes in demand, inventories, and wood quality. In all three scenarios cedar inventories, for example, drop substantially after the first decade. If demand for cedar remains the same, prices for cedar would increase. It is unclear, however, how timber revenue would be affected, and whether the possible increase in cedar prices would carry through the long run, or if higher prices would trigger increases in inventory investments, and an eventual increase in supply and decrease in price. Since our time horizon is only 100 years, however, there is not enough time for a possible increase in supply.

We will apply the FRDA price forecasts to the scenario in which prices rise over time. The authors of the FRDA report constructed their predictions of future prices by first estimating the statistical relationship between historical price trends and historical market factors. The authors found that log prices were largely determined by lumber prices (which are indicative of demand), timber inventories, logging labour productivity, and real wages. Lumber prices, in turn, were found to be dependent on factors such as future housing starts in Canada, the US, and Japan, changes in technology, and sawmilling labour productivity.

There are other factors that support the idea that log prices in the Coast Forest Region may start to increase in the near future. Part of the reason prices have fallen over the past few years in the CFD is the substantial increase in log supply from the interior due to the pine beetle epidemic. Mills on the coast are being flooded with lower priced beetle kill logs and therefore demand for coast logs has fallen. When the excess supply of beetle-kill logs from the interior starts to diminish, demand for coast logs will likely increase along with the price.[1]

While the forecasts in the FRDA report were estimated over a decade ago, the report's predictions for the current period, 2000 to 2010, were accurate in that they predicted a downward trend. They predicted that while Douglas fir log prices would increase by about 0.1% per year during this period, cedar log prices would fall by about 0.7% per year, and hemlock and balsam log prices would fall by about 0.4% per year. The authors do not provide predictions for the less common spruce and deciduous species.

Using their predictions for the period of 2010 to 2040, the average annual price increase for Douglas fir would be about 0.2%, for cedar about 0.4%, and for hembal about 0.1%. For spruce and deciduous logs we will assume an average annual increase of 0.2%. These are the price trends we use to estimate timber value under the assumption of rising future prices.

The FRDA report did not account, however, for the possibility of increased global competition in the supply of logs and wood products. Increased competition from countries with much lower labour costs, such as Russia, could drive down log prices. Russia has been substantially

[1] This is particularly true for pulp grade hembal logs. Excess chip supply from the interior is driving down the price of coastal pulp logs.

expanding its log and lumber production over the past few years, and a large proportion of its log supply is still higher quality old growth. According to a 2003 report by R.E. Taylor & Associates, Russia is currently harvesting less than a quarter of the sustainable annual allowable cut, which means log supply from Russia could continue to increase well into the future. How much this growth in log supply from Russia affects log prices for coastal British Columbia depends on how well Russian logs can compete with BC logs. Russian forests are dominated by pine, spruce, and larch, none of which are a significant portion of the harvest within the CFD. The degree to which prices for cedar, Douglas fir, and hembal will be affected will depend on how well pine, larch, and spruce can act as substitutes. For example, Japan has historically been a significant consumer of hembal logs from BC, and as the Japanese economy recovers so too will their demand for logs. If Russia continues to satisfy a large portion of Japanese demand for logs and lumber then hembal log prices in BC may not recover to the level enjoyed in the 1990s. To illustrate the effects of assuming declining future log prices, we test an arbitrarily chosen annual price decrease of 0.2% per year for all species.

B.3 Detailed Timber Harvest Costs

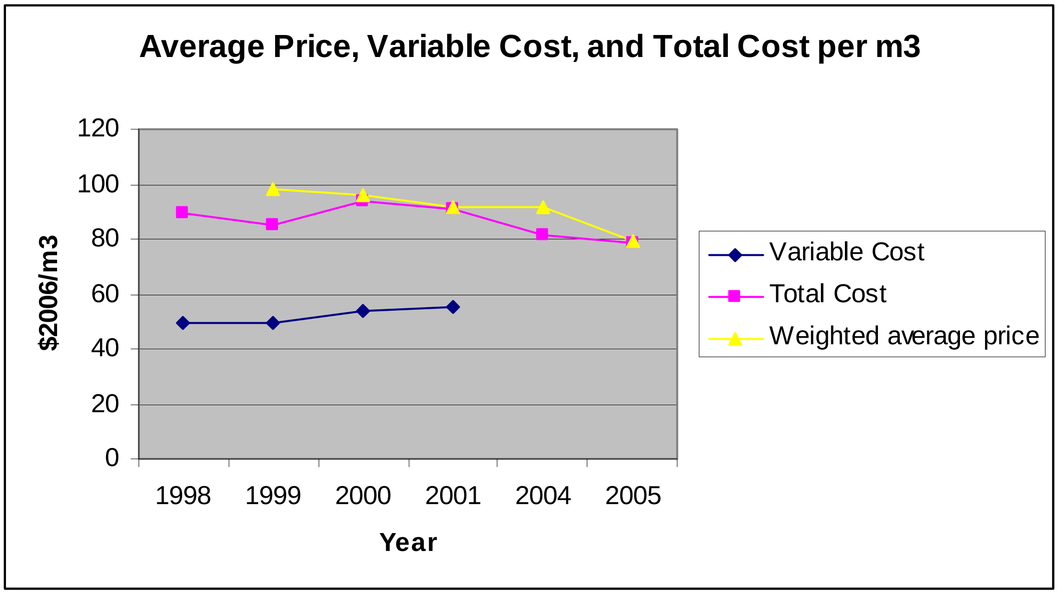
Variable cost estimates provided in the *Analysis of Woodflow* report include falling, bucking, yarding, loading, and other direct costs while total costs also include road construction/maintenance, overhead, and head office administration costs. Road cost estimates could not be distinguished from overhead costs as reported in the *Analysis of Woodflow* report, so in order to include variable road costs in the estimates of variable harvesting costs, we used road building requirements generated by the SELES output. Each year a certain total distance of road is predicted to be built, to which we applied an estimated road building cost of $60,000 per km derived from the *Coast Appraisal Manual 2004*. An accurate road cost estimate requires knowledge of slope, substrate type, bridge requirements, and other detailed information not provided by SELES, so instead we chose a low to mid range value of $60,000 per km from the subgrade construction cost estimates provided in Table 5-2 of the *Coast Appraisal Manual 2004*. This estimated road building cost, as well as an estimated silviculture cost of $4.59 per m^3 derived from the *Coast Appraisal Manual*, are added to a variable cost estimate based on an average of the estimates provided in table 4.1 of $51.79 per m^3. When applying the estimate for total cost we do not include the SELES generated road building cost estimates because road building costs are already included. For total cost we use an average from table 4.1 of $86.51 per m^3.

Figure B-3 compares the variable and total harvesting costs to a species weighted average price derived from harvest data for the Chilliwack Forest District. While prices have been higher than variable costs, prices have barely covered total costs in some years. This is consistent with anecdotal evidence of industry wide losses, especially in years just prior to 2004.

Timber harvesting costs are going to change over the next 100 years, but as with forecasting price trends, estimating the changes is highly subjective. The two main reasons costs have

Figure B-3

Average Price for CFD and Harvesting Costs for CFR



Source: cost estimates are from *Analysis of Woodflow* and our own estimates; price estimates generated from the Harvest Billing System and Log Market Reports.

been high over the past decade are stricter environmental regulations and increasing access costs.

Stricter environmental regulations came in the form of the Forest Practices Code (now the Forest and Range Practices Act) in 1995, which increased standards in such areas as road building, riparian and wildlife protection, reforestation, and watershed protection. Access costs have been high and will continue to be high until the closer, more easily accessible stands that have already been harvested become available for harvest again. Timber harvesting firms naturally harvest the closer, more benignly situated stands first, and currently in the CFD these stands have for the most part been logged and are not yet available for a second harvest. Instead firms must harvest in more remote areas that are costly to access because roads are more difficult to construct and helicopters may be required. Once the previously harvested stands become available, however, harvesting costs should decrease because harvesters can use less expensive ground based equipment to harvest, and because harvesters can reactivate old logging roads rather than having to build new ones. Reactivating roads only costs about \$5,000 to \$10,000 per km compared to about \$60,000 per km required to build new roads.[2]

This decrease in harvesting costs can be partially captured with the SELES output on road construction requirements, which shows a steady decrease in required kilometers of construction over the next 100 years. A calculation of road construction costs per m^3, using a road construction cost of \$60,000 per km and SELES output on harvest volume and road construction requirements, reveals a decrease of about \$10 per m^3 over the 100 year period. The road construction costs cannot be isolated in our estimate of total cost, so to capture the decrease in total cost due to decreasing in road construction costs we will assume total costs fall \$10 per m^3 over the 100 year period, or \$0.10 per year.

As harvesters begin harvesting second growth timber, harvesting costs will decrease because there will be lower road costs and the terrain will be more benign. This fact, along with an assumption that harvesting technology will continue to improve, means that harvesting costs could decrease in the future. However, it is also likely that environmental regulations could become stricter in the future, since societies tend to demand more environmental quality as economies grow, and meeting stricter standards would mean higher harvesting costs.

B.4 Predicting the Effects of Timber Harvesting on Independent Recreation

Recreation benefits will be affected not just by logging on the site where recreation activities take place, but also by logging on adjacent sites. Visual benefits will be diminished for recreation activities that occur in sight of logged areas, and soil erosion could negatively affect almost all types of activities. As well, there could be a change in 'isolation' benefits people derive from recreating in areas with fewer people, depending on the activity. With continued logging in the base case scenario, there will be more logged area for participants of hunting and motorized activities, thereby decreasing the population density and increasing benefits from isolation. For participants of human-powered activities, however, who prefer uncut areas, continued logging in the base case scenario will force participants to concentrate their activities on a smaller land base, thereby increasing crowding and decreasing benefits of isolation. There may also be increased crowding in BC's parks if people who prefer a pristine environment

[2] Based on conversation with Geoff Tindale at the CFD office March 26, 2007 and the *Coast Appraisal Manual 2004* table 5.2.

choose to recreate more in parks and less in provincial forests.

There are a number of studies that estimate the impact of logging on recreational activities. Hunt et al. (2000) examined outdoor recreation participants' preferences for logged settings and found that respondents who participated in angling, hunting, snowmobiling, or motorized water vehicle activities had higher preferences for recreating in logged areas than respondents who participated in human-powered activities such as biking, hiking, water sports, and cross-country skiing or snowshoeing. Englin et al. (2000) developed a marginal amenity value curve for wilderness canoeing in Manitoba in jack pine forests at varying recovery stages after fires. Given that jack pine stands are considered 'old growth' after an age of 65 years, they estimated a two part equation for an individual's amenity value function.

Other recreation activities that benefit from harvesting will generate maximum values at different stages of stand growth. Activities that rely on clearings, such as snowmobiling and ATV use, will only benefit in the interim between harvesting and replanting. Hunting activities will do better when stands are young, as this provides good habitat for game. Calish et al. (1978) gathered information to show how the yield for different non-timber forest products evolves as Douglas fir stands age. They find that elk, for example, will not populate a forest unless it is at least about 20 years old because younger forests do not provide adequate protection. Hunting yields for elk rise steadily after the minimum age of 20, peaking when trees reach the age of about 35, and then slowly declining to about half the peak productivity values by a stand age of 100. Columbian black-tail deer will populate a forest from the very first stages of growth, and hunting yields will peak when the trees reach an age of about 25 and then the current annual increment of harvestable animals per hectare will level off by the time the trees are about 35 years old. The population density of black bears will also peak when trees are young because berries are a major food source for bears, and berries flourish in a more open canopy. Black bears are commonly found in clear cuts, and stands of 15 year old trees hold the highest population densities.[3]

These earlier studies were consulted in developing time profiles for recreation benefits under harvest conditions. Motor-powered land activities most often occur where there are logging roads to follow, although participants will go on clear cuts and wherever there is adequate spacing between trees. We assume values associated with these activities are closely related to willingness to pay for accessibility, visual aesthetics, and wildlife diversity. Since logging will increase accessibility but decrease visual aesthetics and wildlife diversity, we cannot make any unambiguous assumption about the net effect on recreation values. There is also little to no literature on the effects of timber harvesting on recreation values from land-based motor-powered activities. We leave this to future research and focus on the other categories of recreation activities.

Hunting activities generally require road access, but there are also forest cover requirements for

[3] Calish, et al. (1978) also found that the yield curve for cutthroat trout, which is directly related to sedimentation caused by logging, will steadily rise after timber in the watershed has been harvested, from a current annual increment catch per hectare value of about 0.18 at year 0 to 0.52 at year 30. The authors also look at how non-game wildlife diversity and visual aesthetics change as Douglas fir stands age. Using a 0 to 1 index, they find that both wildlife diversity and aesthetics rise steadily as trees age.

wildlife habitat, as discussed above. We assume values associated with hunting will increase steadily after a stand has been harvested, peak at around 20 years, and then fall steadily. We choose year 20 to be the peak as this is the midpoint between the peak for black bears and black-tailed deer, the two main species in the CFD. We assume that hunting values have a long run average of $0.82 per hectare, but that the value follows a pattern of increasing after logging and then decreasing after 20 years. We mimic the curve for current annual increment of harvestable animals per hectare given for Columbian Black-tailed deer given in Calish et al. (1978), as this is the most relevant model available. To create a per hectare recreation value progression with a long run average of $0.82 per hectare, we use a starting value of $0.69 per hectare for a forest at age 0, which steadily increases at $0.11 per year until it reaches $2.78 per hectare at age 20, then declines at $0.20 per year until it levels off again at $0.69 per hectare per year at age 30, as illustrated in Figure B-4.

The value participants of water-based and human-powered activities, such as boating, angling, and hiking, place on forests we assume largely consists of watershed benefits for angling, and willingness to pay for visual aesthetics and wildlife diversity, all of which increase continuously as forests age. Harshaw and Sheppard (2004) assume forests are visually acceptable at age 28 for forests in the Lemon Landscape Unit near Kokanee Glacier Park, while the model created by Englin et al. (2000) shows aesthetic recovery beginning at age 17 and leveling off at age 65 for forests in Manitoba.[4] Current annual increment curves in Calish et al. (1978) are lowest at age 0 and level off when forests are at age 30 for cutthroat trout, age 50 for wildlife diversity, and age 100 for visual aesthetics. Choosing a profile for recreation values for the Fraser TSA based on these other studies is a fairly arbitrary process for two reasons: first, forests are much different in the Fraser TSA than the forests upon which these studies are based; and second, recreation values are not a function of only age. Because forests in the Fraser TSA take longer to reach old growth conditions than forests in Manitoba or the Kootenays, we assume recreation benefits increase from $0 per hectare at age 0 and level off at age 100, as illustrated in figure B-5. Instead of calculating a net present value for each hectare, which would vary according to the age of the forest when it was harvested as well as the year in which it is harvested, we calculate the total area of growing stock within each forest age class each year. We then assign different values to the different age classes.

To estimate the different age class values we assume that, as with hunting values, the average per hectare water-based and human-powered recreation value from the *Outdoor Recreation Survey 1989/90* is representative of stands of all ages. Taking the total growing stock age class profile at year 0, which is identical for all three management scenarios, we estimate a value per hectare for each age class that will form a weighted average of $59.70. At year 0, 8.2% of the total growing

Figure B-4

Hunting Use Values

[4] Harshaw and Shepard's assumption of a green up age of 28 is based on the *Arrow TSA Analysis Report* (2000), BC Ministry of Forest, Timber Supply Branch, Victoria.

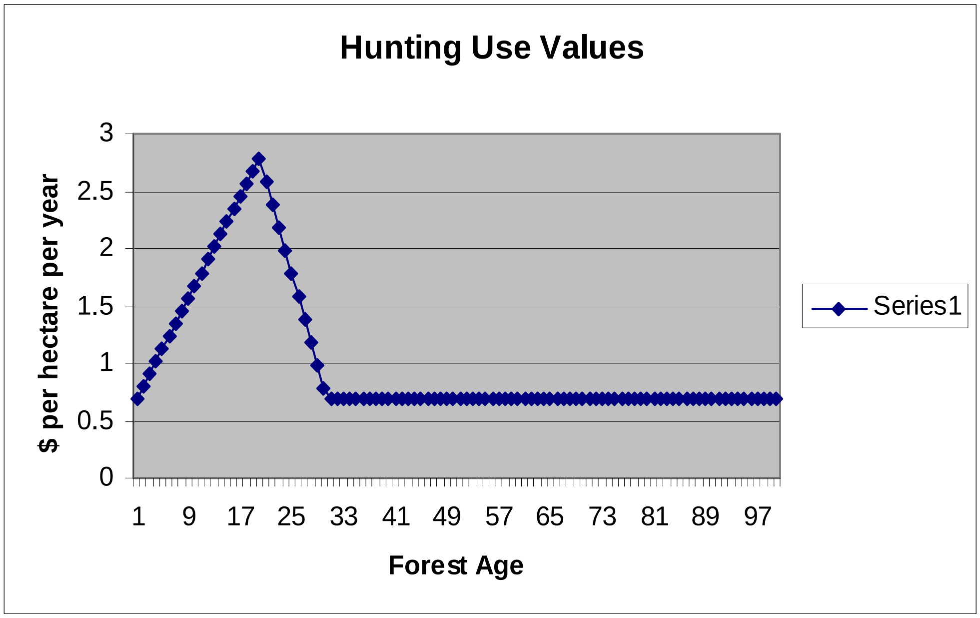
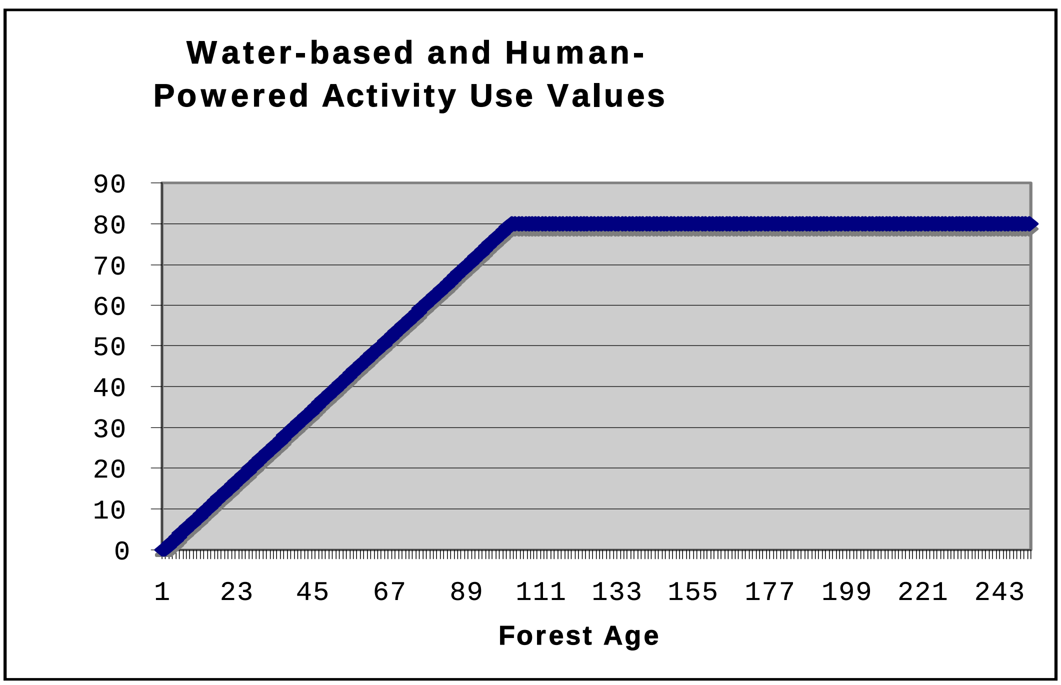


Figure B-5

Water-based and Human-powered Activities Use Values



stock in age class 1 (0 to 20 years), 11.6% is age class 2 (21 to 40 years), 8.5% is age class 3 (41 to 60 years), 6.4% is age class 4 (61 to 80 years), 4.8% is age class 5 (81 to 100 years), 6.4% is age class 6 (101 to 120 years), 6.1% is age class 7 (121 to 140 years), 19.9% is age class 8 (141 to 250 years), and 28.2% is age class 9 (over 250 years). Using values of $8 per hectare for age class 1, $22 per hectare for age class 2, $36 per hectare for age class 3, $50 per hectare for age class 4, $64 per hectare for age class 5, and $78 per hectare for age classes 6 through 9 gives a weighted average of about $59.70 per hectare. We multiplied these values by the total area in each age class in the total growing stock for every year, then discounted and summed to arrive at a net present value for each management scenario.

B.5 Estimating Producer Surplus from Outdoor Recreation

To estimate the producer surplus from commercial outdoor recreation in BC, we used information compiled by Tourism BC's Research Services. Their 2004 report, *Economic Value of Commercial Nature-Based Tourism in British Columbia* (Tourism BC, 2004) compiled data on businesses that offer mid and backcountry tourism services. Activities included in the definition of commercial nature-based tourism are described in Table B.4. Because the timber harvesting landbase in the Fraser TSA is not located near any salt water bodies, we exclude businesses that fall into the marine or salt water fishing categories. The total number of businesses in the Vancouver, Coast and Mountains region, excluding marine based businesses, is 296, which is 13.5% of all nature-based tourism businesses in BC and 27.7% of all non-marine based tourism businesses in BC.

Economic Value of Commercial Nature-Based Tourism in British Columbia estimates the total revenue of all nature-based tourism businesses in BC, but does not divide the revenue estimates by region. The revenue estimate is, however, divided by sub-sector, which shows that non-salt water based businesses account for 63% of revenue. If non-marine based tourism businesses account for 63% of total revenues and the Vancouver, Coast and Mountains tourism region contains 27.7% of those businesses, the total revenue that could be attributed to mid and backcountry areas in the Vancouver, Coast and Mountains region is 17.5% of the total reported revenues of $970.8 million in 2001, or $169.4 million. In 2006 dollars the share would be $188.1 million.

This revenue estimate includes revenue generated through guided activities, equipment rental for self-guided activities, accommodation, meals, merchandise, and all-inclusive packages. Since not all of these categories are directly related to wilderness land, we cannot attribute the entire $188.1 million to the land. We assume that revenue generated from guided and self-guided activities and a proportion of the revenue from all-inclusive packages, which include guided activities, can be directly attributed to wilderness land. A proportion of the revenue generated through accommodation, meals, and merchandise could only be attributable to wilderness lands if the price for these goods included a premium for being linked to the wilderness land.

According to the Tourism BC report, 58% of revenue is generated through guided and self-guided activities; 14% is generated through accommodation, meals, and merchandise; 25% is

Table B-1

Nature-Based Tourism Activities

Bird watching	Fresh water fishing	Riding all terrain vehicles

Back country or tour skiing	Guest ranch	River tours
Canoeing	Hang gliding or para-sailing	Rock/ice climbing, mountaneering
Cat skiing or snowboarding	Heli-skiing or heli-snowboarding	Salt water fishing
Caving of spelunking	Hiking or backpacking	Scuba diving or snorkelling
Cross country or skate skiing	Horseback or trail riding	Sea kayaking
Cultural or historic nature-based	Hunting	Snowmobiling
Cycling or mountain biking	Llama trekking	Surfing
Day sailing or windsurfing	Multi-day yacht cruising	Whale watching
Dog sledding	Power cruising	White water kayaking
Education, nature / outdoor	Rafting	Wildlife/nature viewing/photography

Source: reproduced from page 5 of *Economic Value of Commercial Nature-Based Tourism in British Columbia*

generated through all-inclusive packages; and 3% is generated through other activities. We assume the 58% of revenue from guided and self-guided activities and half of the 28% of revenues from all-inclusive packages and 'other activities' can be attributed to wilderness lands. We thus assume 72% of the $188.1 million in revenues can be attributed to wilderness lands, or $135.5 million.

Tourism BC Research Services was unfortunately unable to collect data on profit levels, and this makes estimating the producer surplus generated within this industry a challenge. We know that 70% of businesses had revenues that exceeded expenses, 26% had expenses that exceeded revenues, and 4% broke even. Operating surplus from the guide outfitting industry used in *The Guide Outfitting Industry in BC: an economic profile of 2002* (GSGislason & Associates Ltd, 2002) is 14% of revenues, although this includes amortization and depreciation as well as corporate profits. Assuming producer surplus is about 5% of revenues on average, total producer surplus for the Vancouver Coast and Mountains Region is about $6.77 million.[5]

The Vancouver Coast and Mountains Region does not align with the Chilliwack Forest District, but includes parts of the Squamish and Sunshine Coast Forest Districts as well. By comparing maps we estimate the Fraser TSA accounts for just less than half of the Vancouver Coast and Mountains Region, or about 45% of the land base. Assuming the tourism industry is spread evenly across the region, we can attribute 45% of the industry's producer surplus to the CFD, or about $3.05 million. The data does not, however, allow us to divide the producer surplus between provincial forests and provincial parks. While some sectors of the industry, such as guide outfitters, would not be allowed to operate in parks, non-consumptive sectors that offer activities such as nature viewing and river rafting would be able to operate in parks or provincial forests. The total area of provincial parks and forests in the CFD is 1.08 million hectares. A total producer surplus of $3.05 million over 1.08 million hectares means each hectare generates about $2.82 per year in producer surplus.

B.6 Detailed Productivity Estimates for Forest Mushrooms

Studies on biological productivity (Freeman, 1997; Pilz et al., 1999; Liegel, 1998) provide estimates of biological productivity on known productive sites, but there is no accurate information on the total area of productive sites within the CFD. The data for ecosystem characteristics provided by SELES is not detailed enough to accurately predict which areas in the CFD would produce pines and which would produce chanterelles. The best estimate we can make is to assume mushrooms can grow productively within any stands in age classes 3 through 7 which are not cedar dominated.[6] A more accurate estimate of mushroom productivity would require data on soil moisture content, elevation, and aspect; however, this information is not available. In the following two sections we use estimates of total provincial harvest levels of pine and chanterelle mushrooms to get a value for average mushroom harvest per hectare of non-cedar dominated, age classed 3 through 7, productive forest land in the CFD.[7]

Pine mushroom productivity

Freeman (1997) estimated biological productivity in the Nahatlatch watershed, which is northwest of Boston Bar and is the most important site for commercial pine mushroom

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[5] A figure of 5% is also used in the *Socioeconomic Baseline Analysis* (Pierce Lefebvre Consulting, 2005).
[6] Discussion with Andy McKinnon
[7] Productive forest land is considered the total TSA area net of land not managed by the BC Forest Service and non-forest or non-productive forest (page 11 of Fraser TSA Analysis Report, 2003)

harvesting in the CFD. Freeman estimated that 5,988 hectares of the 125,770 hectare study area is productive pine mushroom habitat, and in 1996 this area generated a harvest of between 10,202 kg and 11,774 kg of pine mushrooms from a total biological production of 19,799 kg.[8] Total biological productivity is therefore an average of 3.3 kg per hectare on productive sites or 0.16 kg per hectare for the study area. The average volume harvested was between 1.7 kg per hectare and 2 kg per hectare on productive sites, or between 0.08 kg per hectare and 0.09 kg hectare for the study area.

Using import statistics gathered by Royal Roads to estimate harvest levels, the average volume of pine mushrooms harvested in BC between 1995 and 2005 was 356,420 kg. This is comparable to the estimate by Wills and Lipsey, 1999, of between 250,000 kg and 392,000 kg per year depending on weather conditions. The forested area of the province is about 60 million hectares, and pine mushrooms reportedly grow in about 24 of BC's 37 timber supply areas.[9] The total area of productive forest within these 24 TSAs is 15.4 million hectares. Using a total harvest of 356,420 kg, that averages to about 0.023 kg per hectare. The CFD has 636,675 hectares of productive forest, which means approximately 4% of the provincial harvest, or 14,700 kg of pine mushrooms are harvested from the CFD per year. This is more than reported in Freeman (1997), in which total harvest from the Nahatlatch Valley (the primary pine mushroom producing area in the CFD) is estimated as between 10,202 kg and 11,774 kg, but reasonable given that pines are also picked in other areas within the CFD.

There may be in addition some volume that was consumed locally, either by pickers themselves or by local communities. According to Freeman (1997) surveyed pickers reported personally consuming approximately 2% of their harvest. If 14,700 kg is the annual volume sold, then there is approximately an additional 300 kg consumed annually by pickers. According to Godoy et al. (1993), this share of the harvest should be valued using the market price rather than the price paid to pickers.

For pine mushroom production, if 14,700 kg are harvested in the CFD annually, and we assume a harvest rate of 50% (Freeman, 1997; Alexander et al., 2002), then total biological production is about 29,400 kg. Freeman estimated biological productivity to be about 3.3 kg per hectare in productive areas of the Nahatlatch watershed, while Pilz et al., 1999, estimated 4.3 kg per hectare on productive sites in Oregon. If we assume an average biological production of about 3.8 kg per hectare, then there are about 7,684 hectares that produce pine mushrooms within the CFD. Freeman, 1997, estimated 5,988 hectares within the Nahatlatch watershed, which is the prime pine mushroom producing area within the CFD. Since we know there are other pine mushroom producing areas, our estimate of 7,684 hectares seems reasonable. 7,684 hectares is 1.2% of the total productive forest, or 2.9% of the timber harvesting land base. Averaged over the whole forest district, total biological productivity of 29,400 kg would be about 0.046 kg per

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[8] In general harvesters tend to capture about half of the total amount of mushroom volume that grows. Pine mushrooms are most valuable when picked in the young button stage, which does not last long, so many mushrooms are past their prime before they are found.

[9] The estimate of 60 million hectares is from http://www.bcforestinformation.com/undisturbed_overview.asp. All 9 TSAs in the Coast Forest Region, plus Kootenay Lake, Arrow, Kalum, Nass, Lillooet, Williams Lake, Merritt, Robson Valley, Dawson Creek, Cranberry, Kispiox, Bulkley, Morice, Lakes, Golden, and Revelstoke. These areas were identified using Berch and Wiensczyk, 2001, and http://bcmushrooms.forrex.org/ntfp/index.html

hectare on productive forest land or 0.11 kg per hectare on the timber harvesting landbase.

Pacific Golden Chanterelle productivity

Wills and Lipsey (1999) estimate that BC produces a harvest of between 187,500 kg and 750,000 kg per year of Pacific Golden chanterelles, depending on weather conditions. Chanterelles grow in the Coast Forest Region as well as in some of the southwestern forest districts in the Northern Interior Forest Region. We estimate the chanterelles grow in 17 of the province's 37 forest districts, an area with 7.5 million hectares of productive forest land. That works out to an average of between 0.025 kg per hectare and 0.10 kg per hectare of chanterelles. For the CFD, which would contain about 8.5% of the province's chanterelle habitat, the total harvest would be between 15,914 kg and 63,656 kg per year.

According to import data collected by Royal Roads, the volume of chanterelles being exported to Europe from BC between 1995 and 2005 ranged from 59,400 kg to 382,500 kg, with an average of 187,109 kg. The difference between the Royal Roads estimate and the Wills and Lipsey estimate may be different because the import data would only capture part of the chanterelle harvest. To be conservative, we will assume there is an average harvest of 200,000 kg of chanterelles per year, of which 8.5%, or 17,000 kg, can be attributed to the CFD.

Liegel (1998) estimated that productive chanterelle sites produce about 5 kg per hectare, while Alexander et al. (2002) assume that 5 kg per hectare would be the minimum productivity for a site to be considered worthwhile for harvesting. If we assume 5 kg per hectare as average biological production on productive sites, and about 17,000 kg of chanterelles are harvested in the CFD at a collection rate of 75% (Alexander et al., 2002), then there is a total biological production of about 22,700 kg. At 5 kg per hectare, there is approximately 4,200 hectares of productive chanterelle habitat in the CFD; that is about 0.67% of the total productive forest, or about 1.6% of the timber harvesting land base.

B.7 Mushroom Pricing and Collection Rate Assumptions

The prices paid to pickers of pine mushrooms vary throughout the picking season and from year to year. A report by the Royal Roads Centre for Non-Timber Forest Resources (CNTR, 2006b), suggests pickers receive an average of $10 per lb while in the Nahatlatch study (Freeman, 1997), pickers were paid an average of $19.93 per lb ($32.29 per lb for grade 1), which is $24.42 in 2006 $CAN. In 1998 in the Cranberry TSA, pickers were paid an average of $15 per lb and it was observed that when the price fell below $10 per lb, pickers began leaving the area (Olivotto Timber Forest Modelling Consultants, 1999). The average price for grade 1 pines across Canada in 2002 was $40 (Eisbrenner, 2002). We assume an average price for all grades paid to pickers of $25 per lb, or $55.12 per kg.

Harvesters of Pacific Golden Chanterelles receive an average of between $2 and $2.50 per lb (Vancouver Island), $2 and $4 per lb, or $4.50 per lb (1999 season in Haida Gwai), which is much lower than the price for pine mushrooms, but chanterelles can be collected much more quickly than pine mushrooms (Tedder et al, 2000). Freeman (1997) found that pine mushroom harvesters picked an average of 0.89 lbs per hour while Tedder et al. (2000) found that chanterelle pickers collected an average of 4.68 lbs per hour. This is a reasonable difference since pine mushrooms do not grow as densely as chanterelles, and would therefore take more time to pick. Pilz et al. (1999) found that on productive pine mushroom sites there were an average of 150 mushrooms per hectare, while Liegel (1998) found an average of 750 chanterelles per hectare on productive chanterelle sites. We assume an average price to chanterelle pickers of $3 per lb ($6.61 per kg), the midpoint between the range of $2 and $4 per lb. In 2006 $CAN, that would be $3.54 per lb, or $7.80 per kg. We do not consider the price of $4.50 per lb for chanterelles in Haida Gwaii because this higher price reflects the higher transportation costs pickers face getting to the islands, an added cost which pickers in the CFD would not face because most pickers are local.

The average time spent picking has been estimated at 6.61 hours per day, according to a Royal Roads survey of mushroom pickers, and according to Tedder et al. (2000), most pickers spent between 5 and 8 hours per day picking, with one team of pickers spending an average of 6.8 hours per day picking (Tedder et al., 2000). According to the CNTR Mushroom Harvesters Survey, harvesters picked an average of 6.6 hours per day. We assume an average of 6.7 hours per day spent picking. If chanterelle pickers harvest 4.68 lbs per hour, they will harvest about 31.4 lbs per day, or 14.2 kg. If pine mushroom pickers harvest 0.89 lbs per hour, they will harvest about 6 lbs per day, or 2.7 kg.

Appendix C: Net Present Values for Alternative Scenarios

Table C-1

Net Present Values of Timber Benefits Only (in $millions)

	SOMPcurr	Suit100	Terr100
Rising Log Prices			

1% Discount Rate	Revenue	7747.8	5220.5	5039.8
	Costs	7020.1	4883.2	4732.4
	Producer Surplus	727.7	337.3	307.4
4% Discount Rate	Revenue	3142.2	2093.6	2049.6
	Costs	2878.4	1956.7	1940.4
	Producer Surplus	263.7	136.9	109.2
7% Discount Rate	Revenue	1877.2	1253.9	1224.6
	Costs	1744.0	1177.7	1175.7
	Producer Surplus	133.2	76.2	48.9
Constant Log Prices				
1% Discount Rate	Revenue	7240.9	4879.6	4723.5
	Costs	7020.1	4883.2	4732.4
	Producer Surplus	220.8	-3.6	-8.9
4% Discount Rate	Revenue	3021.8	2015.1	1973.8
	Costs	2878.4	1956.7	1940.4
	Producer Surplus	143.4	58.4	33.3
7% Discount Rate	Revenue	1831.2	1224.3	1195.5
	Costs	1744.0	1177.7	1175.7
	Producer Surplus	87.1	46.6	19.8
Falling Log Prices				
1% Discount Rate	Revenue	6704.1	4510.9	4374.1
	Costs	7020.1	4883.2	4732.4
	Producer Surplus	-316.0	-372.3	-358.3
4% Discount Rate	Revenue	2892.7	1929.0	1889.4
	Costs	2878.4	1956.7	1940.4
	Producer Surplus	14.3	-27.7	-51.0
7% Discount Rate	Revenue	2892.7	1929.0	1889.4
	Costs	2878.4	1956.7	1940.4
	Producer Surplus	14.3	-27.7	-51.0

Table C-2

Net Present Values of Benefits Associated with Hunting, Water-based and Human-powered Recreation Activities, and Non-timber Forest Products (in $millions)

Hunting

	SOMPcurr	Suit100	Terr100
1% Discount Rate	15.11	14.81	14.55
4% Discount Rate	5.54	5.53	5.49

7% Discount Rate	3.11	3.14	3.15

Water-based and human-powered recreation activities

	SOMPcurr	Suit100	Terr100
1% Discount Rate	3404.5	3515.2	3544.9
4% Discount Rate	1342.7	1373.4	1380.2
7% Discount Rate	798.0	811.8	814.6

Non-Timber Forest Products

	SOMPcurr	Suit100	Terr100
1% Discount Rate	28.04	25.81	28.16
4% Discount Rate	12.35	11.46	12.31
7% Discount Rate	7.63	7.12	7.56

Table C-3

Net Present Values of Net Carbon Change (in $millions)

Shadow price of carbon $20

	SOMPcurr	Suit100	Terr100
1% Discount Rate	-3.8	111.0	131.8
4% Discount Rate	-10.7	47.9	56.4
7% Discount Rate	-7.7	30.6	35.4

Shadow price of carbon $75

	SOMPcurr	Suit100	Terr100
1% Discount Rate	332.1	652.9	715.1
4% Discount Rate	136.6	299.0	324.1
7% Discount Rate	-183.9	192.4	206.0

Shadow price of carbon $150

	SOMPcurr	Suit100	Terr100
1% Discount Rate	790.3	1391.8	1510.5
4% Discount Rate	337.4	641.5	689.1
7% Discount Rate	213.9	413.0	438.7

Table C-4

Net Forest Values: Timber, Recreation, NTFPs, and Carbon (in $millions)

Carbon shadow price	Discount Rate	SOMPcurr	Suit100	Terr100
Rising Log Prices				
$20	1%	4171.5	4004.1	4026.8
	4%	1613.6	1575.2	1563.6
	7%	934.3	928.9	909.6
$75	1%	4507.5	4546.0	4610.1
	4%	1760.9	1826.3	1831.3
	7%	1028.0	1090.7	1080.2
$150	1%	4965.7	5284.9	5405.5
	4%	1961.7	2168.8	2196.3
	7%	1155.9	1311.3	1312.9
Constant Log Prices				
$20	1%	3664.6	3663.2	3710.5
	4%	1493.3	1496.7	1487.7
	7%	888.2	899.3	880.5
$75	1%	4000.6	4205.1	4293.8
	4%	1640.6	1747.8	1755.4
	7%	982.0	1061.1	1051.1
$150	1%	4458.8	4944.0	5089.2
	4%	1841.4	2090.3	2120.5
	7%	1109.8	1281.7	1283.8
Falling Log Prices				
$20	1%	3127.8	3294.5	3361.1
	4%	1364.2	1410.6	1403.4
	7%	838.3	866.2	847.8
$75	1%	3463.8	3836.3	3944.4
	4%	1511.5	1661.7	1671.1
	7%	932.0	1028.0	1018.4
$150	1%	3921.9	4575.3	4739.8
	4%	1712.3	2004.2	2036.1
	7%	1059.8	1248.6	1251.1

Appendix D: Selected Websites Consulted

Guidelines for Developing Stand Density Management Regimes:
http://www.for.gov.bc.ca/hfp/publications/00083/index.htm#TopOfPage

From BC Stats: employment by industry
http://www.bcstats.gov.bc.ca/data/dd/handout/naicsann.pdf
and http://www.bcstats.gov.bc.ca/pubs/exp/exp0602.pdf

Economics and Trade Branch (stats for person years of employment, etc):
http://www.for.gov.bc.ca/het/

Current sawlog stumpage rates for Chilliwack district:
http://www.for.gov.bc.ca/hva/timberp/coastaverage/April_2006.pdf

Coast Market Pricing System:
http://www.for.gov.bc.ca/hva/timberp/infopapers/MPSCoast.pdf

An Economic Strategy to Develop NTFPs and Services in BC:
http://www.for.gov.bc.ca/hfd/library/frbc1999/FRBC1999MR30.pdf

Mushroom industry possible contact: Bill Sirota, Pemberton
Article: http://www.whycook.ca/articles/article_info.php?a=169

2005 BC Directory of Buyers and Sellers of NTFPs:
http://www.royalroads.net/cntr/buybcwild/Buy_BCwild_Directory_2005.pdf

Interim Guidelines for the Preparation of Socio-economic assessments for Timber Supply Reviews:http://www.for.gov.bc.ca/HET/tsr_sea/DFAM%20SEA%20Requirements.pdf

Chilliwack District Map (licencees, with towns and roads)
http://www.for.gov.bc.ca/ftp/dck/external/!publish/web/gis/plotfiles/chart/operating_areas0405.pdf

Map of Lower Mainland Guide Outfitters Areas
http://ilmbwww.gov.bc.ca/cis/psupport/env_maps/GOA_Maps/Ansi-D_Landscape_lowermainland.pdf

Prince George Forest District Tourism Opportunities Analysis:
http://ilmbwww.gov.bc.ca/cis/initiatives/tourism/tos/Prince_George/PrinceGeorge.pdf

1994 Forests, range, and recreation resource analysis:
http://www.for.gov.bc.ca/hfd/library/frra/1994/index.htm

BC Ministry of Forests. 1995. Botanical forest products in British Columbia: an overview. http://www.for.gov.bc.ca/hfp/publications/00002/index.htm

For ecological impact reports for north/central coast (e.g. consequences of overharvesting cedar compared to other species) see Veridian Ecological Consulting: http://www.veridianecological.ca/links.php

Non-Timber Forest Products links: http://www.sfp.forprod.vt.edu/sfp_link/general.htm and http://web2.uvcs.uvic.ca/courses/ntfp/history/index.htm

Pine Mushrooms and Timber Production in the Cranberry TSA (Prince Rupert Forest District): http://www.for.gov.bc.ca/HFP/silstrat/pdffiles/prov-cranberry-pinemush.pdf

NTFP publications directory: http://www.for.gov.bc.ca/hfd/library/documents/bib95968.pdf

Commercially important wild mushrooms and fungi of BC: what the buyers are buying: http://www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr006.pdf

Fraser Valley Regional District: http://www.regionalindex.gov.bc.ca/Areas/AreaDisplay.asp?areaName=Fraser%20Valley%20Regional%20District&number=6&ind=Forestry

Forest, Range, and Recreation Resource Analysis: describes WTP in BC http://www.for.gov.bc.ca/hfd/library/frra/1994/index.htm

Conference Board of Canada: Canadian Industrial Outlook: Canada's Wood Manufacturing Industry Spring 2006.
-associated news release: http://www.conferenceboard.ca/press/2006/softwood.asp

MOF GIS data: http://srmwww.gov.bc.ca/gis/arcftp.html
and http://www.for.gov.bc.ca/dck/Lim/dck_Maps_prov.html
and http://www.for.gov.bc.ca/hva/

PriceWaterhouseCoopers: http://www.pwc.com/extweb/pwcpublications.nsf/docid/24065403EF7D7B1E852570DC00627B94/$File/2005-lumber-benchmarking-survey-order-form.pdf

Forest Range and Practices Act
http://www.for.gov.bc.ca/code/

BC Forum on Forest Economics and Policy: http://www.bc-forum.org/people.htm