ADDRESSING UNCERTAINTY IN FOREST PLANNING

by

JUAN PABLO CERDA

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Department of FOREST SCIENCES

The University of British Columbia
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ABSTRACT

Forests are complex 'systems' with forest ecosystem, resource, stakeholder and policy 'subsystems'. Knowledge about forest systems is always incomplete, and uncertainty pervades decision-making. Uncertainty produces risk of losses and potential opportunities, which have to be recognized and characterized. From then, the best probabilistic predictions, guesses, judgments, and scenario models can be made. Good planning addresses uncertainty, and adapts to changes. It is based on constant learning, and includes processes that enable feedback on past outcomes to inform future planning.

British Columbia (BC)'s forest land area is 60.6 million hectares. Most of it is publicly owned, and forest harvesting is licensed. Licensees must prepare Forest Development Plans (FDP's), which describe specific areas proposed for harvest. These plans allow for discussion and resolution of environmental and socioeconomic issues. The annual cost of preparing and reviewing FDPs province-wide exceeds $30 million. In spite of this expense, actual outcomes routinely differ from those described in the original FDPs because of uncertainty. This is due mostly to natural disturbance events, shifts in social values or policy, and timber market changes. FDPs are constantly amended. The annual cost of preparation and review exceeds $12 million. Furthermore, unexpected outcomes and frequent amendments undermine public confidence in the planning process.

In addition to highlighting the weaknesses in the current planning processes, a method to address uncertainty through better forest planning in BC is proposed. Complexity in the forest system and uncertainty in planning have a spatial dimension, which is representable and analyzable using Geographic Information System

(GIS) tools. Ecosystem dynamics, and the impact on biophysical attributes of the landscape of changes in resources prices and policies, and people's values can be mapped, and spatially matched with unexpected outcomes of planning. Using the "SAFEPLAN" method these outcomes can be explained, and improvements to the planning processes can be recommended.

Results obtained for southeastern BC show how the adoption of this method could increase the efficacy of forest plans, and improve the cost-effectiveness of the whole planning process, including its role in the proposed context for forest planning in BC.

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ACRONYMS

AAC	Annual Allowable Cut
BC	Province of British Columbia, Canada
BCFPB	Forest Practices Board of British Columbia
BCFPC	Forest Practices Code of British Columbia
BCLUCO	Land Use Coordination Office of British Columbia
BCMOF	Ministry of Forests of British Columbia
BCMSRM	Ministry of Sustainable Resource Management of British Columbia
FSC	Forest Stewardship Council
COFI	Council of Forest Industries
CP	Cutting Permit
FDP	Forest Development Plan
GIS	Geographic Information Systems
ha	Hectares
IFPA	Innovative Forest Practices Agreement
TSA	Timber Supply Area
UBC	University of British Columbia

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I. INTRODUCTION

For anyone concerned with the effects of uncertainty in forest planning, it is hard to imagine a more interesting place than British Columbia (BC), Canada at present. Forests here are multifaceted and highly dynamic, and forestry is controversial. Forest planning processes are complicated, representing the enormous variety of forest ecosystems and stakeholders in the Province. Consequently uncertainty pervades decision-making.

Forest planning in BC is in a time of transition. Processes are criticized. Licensees, officials, NGOs and the public want improvements. These changes are expected to allow more flexibility and reduction of costs, without compromising environmental quality. Requirements for planning will vary, and are expected to be more result-oriented. Compliance will require new approaches for addressing uncertainty, controlling performance (e.g. *efficacy*) and accounting for outcomes.

1.1 Goals and Objectives

The goal of this thesis is to develop an approach for addressing uncertainty and thereby improve forest planning. Specific objectives are:

1) to develop a quantitative method for evaluating forest planning outcomes and uncertainty; and

2) to test the capabilities of the quantitative method in a case study in southeastern BC.

To provide context for this work, a new conceptual framework for forest planning is presented, weaknesses of present planning processes in BC are described, and applications of the quantitative method in a reformed context for planning are discussed.

1.2 Structure

The thesis is composed of two parts. The first part contains a literature review from which a conceptual framework for forest planning is proposed. In Chapter II forests are defined as complex systems with dynamic ecosystem, resource, stakeholder, and policy subsystems. Chapter III discusses how uncertainty pervades forest planning. Better forest planning is introduced as a learning process that provides feedback from past outcomes for future plans. Spatial representation of uncertainty as a source for feedback is explained.

The second part of the thesis presents results of investigations into forest planning outcomes in BC, a method for analysing planning outcomes, and strategies for reducing uncertainty. Chapter IV describes current weaknesses of forest planning processes in BC and provides results of a survey of the Ministry of Forests and licensees operating throughout BC. Chapter V introduces a GIS-based method called SAFEPLAN for analysing forest plans efficacy and sources of uncertainty. The method is applied in an area in southeastern BC to extend the analysis of planning weaknesses described in Chapter IV. Principles for strengthening planning through addressing uncertainty are proposed. Chapter VI discusses key issues and initiatives in the transition in forest policy that is moving BC towards a more results-based context for management. The need for addressing uncertainty in this new context is highlighted, and applications of the SAFEPLAN method and principles for better planning are proposed.

Throughout the thesis technical terms are indicated in italics on the first use. These terms are defined in a glossary in Appendix 1.

CHAPTER II. A CONCEPTUAL FRAMEWORK FOR FOREST PLANNING

2.1 An Introduction to Forest Management

Forest management, or forestry[1], consists of a regime of integrated and coordinated actions that shape the forest's attributes for specific purposes (FAO, 1998; Romm, 1998), in a manner that provides desired values (Erdle and Sullivan, 1998). Gordon Baskerville (personal communication, March 2002) summarizes forest management as "the process of creating a defined future forest from a present forest". Forest management then is about defining values and setting purposes, and directing and controlling actions in the forest. This requires planning and organizing. However, the specific actions included in forest management are not precisely defined, and change with time. According to the Santiago Declaration (1995) and Shindler and Cramer (1999), management changes in response to new *knowledge* of how forest ecosystems function and respond to interventions, and to changing public demands for forest products and services. Silviculture is only part of forest management (Smith et al., 1997). Fedkiw (1998) sees silviculture as being integrated with other disciplines in forest management, such as ecosystem and landscape management, economy, and sociology.

As J. Wilson (1998), Hayter (2000), Tollefson (2000) and Cashore et al. (2001) chronicle in their reviews of the evolution of forestry in BC, productivity of forest sites and accessibility were the major constraints on producing timber until the late 1970's. Forest decision-making was mostly concerned with improving yield and surpassing technical

[1] Forest Management and forestry are synonyms (Dictionary of Science and Technology, 1992; Oxford English Dictionary, 1996; The New Encyclopaedia Britannica, 1997; McGraw-Hill Dictionary of Scientific and Technical Terms, 1997).

engineering difficulties. More recently however, actions dealing with wood yield have become just a fraction of the actions required to manage forests acceptably. Sheppard (2001) for example summarizes actions required to deal with the new dimension of public perceptions towards forestry. Forest managers carry out actions that interact not only with forest ecosystems but with communities and markets. Also, they must act with consideration for current generations and generations to come. Propper de Callejon et al. (1998) describe this new context for management, where wood yields are only optimized to the extent that other goods produced by the forests are not weakened. People expect these goods, and demand that they persist into the future.

Forest managers are making decisions with respect to a broad and more complex system. In dealing with this new context, they are encountering not only new obligations, but also new opportunities (e.g. new non-timber resources). Conflicting demands and requirements dictated by ecological limitations, technological constraints, and socio-economic realities have to be harmonized (Kleine, 1997). Forest management is moving along a pathway of emergent paradigms towards broader sustainability.

2.2 Forest Management, Sustainability and Emergent Paradigms

The World Commission on Environment and Development in 1987, and the United Nations Conference on Environment and Development in 1992 broadened the former mostly biological and economic concept of forest sustainability to include social issues. The concept of sustainable forest management has been constructed to fit different values and needs (Schanz, 1994), and as such has more than fourteen different categories of definitions (Schanz, 1998). Dovers and Handmer (1993) have identified many contradictions among the elements of existing definitions, such as growth versus limits, individual versus collective interests, intergenerational versus intragenerational equity, and adaptability versus resistance. Although there is no clear definition of what constitutes sustainable forestry, there is a general consensus that sustainable forestry in some form or another should be practiced (Sedjo et al., 1998). It is presented by Schanz (1998) as the main objective of all effort in forestry.

A succession of paradigms have emerged from the concept of sustainability. Schools of sustainable forest management include *social forestry* (Gregersen et al., 1989), *new forestry* (Franklin, 1990), *holistic forestry* (Hammond, 1991), *ecosystem management* (Society of American Foresters, 1993), and *eco-forestry* (Drengson and Taylor, 1998), among others. Kuhn (1970) defines paradigms as beliefs, accepted standards, procedures and exemplars. According to Barker (1993), each paradigm is a theory or dogma that establishes boundaries and regulations. Paradigms are dynamic, and can complicate forest management. Managers are permanently challenged to *understand* them. As Barker (1993) notes, data conforming with the paradigm are overemphasized, preventing new developments that come from outside the paradigm. Knowing what people want, and what they expect from a paradigm is difficult. Meanwhile, managers have problems convincing people that adequate forest management can be carried out without subscribing to a given paradigm. As an example, Stanbury (2000) identifies difficulties in being pressured to managing in accordance with ecological paradigms. Forestry is challenged not only by having to operate inside of established paradigms, but also by the necessity of proving to people that it is not operating outside of them. Although economic, scientific, and political debates precede and follow the proposition of each new paradigm, there is no definitive agreement on what constitutes "adequate", or socially desirable, forest management.

Forest management should be by definition sustainable. Management actions are planned (e.g. integrated and coordinated), and they are directed toward previously defined objectives (e.g. desired values). A main challenge, however, is that "it is impossible to be certain at any moment that a forest is being sustainably managed" (Poore et al., 1998). Consequently, numerous *criteria* and *indicators* by which to judge the sustainability of management regimes are being discussed worldwide under various schemes. These initiatives pursue environmentally responsible, socially beneficial, and economically viable management of the forests in response to public forest concerns (e.g. FSC, 1999). The more than 100 indicators of sustainability are a good indication of the breadth of people's concerns about forests. They refer to issues as diverse as land tenure, indigenous people's welfare, ecosystem conservation, reduction of environmental impacts, optimal utilization of forest products and services, and participatory management planning (FSC, 1999; Meridian Institute, 2001).

2.3 Forests as Systems

A system is a network of hierarchically related components and processes that work as a whole to maintain its particular properties (Sinnott, 1998; Ford, 2000). The system's uniqueness is given by its components, which have internal relationships that are closer than with those of components in the surrounding environment (Naveh and Lieberman, 1994). Subsystems are parts of the larger system and are defined by a subset of its components (Odum, 1994). Components of subsystems have a relationship that is closer than the one with the rest of the components of the system.

Since the beginnings of modern forestry, forests have been seen as systems including more than just trees. Fernow (1902) stated, "A forest... is by no means a mere collection of trees, but an organic whole..." Pinchot (1903) stated, "Although it is composed of trees, the forest is far more than a collection of trees standing in one place..." Forestry has further broadened from the view of these visionary men. Oliver et al. (2001) recommend a systemic approach to the management of forest ecosystems, which concentrates on the relations among grouped biophysical components. Marshall (1984) goes further, and visualizes forests as systems being composed of a biophysical portion and a social component. However, he mentions only biological and physical mechanisms of the forest system when commenting on what should be understood about the system to adequately manage it.

Systemic visions are common in natural resource management (Odum, 1994; Grant, 1998). Haworth et al. (1998), Kiang (1998), and Kropff et al. (2001) describe a systems approach to agriculture, Charles (2001) to fisheries, Robinson et al. (1999) to ocean resources management, and Clayton and Radcliffe (1996) to environmental and sustainability problems. Systemic approaches towards the management of forest systems are scarcely reported. Prabhu et al. (2001) aim in this direction by introducing the concept of "systemic sustainability" as a system of indicators of forest sustainability, which would be holistic and greater than the sum of its parts. The Clayoquot Sound Scientific Panel (1995) constitutes an operational example of viewing forests as broad systems. In its 120 recommendations towards the sustainable ecosystem management of the forests of western

Vancouver Island, BC, the Panel made recommendations on the management of trees, wildlife and streams. Furthermore, it made recommendations on the integration of recreational and spiritual demands, and community and first nations interests.

A 'forest system' is composed of ecological and socio-economic subsystems, which interact with each other to function as a whole. Major subsystems are:

1. Forest ecosystems subsystem, with trees, streams, wildlife, fire, wind, and stored carbon.
2. Forest resources subsystem, with the wide range of environmental, economic and social benefits derived from the forests ecosystems and perceived by present and future forest stakeholders.
3. Forest stakeholders subsystem, with forest owners and workers, local communities, inhabitants of the forests, and forest resources and services processors and consumers.
4. Forest policies subsystem, with the goals and objectives, instruments, and specific instrument settings of policy that direct how forest users intervene forest ecosystems to benefit from forest resources.

Dynamism is also an inherent component of each subsystem. The ecosystems subsystem includes a series of endemic processes and disturbances, the stakeholders subsystem includes shifts in stakeholder values, the resources subsystem includes changes in resources valuation and prices, and the policies subsystem includes policy changes.

Forestry, then, encompasses the management of a forest system –the assemblage of given subsystems-, which is unique and particular to a location and time, and has particular properties. Based on what Amen (1966), and then Beishon and Peters (1972), Maturana and Varela (1980), O'Neill et al. (1986), Odum (1994), and Sinnott (1998), describe as general properties of systems, a forest system has the following properties:

1. Hierarchy. It is composed of subsystems, which are composed of other subsystems and so on. The system, itself, is a component of larger suprasystems (e.g. the national economy system).
2. Boundaries. It can be arbitrarily delimited in time and space. Its components can be circumscribed by a boundary (e.g. a watershed; 120 years).
3. Openness. It connects in space and time with other systems. Its functioning may change in response to external stimulus (e.g. economic crisis affects demand for forest resources).
4. Dynamism. It changes over time as a whole. Its individual components change over time as well (e.g. tree growth).
5. Synergy. Among its components positive and negative synergy coexists. Its behavior is not predictable by looking at the sum of the components, due to emergent properties (e.g. ecosystem resilience, stability, and efficiency).
6. Autopoesis. It tends to self-organize. The interaction among its components creates new internal structures and flows that are more "efficient" for the functioning of the system (e.g. demand for and supply of forest resources).

According to O'Neill et al. 's (1986) Hierarchy Theory, within systems components interact with other components at the same level of hierarchy and between different levels of hierarchy. Each component in the forest system (e.g. a tree, wind, a recreationist, the price of timber, etc) behaves, or it is induced to behave, actively, inducing changes in subsystems and eventually in the forest system (Figure 2.1).

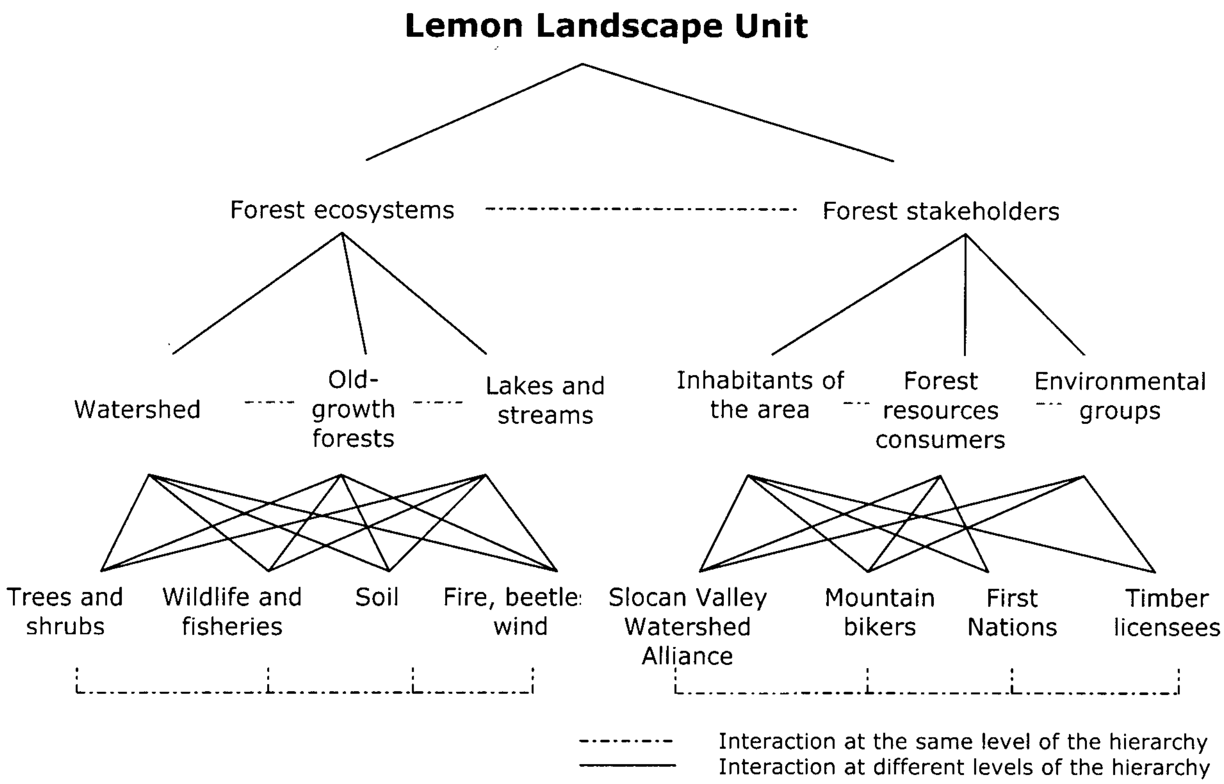

Figure 2.1. Levels of interaction within forest systems. Simplification of a forest system in Lemon Landscape Unit, BC and some components of its ecosystem and stakeholder subsystems.

The distinctiveness of a forest system is the result of constant change over time. For this change to occur, Sinnott (1998) states that some entropy –or disorder- has to be present. From this disordered *state*, systems tend toward *homeostasis* through feedback from within and from without their boundaries (e.g. autopoeisis). Axelrod and Cohen (2000) explain that components of the system change to adjust to a context (subsystem/system) in constant change. External stimuli also change the system as a whole. Forest systems are complex systems that progress through *deterministic*, *stochastic*, and *chaotic* processes.

2.4 Determinism, Stochasticity and Chaos in a Forest System

Determinism refers to the principle that exact laws are followed, so that what will happen in the future is a necessary consequence of states at any given moment in the past (McGraw-Hill Dictionary of Scientific and Technical Terms). Given sufficient knowledge of the initial state of a deterministic system, its future can be determined exactly (Denny and Gaines, 2000). However, very few systems are purely deterministic (Gillman and Hails, 1997). Stochastic processes incorporate chance. Even if the exact state of a stochastic system is known at one time, exact states in the future can never be predicted (Denny and Gaines, 2000). Determinism and stochasticity are not rigid properties, though. Denny and Gaines (2000) describe the commonly known stochastic flipping of a coin as a process with an outcome that could be exactly predicted. Knowing enough about the factors affecting the landing of the coin (i.e. the initial state of the coin, height above the ground at which the coin is flipped, the initial angular velocity, and air resistance, etc.) it would be possible to know exactly when the coin will land heads up. Flipping a coin in a context of sufficient knowledge and understanding would be a deterministic process. Some outcomes, however, are extremely sensitive to the initial state. These outcomes are said to exhibit deterministic chaos (Sarewitz et al., 2000) because they are unpredictable due to non-measurable shifts in initial conditions. These outcomes can reasonably be assigned to "chance" (Denny and Gaines, 2000).

Forest systems contain many deterministic processes. As Kimmins (1997), Kimmins et al. (1999), and Baker and Mladenoff (1999) illustrate through numerous examples, science and forest expertise have deepened knowledge and understanding of many of these deterministic processes (e.g. tree growth, mortality and competition, and biomass accumulation in forests). Timmermans (1991) describes some deterministic components of human decision-making processes and choice behaviour on relating with the environment. Many outcomes in forest systems, however, appear to be far from deterministic. *Complexity* and subsequent uncertainty make many of these outcomes and the underlying processes seem stochastic. Further, even if complete knowledge were possible, chaotic and *non-linear interactions* limit knowing all future outcomes.

2.5 Complexity of a Forest System

Viegas (1982) points out that when decision-making involves several deciding bodies and several sets of values and interrelations, complexity arises. Complexity makes acquiring knowledge for better decisions challenging in forestry. The ability to manage forests systems ultimately depends on acquiring knowledge and addressing the complexity arising from ecosystems, stakeholders, resources and policies.

2.5.1 Complexity in the Forest Ecosystem Subsystem

The terms 'ecosystem' and 'forest' are variously defined (UNEP/CBD/SBSTTA, 1997a; Commission on Sustainable Development, 1996). More than one hundred definitions were found during this thesis research. Kimmins (1997) suggests that few people really know what the term ecosystem means, and Seastedt (1996) believes that ecosystem may mean whatever the users want it to mean. The term forest, according to Meridith (1993), may also mean everything and whatever we want it to mean. Definitions of ecosystem and forest are constructed from ambiguous concepts, such as communities and environments, which themselves have hundred of definitions. The lack of precise and operative definitions makes it difficult to know how interventions relate to forest ecosystems, given that ecosystems do not have boundaries naturally fixed in time or space (Dunster and Dunster, 1996; Perry, 1994). In a practical sense, ecosystems are functional units relative to given management objectives (BCMOF, 1998a; Seastedt, 1996; Jensen et al., 2001). Division of forest ecosystems into manageable units is one of the very first issues that foresters have to deal with, and constitutes a good example of how forest decision-making should involve the four subsystems of the forest system (Figure 2.2).

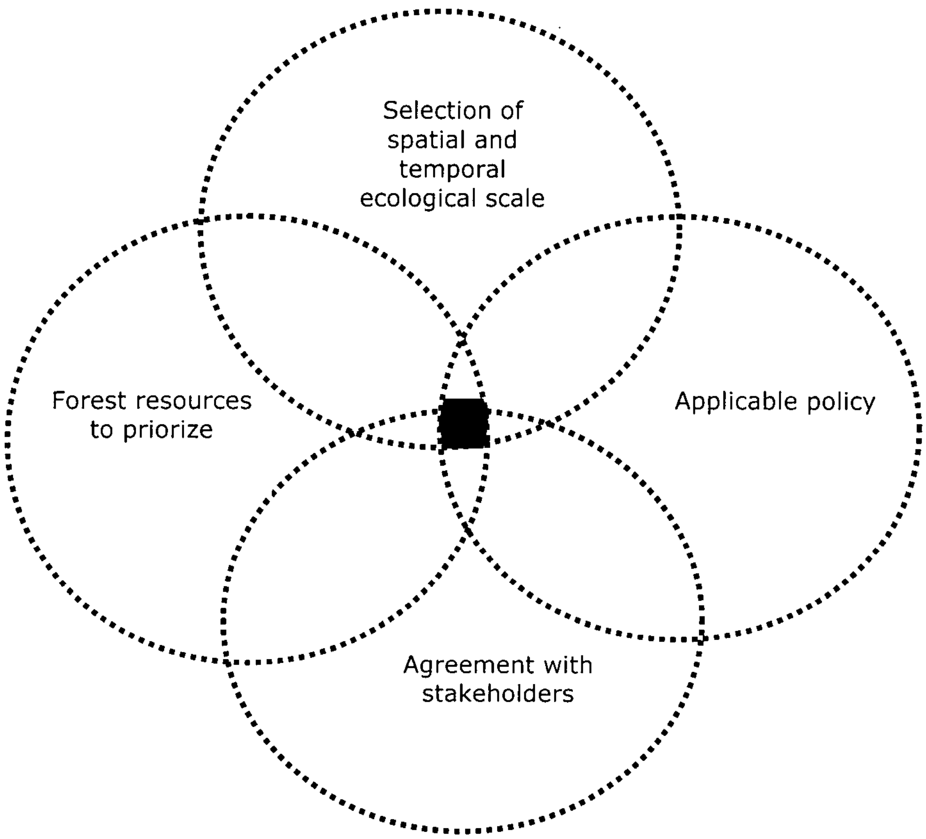

Figure 2.2. Definition of a forest ecosystem. The filled area shows the convergence of components of the four subsystems of the forest system in answering the question: Which is the unit of management?

Forest managers must agree with stakeholders of the forest system on the temporal and spatial boundaries of forest ecosystems, in accordance with the scientific, management, or policy questions being considered. Although in forestry the basic subdivision is a *stand*, depending upon specific purposes a single forest stand, a watershed, or an entire forest region may be the spatial unit for management. The temporal scale of management may be the present state, only one human generation, a stand rotation, or perpetuity.

2.5.1.1 Characteristics and Dynamics of Forest Ecosystems

Complexity pervades forest ecosystems. They are the most biologically diverse terrestrial ecosystems, as acknowledged by the Convention on Biological Diversity (UNEP/CBD/SBSTTA, 1997b), and present an intricate structure, made up of many biological components with a high degree of interaction and often a considerable degree of interdependency (Mauersberger, 1995; Kimmins, 1997). Instead of averaging out, the mostly non-linear interactions among components of ecosystems modify the characteristics and functioning of the ecosystems (Jorgensen and Muller, 2000; Green, 1997). Through both positive and negative feedbacks, some outcomes of interactions return as inputs to the ecosystem, further affecting some characteristics and processes.

A forest ecosystem is hierarchically structured. According to Perry (1994) each ecosystem when defined in space comprises numerous smaller ecosystems and, at the same time, is part of and in interacts with a hierarchy of larger ecosystems. Van Dyne (1966) summarizes basic ecosystem functions as transformation, circulation, and accumulation of matter and flow of energy through the medium of living organisms and their activities, and through natural physical processes. As open systems, ecosystems exchange energy and materials with other systems, including adjacent forests, downstream ecosystems, and the atmosphere (U.S. National Science and Technology Council, 1996; Waring and Schlesinger, 1985).

Forests are not static. Many authors argue that they are rarely in *equilibrium* (Waring and Schlelsinger, 1985; Botkin, 1990; Perry, 1994; Pahl-Wostl, 1995; Carpenter, 2000; Jensen et al., 2001). Their composition, structure and functioning are dynamic (Wilds and White, 2001). Many states of equilibrium, or *optimal operating points*, may exist for an ecosystem (Carpenter, 2000; Perry et al., 1990; DeAngelis and Waterhouse, 1987). Different states of forests present a great range of turnover rates, which range from forests that are replaced by disturbances with frequencies of thousands of years, to forests that are naturally disrupted much more frequently (Carpenter; 2000). Forests owe their properties to an interplay between deterministic processes and stochastic events, which include:

- gradual changes or trends in ecosystem's characteristics that occur at broad scales and over very long time periods (DeAngelis and White, 1994). Jensen et al. (2001) refer to these changes as succession along multiple pathways, and Turner and Johnson (2001) as transient dynamics;

- natural periodicities that constitute seasonal variations or semi-periodic environmental fluctuations (DeAngelis and White, 1994); and

- disturbances. DeAngelis and White (1994) refer to these as discrete, disruptive events; Carpenter (2000) refers to them as surprising outbreaks and collapses; and Jensen et al. (2001)

refer as discontinuities and unexpected changes. These terms give a sense of how disturbances are considered stochastic events for the most part.

Gradual changes and natural periodicities constitute deterministic processes that tend to be smoothly absorbed by forest ecosystems (Scheffer et al., 2001). As discussed in Section 2.5, these can be fairly well described. However, forest development is not an orderly and predictable process. Rather, in most forests succession is periodically disrupted by disturbances, deflecting them from some otherwise predictable successional path (White, 1979; Attiwill, 1994; Kimmins, 1997; Parminter, 1998). Disturbances may be artificial or natural. Forest management, clearance and burning of forests, agriculture, and urbanization artificially disturb forest ecosystems. Wildfire, insects and pests, wind, floods and landslides naturally disturb them. Forests are in fact highly dependent or contingent on natural disturbance and its spatial and temporal distribution for survival (e.g. maintenance of properties) as reported by White and Pickett (1985), Wilds and White (2001), and Forman (1995). Each forest reflects a particular disturbance regime (e.g. distribution, frequency, and return interval of fire), which affects not only the state of an ecosystem immediately following a disturbance, but also the rate, degree and nature of its recovery (Pickett and White, 1985; Wilds and White, 2001). Disturbance regimes vary along environmental gradients, which reflect spatially varying features of the landscape, which trigger disturbances or influence the impacts that they have on the forests (Naveh and Lieberman, 1994). Although natural disturbances may be necessary for long term ecosystem health and survival, they do not necessarily serve forest management objectives (e.g. windthrow of partial cut residual trees). Disturbances disrupt communities and population structures, and change resources, the availability of suitable habitats, and/or the physical habitat (Parminter and Daigle, 1997; White and Pickett, 1985).

Ecosystem dynamics is the result of many interacting factors. Understanding these factors for managing forests is a challenging task and requires significant knowledge. Understanding deterministic processes requires knowledge of present states and cause-effect processes occurring in ecosystems. Understanding disturbances requires knowledge of both deterministic processes and random events and how they affect those predictable pathways.

2.5.2 Complexity in the Forest Resources Subsystem

Forest resources are a compound array of goods and services obtained from forests that are valued by people (Rollins, 2001). These resources include timber products, such as lumber, pulp and paper and plywood, and fuelwood; non-timber products, such as herbs and mushrooms, tree bark and leaves, and medicinal plants; ecological functions, such as carbon storage, water regulation, and soil stability; and social functions, such as habitat for human communities (i.e. First Nations), recreation, and spiritual solace.

Provision of some of these resources (i.e. timber) is mostly achieved through forest management. Other forest resources, even when not directly provided by forest management, are affected by it. As the capability of ecosystems to provide forest resources is finite, the people that can benefit from each ecosystem are also limited. To know who, how, and in what quantity people benefit from forest management is difficult. What makes this task even more difficult is the fact that people vary in their valuation of resources. Even the same individual's valuation of a resource varies during his/her life. Adding the many individual rationales behind valuation is a very onerous scheme for managing forests.

2.5.2.1 The Economics of Forest Management

Duerr and Vaux (1953) state that most forestry concerns are economic concerns. Economics enters into the solution of all the major practical problems in a forest system, such as decisions about when, where and how to harvest a forest, and do so with *effectiveness* and *efficiency* (Pearse, 1990). Production of timber, by far the most requested forest product, presents unique characteristics, such as (Ghebremichael et al., 1996):

- the dual nature of timber. Trees are both a final product (timber), and a "manufacturing plant" that produces the final product;
- a long production period. Timber production takes years to reach a harvestable age. This makes the choice of an appropriate discount rate a vital matter. It also requires estimates of future benefits, which are extremely uncertain due to the length of time involved;
- joint production of multiple outputs. Multiple benefits are associated with the production of timber;
- immobility. Timber is fixed in a specific place; and
- derived demand. Demand for timber is derived from the demand for the various intermediate input products (e.g. lumber, plywood, pulp). In turn, demand for these is derived from the demand for end-use products (e.g. housing, furniture, paper).

Forest management is challenged by this diverse array of characteristics. Adequate knowledge is necessary for solving the many questions that arise in timber management, such as harvesting the timber from the forest in the very best moment, choosing an appropriate discount rate, estimating future benefits of timber harvesting in the long run, selecting which other forest resources will be prioritized along with timber production, and which will be sacrificed, pricing timber, and forecasting demand for timber, from the many individual demands for forest products (e.g. Gunter and Haney 1984, Klemperer 1996). Markets give answers to many of these questions. Numerous forest resources do not have a market value, however. As Van Kooten and Kremar (2000) argue, "in seeking to value environmental amenities and public goods, individuals often have trouble trading off the (vague) amenity or good against a monetary measure". The value of non-market resources has to be estimated through evaluating the willingness of people to pay for them, instead of establishing a market value for them (Kengen, 1997). As they do not have an exchange value, their value is not comparable with market value of other resources. This issue is a major challenge for forestry. As the chapter 11 of Agenda 21 emphasizes, a major reason for the failure to practice sustainable forestry is the inadequate recognition and the underestimation of the value of the total package of resources provided by forests (Commission on Sustainable Development, 1992).

Market conditions for forest resources are not static. Prices of products rise and fall due to changes in quantities of products being demanded and supplied (Pearse, 1990). Markets become less attractive not only due to reduction in prices, but also due to lack of economic supports given in the past (Koln, 1998), decreases in volume of demand, and internal social and political instabilities (Chambers, 1999). Markets also impose sanitary, political, economic, ethical and environmental barriers to the exchange of products (World Trade Organization, 2001). As PriceWaterhouseCoopers (2000) argues, globalization has become a two-edged sword for forestry, offering the possibility of market expansion but also increasing the chances of costly damages from new barriers. Barbier (1996) identifies the most common non-tariff barriers as quantitative restrictions and/or quality controls that have been targeted at specific products, wood species and even individual exporters. Abrupt shifts in consumer attitudes also change markets. For example, in August 1999 *Home Depot* surprised the forest industry with the announcement that the company intends to avoid all wood products made from lumber harvested from endangered or environmentally sensitive forests by the end of 2002 (The Home Depot, 1999). Furthermore, in November 1999 *HomeBase* and *IKEA* resolved that they would be phasing out all purchases of forest products of non-certified origin (I. Lumber, 1999a; I. Lumber, 1999b).

The main task in forestry is to solve the many questions that arise in deciding what resources to prioritize. Another task is to deal with the issue of who eventually benefits and who potentially loses from interventions in the forest.

2.5.3 Complexity in the Forest Stakeholders Subsystem

Stakeholders are all the people who have an interest in a forest and who may be affected by any activity in it, or who may have an impact on the forest (Bass et al., 2001). Although people often have more than one 'stake' in forests, being hardly classifiable, major stakeholders of a forest (Higman et al., 1999) are:

- Forest managers. Their objective is to fulfill the owner's objectives through interventions of the forest.
- Owners. They pursue objectives such as profit maximization, steady income, aesthetic quality, etc.
- Forest workers. They depend on the wages resulting from forest management.
- Residents/visitors. People who live in or near the forest, and people who live further away and who come to the forest. These people can be directly affected by forest management.
- Environmentalists. They often do not live in or near the forest, but influence other stakeholders on environmental conscientiousness.
- Forestry officials and politicians. They set the rules for the context in which forest management occurs.
- National and global citizens. These people are from a country (on national issues) or from the world (issues that surpass boundaries). Some of these are organized (e.g. environmentalists).
- Consumers. They consume products resulting from forest management.

Each forest system presents a particular configuration of stakeholders. Concerns about the management of an uninhabited forest will probably rise from environmentalists, as pristine forests are among the emblematic issues on which environmentalists engage people (Mercier, 1997). Conversely, the management of a highly inhabited forest will mostly concern people living in it, who drink water from its watersheds, enjoy its scenery, and make their income from it. To identify the main stakeholders when managing a particular forest ecosystem is difficult (Bass, 2001). As the World Bank (1996)'s Participation Sourcebook states, not all parties can automatically be assumed to be relevant or irrelevant. For every development concern being addressed, a broad spectrum of stakeholders exists, ranging from directly affected parties to individuals or institutions with indirect interests. The spectrum of stakeholders in a system is not rigid, but changes, mainly because of what Mercier (1997) and Duerr (1982a) refer to as constant evolution of motivations and values of people respect to their relationship with forests, and because new people become involved.

Forests affect people and people impact forests. This close relationship leads to the widely spread view of people as components of ecosystems (UNEP/CBD/SBSTTA, 1999; Christensen, 1997; Meyer, 1997; Suzuki and McConnell, 1997; Wodley et al., 2000). Although many human actions impact forest ecosystems, only some of them disturb them. From Franklin and Forman (1987) a forest is disturbed only if *modified*. Verification of modifications in an ecosystem, even when possible through tests of ecosystem integrity (e.g. loss of nutrients, loss of diversity), is very difficult (Treweek, 1999; Holling et al., 1987). Ultimately, assessing significance of impacts on ecosystems requires an intricate collective human judgement (Garling and Evans, 1991; UNEP, 1996). What some individuals perceive as significant might be non-significant for others. As Kimmins (1997) notes, scientists and the public commonly do not agree about what human actions disturb the environment.

Forest managers are challenged to explain to other stakeholders the actual significance of their management (Sheppard, 2001). With respect to environmental issues, however, people's knowledge –and managers' knowledge- is sometimes distorted, more than being incomplete. This makes it difficult to reach agreements. Another issue that managers deal with is the tendency of people to not internalize the fact that capturing benefits from the forests impacts and potentially disturbs these ecosystems (Mercier, 1997). Criticisms against intervention in forests are directed not only at the way in which these interventions are done, but also at the mere fact of intervention. For example, more than 170 forest stakeholders cosponsored the bill "National Forest Roadless Area Conservation Act" introduced in the U.S. House of Representatives in June 2002. In confronting these challenges, managers have to deal with multiple stakeholders. These are not "external factors" that affect management, but a component of management itself.

2.5.3.1 Dealing with Stakeholders

Engaging stakeholders is essential in various stages of decision-making in forestry. Bass et al. (2001) describe multiple benefits of doing so, such as improving credibility of objectives and targets, making use of a broader range of ideas, skills and inputs, ensuring practicality and focus of resulting standards, objectives and targets, and building a stronger foundation of stakeholder trust and accountability.

However, managing stakeholder' involvement is a difficult task. Stakeholders present different rights, capacities, responsibilities, interests, rewards, and relationships with other groups (Dubois, 1998; Bass et al., 2001; Foteau et al., 1998), and there are a number of potential constraints to effective public participation. These range from behavioural norms or cultural practice that inhibit involvement of some groups, to legal systems that may be in conflict with traditional systems, and cause confusion about rights and responsibilities for resources (Burke and Trahant, 2000; Mercier, 1997; UNEP, 1996). To surpass these difficulties, managers consider different modes of participation, such as coercion, co-option, compliance, consultation, cooperation, co-learning and joint action, and collective action (Cornwall, 1996; Bass et al., 2001). As the performance of each of these modes varies from stakeholder to stakeholder, selecting the best combination of them challenges managers. From simple improvements in public involvement in decision-making, managers are being pressed to use highly elaborated tools that allow the visualization of simulated future scenarios resulting from harvesting (Sheppard, 2001).

2.5.4 Complexity in the Forest Policy Subsystem

Forest policy refers to the purposive course of action or inaction followed in dealing with the use of forest resources (Cubbage et al., 1993). It guides how forests are managed, what resources are produced, and who benefits from forests. According to Duerr (1982b), the forest policy subsystem comprises an interrelated hierarchy of means and ends. It includes not only particular forest procedures and objectives, but also numerous other environmental, economic, and social procedures and objectives. Forest policy is made up of stakeholders' motivations, choices, and selections. According to Stanbury and Vertinsky (2000) and (Hoberg, 2001), it considers goals and specific objectives that derive from the reasons that motivate the government to intervene, instruments that best help these goals and objectives, and the selected form that instruments acquire. Each one of these results from complicated decision-making processes that include multiple actors (e.g. policy makers, forest managers, environmentalists) and an array of values (e.g. environmental protection, economic efficiency, social effectiveness).

In addition to the widely described five steps in forest policy making (e.g. Howlett and Ramesh, 1995), Anderson (1994) includes an initial step, 'problem formation'. Many issues concern stakeholders, but for these issues to acquire the status of problems in the view of policy-makers, intricate power interactions between stakeholders must occur. Issues that concern one group of people do not necessarily concern another. As Cubbage et al. (1993) note, stakeholders struggle to impose their various priorities, and this priority can be to keep the status quo from which benefits are being obtained. Hellstrom (1997) reports a number of instances in which forestry conflicts have been constructive elements of the forest policy cycle. For forest managers to know these priorities and processes, and from there predict what problems will eventually lead to what future forest policy instruments is difficult. These future policy instruments will strongly influence the way in which management is done. For example, if instruments are coercion-focused (Stanbury and Verstinsky, 2000), or "command and control" as referred by Pearse (2000), the behaviour of managers will be restricted by legal provisions (Cubbage et al., 1993). If they are incentive-focused instruments (Stanbury and Verstinsky, 2000), or economic instruments (Pearse, 2000), management will be driven by economic incentives to perceive. If reference-focused instruments (Stanbury and Verstinsky, 2000), managers behavior will be modified by means of altering their preference ordering.

2.5.4.1 Dynamics of Forest Policy

Policy processes conclude with policy evaluation. Hoberg (2001) and Cubbage (1993) connect the results of this step with the beginning of the policy cycle through feedback. Forest stakeholders may be critical of the current outcomes of a forest policy (e.g. unexpected increase in costs of operation, weakness in protecting forest attributes). These criticisms are concerns that can eventually result in problems that a refined forest policy has to deal with. The ability of stakeholders to have their concerns included in the forest policy agenda varies. According to Cobb et al. (1976), the agenda can be established by an outside initiation model, which means that environmental groups raise issues that are taken and expanded by many stakeholders, and eventually passed to policy-makers that include them into the agenda; by a mobilization model, which means that issues are placed directly into the agenda by policy-makers; or by inside initiation model, which means that issues are promoted by certain stakeholders that do not seek to have them expanded by other stakeholders. Policy-makers perceive these issues and eventually incorporate them into the agenda. Forest managers have to be knowledgeable about the issues that stakeholders with particular interests are trying to integrate into the policy agenda.

Various instruments constrain managers' actions, but also present with other opportunities for benefit through incentives. Complying with constraints and taking advantage of opportunities requires a great deal of knowledge. If forests are not managed according to current laws and regulation, eventually punitive measures against the manager result. In addition, if advantage is not taken of incentives offered to manage forests in a given way, managers may lose valuable opportunities.

2.6 Conclusion

Forests are systems made of ecosystem, resource, stakeholder and policy subsystems. Multiple components and their interactions make a forest system a complex adaptive system. Management of this system, including all its subsystems which are in constant change, is difficult. Sufficient knowledge is required for planning and implementing management actions that are the best ecologically, economically and socially for the present and future. As this knowledge is always incomplete, forest planning is done under uncertainty.

CHAPTER III. UNCERTAINTY AND BETTER FOREST PLANNING WITH INCOMPLETE KNOWLEDGE

3.1 Uncertainty. A kind of Ignorance

Although *uncertainty* and *ignorance* are frequently considered synonyms (Vercelli, 1998), as Smithson (1989) argues, uncertainty is not as broad a concept. The Oxford Dictionary defines ignorance as lack of knowledge. Both ignorance and knowledge are constructs, so are determined by people (Golledge, 1991). Once something is considered valid knowledge, unawareness of it is considered ignorance in the context and time in which its validity was determined. Ignorance varies in kind. Intentional ignorance arises from inattention to something due to personal convenience or social taboo. Some knowledge is considered irrelevant or undesirable, and learning it is neglected. In contrast, distortion and incompleteness of knowledge are unintentionally created ignorance. Some ideas and concepts are considered relevant, and are acquired as knowledge. If this knowledge includes bias, inaccuracies and confusion, it is distorted. If it is incomplete, it is uncertain (Smithson, 1989).

Uncertainty refers to a state of incomplete knowledge. Ideas and concepts are present but in a vague, probabilistic, ambiguous, fuzzy or non-specific state (Smithson, 1989). Uncertain knowledge, therefore, has the potential to be more complete. It reflects the confidence with which any estimate can be accepted as representing the future outcome of a process (U.S. EPA, 1999).

3.1.1 Origin, Assessment and Representation of Uncertainty

A system is not uncertain, but complex. Uncertainty arises from a human incapability of having complete knowledge about the system due to its complexity (Viegas, 1982; Holling et al., 1987). Incomplete knowledge impedes understanding of the original states of forests, and predictions of their future development. This hampers wise decision-making (Holloway, 1979). Although a necessary task (e.g. uncertainty can be so large that predictions are irrelevant), assessment of uncertainty is generally difficult (Smithson, 1989). As Stewart (2000) states, in some cases assessing the uncertainty associated with a prediction is more technically difficult than making the prediction. Mathematical approaches for assessing uncertainty include probability theory (La Place, 1820), classical set theory Cantor (1883), fuzzy set theory and fuzzy measure theory (Bellman and Zadeh, 1970), and rough set theory (Pawlak and Skowron, 1999). Although the most widely used (Sutton, 1982; Klir, 1994; Isukapalli, 1999), these approaches are not the only way to estimate the degree of uncertainty in specific decision situations. Sarewitz et al. (2000) indicate that apart of being difficult, one of the disadvantages of using purely probabilistic approaches to describe uncertainty is that probabilities are built upon mostly uncertain assumptions. This fact leads Ritchie and Marshall (1993) to argue that uncertainty cannot be described based on another uncertainty. In spite of this, the public, managers and scientists seem to better trust representations of uncertainty that use mathematics (Fahey and Randall, 1998). Forest managers are frequently tempted to manage based on official mathematical models leaving aside their *instinct*, and even sometimes, their common sense. As Ascher (1981) and Pielke et al. (2000) argue, the last test of a prediction of a future outcome is to evaluate its accuracy against actual outcomes as they unfold. Sufficient feedback makes assessment of uncertainty a more straightforward matter (Stewart, 2000). Past predictions can be matched with current data to assess fit. Although challenging, as Rayner (2000) discusses, "retrodicting" past events has been central to the assessment of climate change models, for example. Together with adequate feedback, assessing uncertainty can involve judgment (Stewart, 2000). Through experience, ranges of uncertainty can be learned, and the associated risk can be taken in to consideration during decisions.

3.1.2 When Uncertainty becomes Risk

Risk has numerous definitions, as acknowledged by Ritchie and Marshall (1993), Cool (1999), and Treweek (1999). Most definitions, however, seem to converge on two key elements: loss caused by an event, and probability of occurrence of the event (e.g. a probability between 0 and 1).

As knowledge about a forest system's future is incomplete, many outcomes are not known. For example, as Cool (1999) states, if at least one of these possible outcomes represents a loss, then there is risk involved. Risk therefore arises from uncertainty. The uncertainty about the future leaves people worried over which of several undesirable consequences may result (Ritchie and Marshall, 1993; Holzheu and Wiedemann, 1993). How worried people feel, and their willingness to cope with an uncertain future, varies among individuals (Starr, 1980). People also change their perception and willingness to take risks when confronted with different situations (Leiss and Chociolko, 1994). Acquisition of adequate knowledge reduces uncertainty, and can eventually change perception of risk itself (Ritchie and Marshall, 1993; Rescher, 1983). As with uncertainty, feedback and judgment is useful for estimating and evaluating risk. Evaluation of past threatening situations and vulnerabilities, their outcomes and associated losses, help to plan responses to potential damaging events occurring in the system being managed. Mathematical quantification of risk is common. Probabilities of losses due to change in markets (e.g. Ritchie and Marshall, 1993), and natural disturbances such as beetle attacks (e.g. Shore and Safranyik, 1992), fire (e.g. Thompson et al., 2000), windthrow (e.g. Mitchell at al., 2001), and landslide (e.g. Anbalagan et al., 1996) is knowledge available to forest managers. Retrodicting past events to learn from previous damaging events in a systematic way, however, is less reported.

3.1.3 Crippling and Overlooked Uncertainty

If there was no uncertainty, managers would always know exactly what course of action to take and exactly when, where, why and how to take it. Though a fact of life, the effects of uncertainty are frequently overlooked. Conversely, uncertainty about the future worries and eventually cripples decision-making in certain people (Georgantzas and Acar, 1995). The wait-and-see approach is a common approach in managing natural resources (Rayner, 2000). Some stakeholders propose strict interpretations of the *precautionary principle* as the best way of dealing with situations of uncertainty in forestry. As Dunton (1998) discusses, they suggest that no action should be taken if there is any likelihood, however small, that environmental damage could occur.

Fear of uncertainty narrows options for risk averting managers, who wish to be certain about no possibility of losses before making decisions (Ritchie and Marshall 1993). Courtney et al. (1999) state that assuming that the world is completely uncertain can lead managers to abandon analytical rigor when planning and base decisions purely on instinct. However, instinct cannot be excluded from decision-making (Fahey and Randall, 1998). I. Wilson's (1998) description of the "intuitive logic" approach to scenario planning implemented by Dutch/Shell in the 1970s illustrates the important role that gut feeling occupies in decision-making.

Other managers make decisions presuming that knowledge is complete (Chambers and Taylor, 1999). They overlook uncertainty and, as a result, do not consider the chance of loss. Recognizing managers' limited understanding of forest processes, Nelson (2001) recommends incorporating into analysis of future forest conditions "appropriate warnings of the inherent uncertainty in forest management, especially the magnitude of catastrophic events such as fire and insects". As Courtney et al. (1999) point out, underestimating uncertainty can lead to strategies that neither defend against threats nor take advantage of opportunities. The importance of acknowledging uncertainty and eventual risk made Newman (1988) to predict that these tasks would be the next fundamental issue for forest economists to address. As Brazee and Newman (1999) note, there has been an explosion of papers on uncertainty and risk in forest economics.

3.2 Forest Decision-Making Under Uncertainty

A decision is the selection of a course of action (Rowe, 1992). Forest decisions range in scope from those concerning day-to-day activities, to those concerning the very long-term future of the forest, and from small stands of trees to entire forest regions (Buongiorno and Gilles, 1987). At nearly every level in forest decision-making there are alternatives to be weighed (Duerr, 1982c). As Holloway (1979) states, when alternatives have known outcomes, and consequences are described, then making decisions is a simple task. This rarely occurs in forestry. Furthermore, Rowe (1992) argues that full knowledge at a given point in time could assure one good individual decision at that time, but not all successive decisions. When making decisions, diligent forest managers collect the best available information and analyze it. From this, they learn about trends and patterns, and can infer much about the future. However, uncertainty remains. Courtney et al. (1999) classify this uncertainty into four levels:

1. A clear-enough future. The manager can develop a single forecast of the future –or scenario- that is precise enough for planning management.
2. Alternate futures. The manager can describe the future as one of a few alternate scenarios. If the scenario were predictable, some of the elements of the plan would change.
3. A range of futures. The manager can identify a range of possible futures. There are no naturally discrete scenarios, and planning has to be flexible enough to adequate to any changing conditions and resulting scenario.
4. True ambiguity. Possible futures cannot be identified. Even trends that define the future cannot be identified, or their behavior predicted. Planning will hardly drive management, but has to be flexible to incorporate knowledge once produced.

As these authors argue, most decisions that managers make fall into the categories "alternate futures" and "a range of futures". A preliminary step in forest decision-making is to identify the level of uncertainty that surrounds the decisions being made, as each level of uncertainty demands a different approach to deal with (Ritchie and Marshall, 1993).

From what Stewart (2000) describes as the general environment for decision-making and prediction, the environment in which forest decision-making occurs can be conceptualized as: the forest system itself; the information channel, which brings information from the system to the manager; and the decision context, that influences the way in which decision-making is done (Figure 3.1). Uncertainty pervades forestry due to the combination of properties of these three elements.

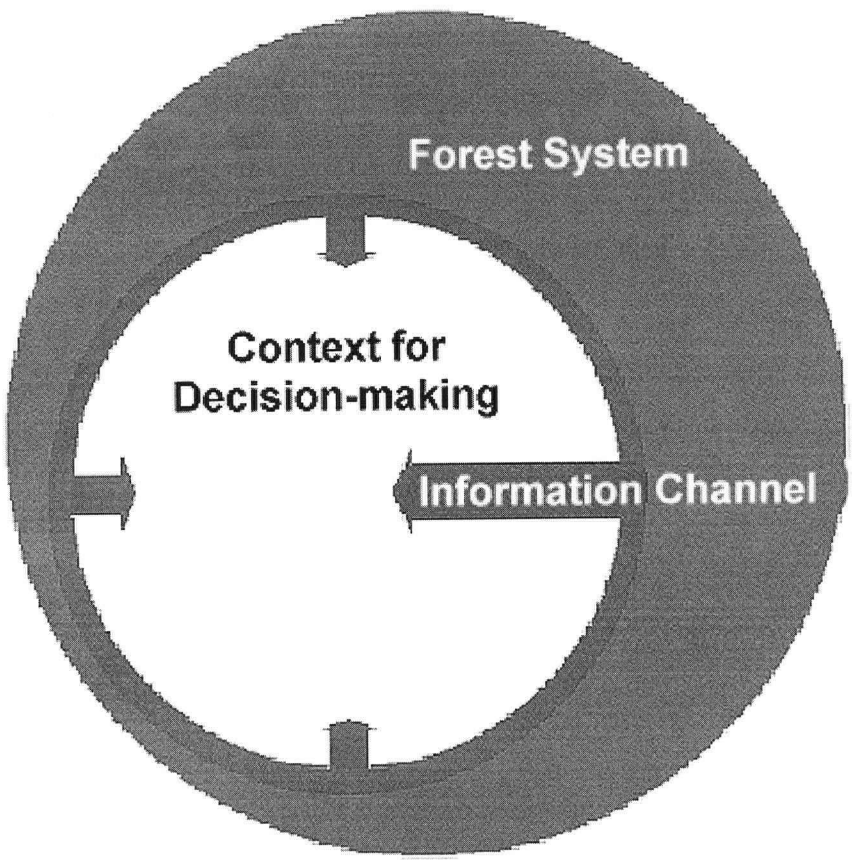

Figure 3.1 The environment for forest decision-making.

3.2.1 The Information Channel

The information channel includes instruments, observers, data links, and various displays of data (Stewart, 2000). All these help managers to understand the forest system. According to Zucchetto and Janson (1985), people tend to organize their conception of (e.g. understand) the environment with the aid of some form of model. A model is an abstract representation of a system or process (Turner and Johnson, 2001), a simple representation of a given understanding (Chambers and Taylor, 1999), or an abstraction of how we think nature operates (DeAngelis and Waterhouse, 1987). Managers use models to simplify forest systems in order to understand them.

Models have many uses in forestry, and guide the observation and representation of ecological phenomena (Haag and Kaupenjohann, 2001; Turner and Johnson, 2001). As models are to be used for specific purposes, to decide which to use is a challenge (Botkin, 2001; Shenk and Franklin, 2001). Continuous evaluation of models should be a key issue in forestry. As Caswell and Trevisan (1994) and Turner and Johnson (2001) argue, evaluation should be made in terms of how well they are meeting objectives and agreeing with empirical observations. Sensitivity analyses are run, and the relative importance of particular parameters within the model is evaluated. Uncertainty analysis is also done (Ricotti and Zio, 1999). Botkin (2001) points out that a central challenge in modeling is to improve communication between theory and observation. Landsberg (2001) argues that managers and scientists need to find common ground in this regard. Many current efforts in modeling aim to better capture the particular features of the forest system. As LeMay and Marshall (2001) state, models have new demands. Shifts in forest management have changed information needed to make informed decisions in forestry. In using only the best available models, managers can improve knowledge about the forest system.

Mathematical models, however, are not the only possible way of getting to understand the forest system. Managers should use other approaches when cause-effect relations are too uncertain (Thompson, 1967). Judgment, imagination, and instinct as sources of knowledge are widely reported (Thompson, 1967; Mumpower and Stewart, 1996; Schwartz, 1996; Fahey and Randall, 1998; Stewart, 2000). In learning public attitudes towards forests, for example, the information channel should include different instances of direct communication with the stakeholders of the forest system. Possibly, however, the most important way of acquiring knowledge from a forest system to manage is direct monitoring of the outcomes of management actions.

Problems in the information channel promote confusion, decrease certainty, and produce ignorance through distortions. Failures in managing natural resources resulting from a weak information channel are widely reported (e.g. Sarewitz et al. 2000). A good example in BC forestry is the report during the last round of the timber supply review that revealed that many of site index estimates on which yield predictions were based were poor. Generally site index has been underestimated (Site Productivity Working Group, 1997).

3.2.2 The Context for Decision-Making

The context for decision-making is made-up of the procedural, social and bureaucratic issues that surround forest managers when making decisions. As Rowe (1992) points out, decision-making is not an isolated psychological activity, but a process that takes place in groups and involves conflict. Thompson (1967) argues that what is decided and features of the context that affect how this is decided are equal concerns to managers.

Procedures used to make decisions may be specified and be rigid. As Iverson (1998) explains, forest decision-making is often forced into rigid straightjackets such as rational planning, or command and control decision-making. As an example of how forestry decisions are framed by a context, Nyberg (1999) identifies regulatory and institutional inflexibility and reluctance of institutions to change practices, objectives or opinions as major barriers to adaptive forest management. The framework of goals and management procedures for public assets are particularly rigid, especially in public forests which are expected to generate a wide sort of benefits. Binkley (1997), for example, discusses how forest tenures can impose a rigid and uniform grid that constrains management. Other examples are given by Daniels and Walker (1997) and Solberg and Miina (1996) in describing how very specific requirements for involving stakeholders in forest decisions create all sort of temporal constraints.

Elements of the context for decision-making also constrain the information channel, specifically how and where to obtain information from the forest system when making decisions. Information requirements are set in many instances, such as BC, in where mandatory information to be included in forest planning is specified by the Section 10 of the BCFPC and Sections 18-20 of the Operational Planning Regulation (BCMOF, 1995 and 1998b). Rigidity goes further, in legally defining "known information" to be included in forest plans in the Province. Requirements that information focus on specific processes more than on results also challenge the acquisition of knowledge. In instances, acquiring knowledge is constrained by an array of "official" sources of information, such as national statistics, public forest covers, and public environmental monitoring data. This information constitutes the basis over which the rest of the information has to be built up. Managers have to fit their knowledge with this official information, and if the official information is wrong must defend their own knowledge.

The acceptability of uncertainty and risk is also reflected in the context for decision-making. Stakeholders can be risk averse, and this is passed on to managers (Ritchie and Marshall, 1993). Some contexts will be more tolerable to *type two errors*, while others will prefer to assume the risk of *type one errors* on predictions of future outcomes. In the context for forest decisions, where ecological risk is perceived, it is appropriate to expect that managers try to demonstrate that their management will not harm ecosystems. But on the other side, as Treweek (1999) describes, regulators set thresholds for type two errors. Policies in the forest system reflect the tolerance to risk that governments are able to accept. Democratic governments are under greater scrutiny and tend to have low tolerance of failure. As described in BCMOF's (1999a) "Managing Risk Within a Statutory Framework", forest policy sometimes allows for discretion in determining acceptable and unacceptable levels of risk. And governments usually assume a risk-avoiding position, which increases constraints to forest decisions.

Managers' decisions are also influenced by various social conventions, restrictions, or incentives. Decisions can be influenced by praise or criticisms received for recent successful or unsuccessful predictions and decisions (Stewart, 2000). Forest managers are increasingly under public scrutiny, and are professionally accountable for their work (Rattray, 1999). As knowledge about elements of the forests system commonly differs between the public and forest managers, agreements on many decisions are difficult. Managers are almost certain about many things that the public are uncertain or broadly ignorant about, and vice versa. For many people, for example, the biological processes that follow harvesting are not clear (Kimmins, 1997), and concepts such as sustainable forest management can have a completely different meaning.

In competitive business environments, forest managers' bosses can consider risky decisions that result in positive outcomes worth taking, and will provide incentives to take them. However, these same bosses are less likely to accept the downside of these same risky decisions, and this puts managers under stress. Changing conditions within the forest system also constrain the freedom for making decisions. For example, Chambers and Taylor (1999) describe the pressure for rapid return on investments when market conditions change. Responding to natural disturbances in forests is another example of having to make decisions with a very narrow range of possibilities, as the response to the present epidemic of bark beetle in BC forests shows (BCMOF, 2001a).

These rigidities in the context for decision-making contrast with the flexibility that forest planning processes should be granted to occur in. Kimmins (1997) relates wise decisions about how forests are managed to careful planning. And, as Fahey and Randall (1998) argue, better planning occurs in a flexible and adaptive forest planning scheme that allows for constant learning.

3.3 Better Forest Planning: A Constant Learning Process

Planning is an integral and fundamental component of forestry (Duerr, 1982c). The FAO (1998) describes planning as an active process requiring careful thought about what could or should happen in the future and that involves the coordination of all relevant activities for the purpose of achieving specified goals and objectives. Chambers and Taylor (1999) identify the stages in planning as:

1. Review and understanding. In this stage managers incorporate knowledge about the system.
2. Goal formulation. Having identified the system, goals for it are formulated.
3. Problem formulation. The specific problem to approach is identified and characterized.
4. Plans. A number of solutions to the problem are prepared.
5. Evaluation. Consequences of each plan are measured. Plans are compared in terms of their accomplishment of goals preset.
6. Selection. The best plan is chosen for implementation.
7. Implementation and control. The plan is put in place and monitored.

As Rowe (1992) asserts, decision-making and planning feed each other. Planning eventually results in what Johnston et al. (1967) described as anything between a series of arbitrary or dogmatic decisions, and a critical and sophisticated investigation into the whole range of possible choices open to managers. Uncertainty goes together with these decisions.

Setting adequate objectives and selecting the best way of achieving these in an ever-changing system has to be learned through practical experience (Fedkiw, 1998). As Henriksson (1999) states, better planning involves constant learning (e.g. acquisition of knowledge). Kolb (1984) has suggested four stages in a learning cycle (Figure 3.2).

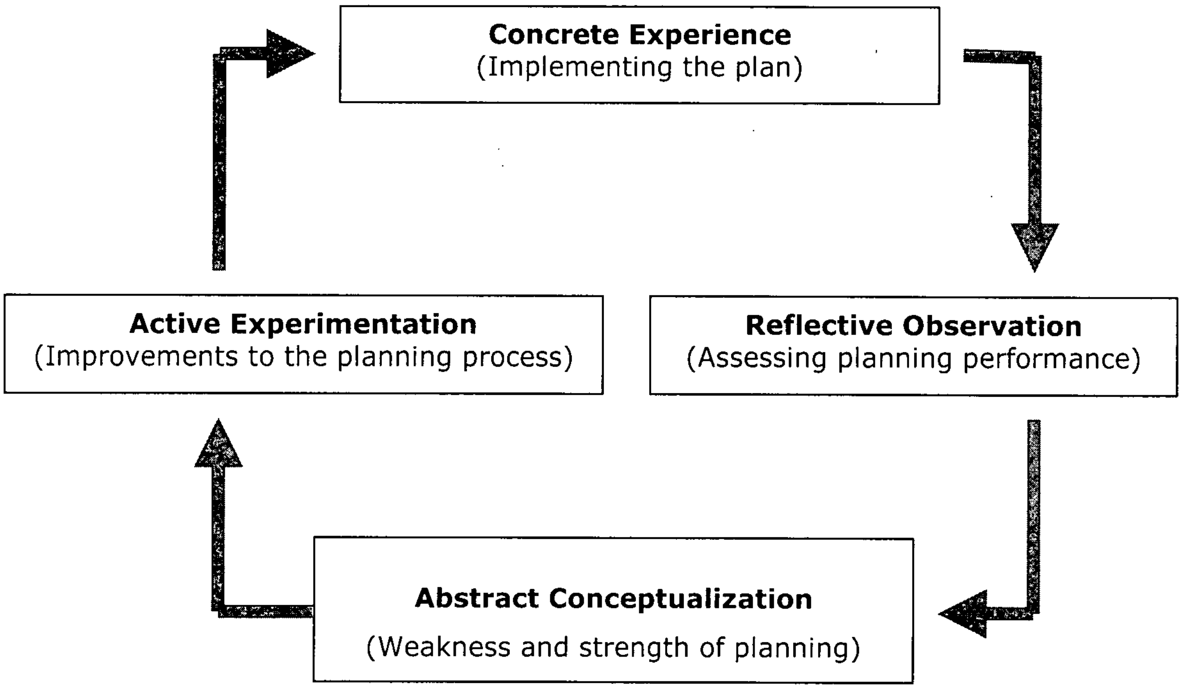

Figure 3.2 Planning and the learning cycle (based on Kolb, 1984)

Learning as a component of planning is widely reported as a condition for successful management (Rowe, 1992; Ritchie and Marshall, 1993; De Geus, 1997; Henriksson, 1999; Mintzberg, 2000; Mintzberg et al., 2001). As Rowe (1992) discusses, some managers benefit from abstract conceptualization over reflective observations (pragmatists), while others prioritize reflective observation over concrete experience (theorists). In forestry, Weetman (personal communication, February, 2002) and Baskerville (personal communication, March 2002) support the need of continuous learning, and references in articles are not scarce (e.g. Walters, 1986; Kimmins, 1997; Wollenberg et al., 2000). Adaptive forest management has been inspired in this need for constant learning and incorporation of new knowledge (Taylor et al., 1997). However, planning as a learning process has not received the same attention from managers as adaptive management has. Adaptive management within rigid planning will not be successful. To be efficacious, management has to incorporate a flexible and adaptive planning process that can be constantly improved after showing weaknesses. This results not only in better current forest plans, but also in plans that can drive adequate management in the future.

3.3.1 Better Present and Future Forest Plans

Forest plans state for what purposes forests will be managed and how (Duerr, 1982c). Weetman (2000) recommends that plans have certain desired features, such as being credible, implementable, auditable, and to conform with continuous learning and improvement through adaptive management. Dunster and Gibson (1989) discuss more specific requirements for adequate forest plans, such as having: measurable and attainable objectives for the activities; analysis of impediments to achieving these objectives; explicit means of overcoming these impediments; schedules of operations for implementation of the plan; measures to determine the efficacy of these actions in moving towards the desired objectives of the forest activities; and means of evaluating actual progress relative to desired progress toward the accomplishment of the objectives of the forest activities.

Plans directing the management of forests that do not acknowledge uncertainty are fragile (Duinker and Hay, 1994; Aber et al., 2000). Experience in many disciplines, such as economic planning, fisheries and ecology of climate change shows how dangerous it can be to rely too heavily on a plan based on predictions about uncertain future outcomes (e.g. Schwartz, 1996; Fahey and Randall, 1998). Marsh (1998), for example, reports how wrong have been traditional predictions about future energy availability. In another example, Ringland (1998) reports how a group of scientists were asked in 1966 to predict the state of the world twenty years ahead. These scientists elaborated 335 predictions. Twenty years from then, nearly every prediction was wrong. As a result, Sarewitz and Byerly (1999) recommend that predictions not be considered as products, but rather processes within decision-making.

Courtney et al. (1999) propose alternative approaches to deal with uncertainty in planning. From these, better forest plans respond to the amount and kind of uncertainty surrounding the knowledge of the forest system under management. When the future is clear enough, a plan should be based in a single forecast, and objectives and actions should be built toward this almost certain future. When a few alternate futures are predicted, plans should identify the possible futures outcomes and to clarify the paths to reach those alternative futures. If a range of future outcomes are identified, then plans should not only recognize these potential future outcomes but equally importantly, they should focus on the trigger events or patterns that could give an indication that change is going toward one or another scenario. Finally, if managers have no clue about probable future outcomes or scenarios of the forest system, and planning deals with true ambiguity, plans should identify at least a subset of variables that will determine the future. Plans also should identify indicators of the evolution of these variables.

An interesting experiment in addressing level 2 and 3 uncertainty (Section 3.2.1) is underway at the McGregor Model Forest, located near Prince George, BC, and one of the 11 forest models in the Canadian Forest Model Network. McGregor's approach to sustainable forest management consists of three linked components: scenario planning, strategic and operational planning support, and indicators and adaptive management (McClain, 2002). At the tactical level, alternative future scenarios are explored, bringing forest stakeholders' interests together. What is needed to achieve agreed future scenarios is assessed. From then, the best tools for modeling, forecasting and visualization are selected to assess the likely implications of different management strategies. Operational plans can be developed. Indicators are used to monitor measurable forest attributes to ensure compliance between planned objectives and actual performance (McGregor Model Forest Association, 2001). This actual performance, therefore, refers to management effectiveness. Efficiency of management, and planning, is not assessed. Better future management results from plans that incorporate continuous evaluation not only of the planning efficacy (e.g. effectiveness and efficiency), but also of the factors that affect this efficacy.

3.3.2 Forest Plan Efficacy and Indication of Planning Uncertainty

The performance of a plan should be tracked in terms of its efficacy. The forest plan is supposed to contribute to certain outcomes (e.g. to produce sufficient timber according to a defined objective quantity). Its effectiveness, from O'Connor (1983) and Hodgetts (1982), refers to how well its implementation contributes towards these outcomes (e.g. the plan is effective if allows the manager to obtain that amount of timber). Its efficiency, from Hodgetts (1982) refers to the inputs required to reach the outcomes (e.g. an efficient plan is one that uses relatively little efforts to produce the desired amount of timber). Efficiency can be expressed in relative terms (e.g. this year's forest plan is more efficient that the one of the past year). Efficiency can also be specified in absolute terms (e.g. this year's forest plan required 20% less time to be implemented). An efficacious forest plan should be both effective and efficient. Further, it has to perform well in the future and in response to *contingencies*.

Assessment of plan performance is a necessary stage in improving planning and plans (Rowe 1992, De Geus, 1999). The greater the discrepancy between actual and planned outcomes, the more uncertain was the knowledge that the manager had when designing the plan, and when implementing it. This lack of knowledge can then be strengthened for the next plan, thus improving planning performance. Planning is done to better conform with agreed ecological, social, and economic targets. Proving that harvesting occurs as planned, then, should represent a key effort in forestry. Assessment of criteria and indicators should be used not to track forest management efficacy, but to help refining targets.

3.3.3 Estimation of Planning Uncertainty: A Spatial Approach

A forest plan has a spatial component. For example, harvesting is proposed for specific geographic areas of the landscape (planned outcomes), which can be mapped. Actual harvesting has also a geographic distribution in the landscape (actual outcomes). Overlapping of planned and actual outcomes allows for identification of specific areas of the landscape where harvesting differentiates from what one, or more than one, forest plan(s) propose(s). In this thesis these areas of the landscape are referred as "areas of planning discrepancy" (Figure 3.3). Areas of planning discrepancy are due to either planned harvesting that did not take place, or unplanned harvesting that did take place (e.g. salvage).

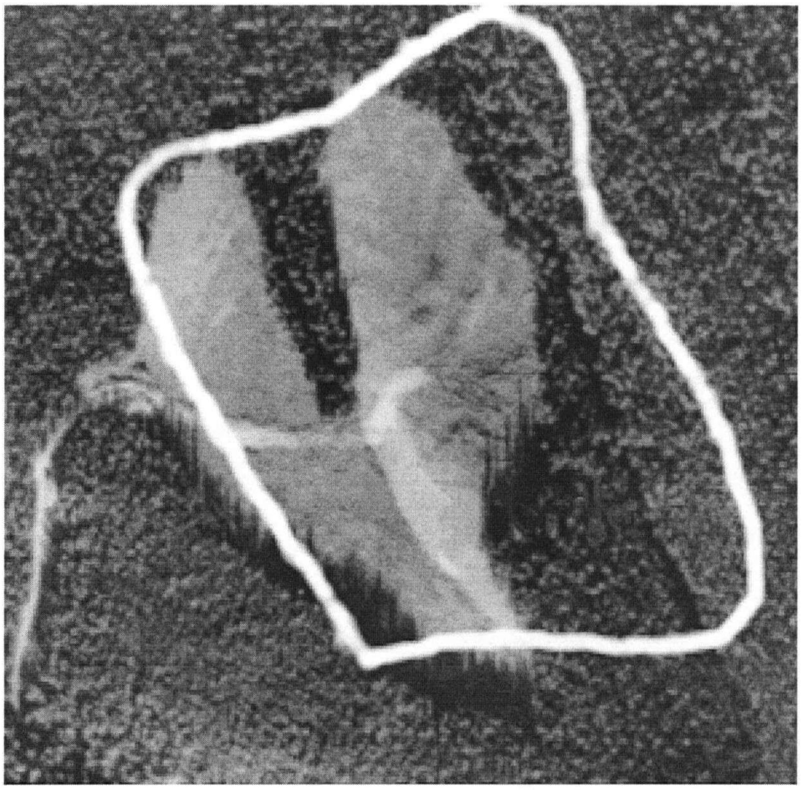

Figure 3.3 Discrepancies between the 1995 forest development plan (red line) and 1998 harvesting.

As discussed by Lang (1998) and O'Looney (2000), Geographic Information Systems (GIS) can assist forest managers in designing plans and in monitoring the outcomes of forest management. Uncertainty in forest systems has also a spatial dimension, and can be represented and analyzed using GIS tools. When concern shifts towards a particular wildlife species, for example, the range of this species is representable in the landscape. The geographic distributions of "old" and "new" concerns can be mapped, and analysis respect to constraints to forest planning can be done. Following the same principle, the effect of a change in pulpwood prices on stand values can be mapped, as can the effects of new policies, and new forest resources. Uncertainty becomes much more concrete when visualized as an area of landscape (Buttenfield, 2001). Once mapped, the influence of sources of uncertainty can be matched with maps of areas of planning discrepancy, to look for causes to explain them. Analysis of areas of the landscape where planned outcomes were not reached provides feedback for the planning of next outcomes. Planning processes may well change for these areas (e.g. to use different tools for predicting occurrence of natural disturbances; to improve communication tools for dealing with people's concerns), and targets of management may be redirected to fit newly known elements of the system.

3.4 Conclusion

The complexity of the forest system, difficulties in characterizing it, and a context that impedes acquisition of this knowledge means that uncertainty pervades forestry. As complete knowledge is impossible at any moment in time, and assessment of uncertainty is not as straightforward as expected, better planning has to be a constant learning process. This produces forest plans that can drive management under a broad range of futures. When plans fail, improvements can be made if these failures are detected. Evaluating plan efficacy spatially, and the association of uncertainty with areas of the landscape, can contribute to constant improvement.

CHAPTER IV. FOREST PLANNING IN BRITISH COLUMBIA, CANADA. A CASE FOR BETTER PLANNING

4.1 Introduction to Forest Planning in BC

In BC, 95% of forest land is publicly owned, and forest harvesting is licensed to forest companies. Under the present legislation, licensees must prepare Forest Development Plans (FDPs), which describe in detail specific areas proposed for harvest. The BCMOF (1994) describes how forest practices in BC have gone through several stages: pre-regulation -before 1909-, early regulation and establishment of the forest industry –1909 to 1940-, sustained yield forestry and growth of the forest industry –1940 to 1970-, multiple use forestry and limits to growth –1970 to 1984-, and towards broad sustainability -after 1984-. The introduction in 1979 of the MOF Act and the Forest Act marked a turning point for forest planning. Among other initiatives, the Acts introduced a multiple-use planning process, and requirements for public review and participation. From 1987, licensees were required to prepare a pre-harvest silviculture prescription for approval prior to receiving a cutting permit. This prescription outlined how environmental and social values would be accomodated on harvested areas (BCMOF, 1988). About the same time, the government established the first comprehensive processes to plan for land use at strategic levels, such as the South Moresby Land Use Agreement in 1988 (BCMOF, 1993). The introduction of the Forest Practices Code of BC (BCFPC) in 1994 established new requirements, and consolidated existing ones, for forest planning in BC. Presently, forest planning in BC is hierarchically structured with three levels:

1) Strategic land use planning (e.g. strategic plans, regional land use plans, subregional land use plans). A framework for public land use decisions over a broad region is provided. Stakeholders assign priority to land use activities, define objectives and strategies for an area.

2) Tactical planning (e.g. resource management zone objectives, landscape unit objectives, sensitive area objectives). Objectives for specific landscape units are set, which are legally binding on subsequent operational activities.

3) Operational planning (e.g. FDP, silviculture prescriptions, stand management prescriptions). Site-specific objectives and strategies for operational activities in an area are designed in order to be consistent with higher level plans.

In this scheme for planning in BC, FDPs are the cornerstone of operational planning. These plans, updated annually or every two years, describe how forest managers intend to access, harvest, renew and protect an area under license over the next five years. FDP approval of a cutblock allows for its harvesting after a cutting permit has been issued and a silvicultural prescription approved. The Forest Development Plan Guidebook (BCMOF, 2001b) states the two primary goals of FDPs:

1) To provide information covering a five-year period on the features of proposed actions, in a manner which demonstrates management for biological diversity, soil conservation, water, fish, wildlife, and other forest resources, and recognizes the economic and cultural needs of peoples and communities.

2) To describe how higher-level plans for the area will be carried through in subsequent operational plans.

As a key vehicle for inter-agency and public consultation, FDPs enable resolution of multiple interests and demands on the BC forest land base. FDP preparation requires considerable amount of detailed information, which is specified by the BCFPC and its Operational Planning Regulation (Figure 4.1).

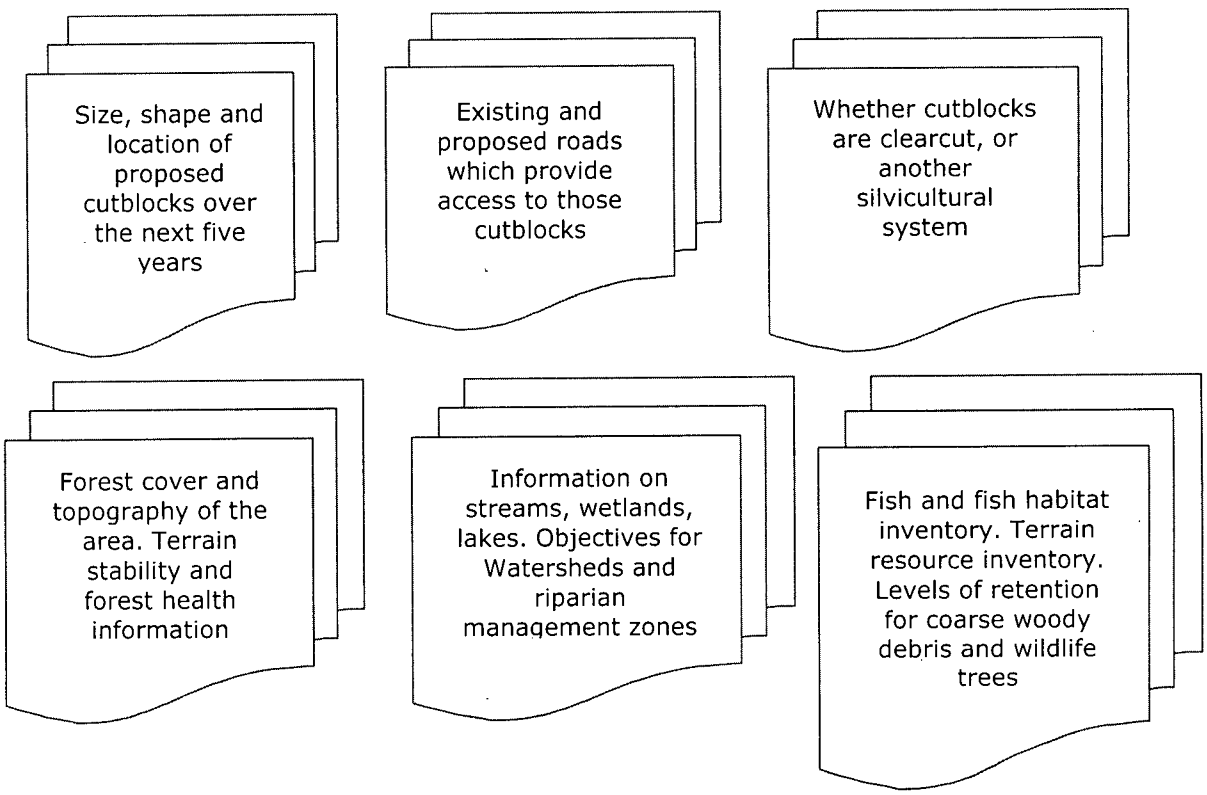

Figure 4.1 Main information requested for FDP preparation. (Based on BCMOF, 1998b).

As discussed in Chapter III, when preparing FDPs, managers have incomplete knowledge of the current and future states of the forest system. From Haddock and Brewster (1998), managers preparing FDPs have to acquire spatial knowledge on complex biophysical issues of the forest (e.g. natural disturbances). And issues such as protected areas, wilderness areas, sensitive areas established in accordance with the BCFPC, wildlife habitat areas, forest ecosystem networks, old growth management areas, scenic areas, ungulate winter ranges, community watersheds, community water supply intakes and related water supply infrastructures, fish stream, riparian class of streams and wetlands and lakes, temporary or permanent barriers to vehicle access, objectives for known ungulate winter ranges, and water quality objectives for community watersheds. If this knowledge were complete, the spatial distribution of forest system features in the landscape would allow for identification of constraints and opportunities for harvesting. The best alternative plans would be selected according to best visualized future scenarios under uncertainty. Candidate harvesting areas would be then located, and cutblocks proposed in previous FDPs would be refined.

Weaknesses in the allocation of cutblocks, and further, in the planning processes, were identified in the mid 1990's (BCFPB, 1999 and 2000). In response, the Operational Planning Regulation of the BCFPC introduced significant amendments to planning regulations, and specifically to cutblock requirements in 1998. An important aim of these amendments was to increase certainty during the planning process, specifically to reduce the likelihood that harvesting would be rejected after licensees incurred planning costs and received initial approvals (Haddock and Brewster, 1998). Various categories of cutblocks were introduced. Despite this, and other changes to planning processes in BC, uncertainty remains. Forest plans often do not perform ecologically, economically, and socially as desired by the multiple stakeholders in BC forests. In consequence, forest plans fail to drive forest management.

4.2 Current Challenges to Forest Development Planning in BC

Recent headlines in BC newspapers give a sense of the array of changing circumstances in which forest planning occurs:

> *"Forest fires break out"*[2]*; "Pine beetle epidemic triples"*[3]*; "Land-use issue inflamed"*[4]*; "Court halts logging in land-claim area"*[5]*; "One owl cuts logging"*[6]*; "Parameters in forest fight changing"*[7]*; "Forest tenure, logging rules could be changed"*[8]*; "Logging companies await review of AAC"*[9]*; "Forestry faces market access uncertainties"*[10].

Implementing FDPs under these circumstances is difficult. Frequently, expected outcomes (e.g. harvesting of cutblocks) have to be delayed, or even discarded. As examples, the Coulson Group (2001a) reports, "This permit is nearly 100% hembal and was put on hold late 1997 after the hemlock market collapsed. It has been in the bank waiting for markets to improve". Slocan Forest Products (2001) reports, "Compliance with the (Forest Practices) Code has increased operating costs and administrative requirements for companies...and has resulted in delays in certain of activities..." The same licensee adds, "...such situations (road blockades) cause delays in access to timber..." On the other hand, forest management outcomes are often the result of interventions that were not-originally planned. Contingencies force

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[2] National Post 05/23/2001
[3] National Post 11/11/2000
[4] Vancouver Sun 09/04/2001
[5] Vancouver Province 08/06/2000
[6] The Daily News 07/23/2001
[7] Vancouver Sun 08/10/2000
[8] The Daily News 07/31/2001
[9] Creston Valley Advance 06/08/2000
[10] The Northerner 03/13/2001

managers to change the original plans. The CLMA/NFPA Mountain Pine Beetle Emergency Task Force (2000) reports:

> Licensees on the front lines of the (mountain pine beetle) infestation are redirecting up to 100 per cent of their allowable annual cut to beetle management in the 2000/2001 season in an attempt to get ahead of the infestation.

When not adequately addressed, uncertainty affects forest plan efficacy. Expected actions are not carried out, and non-expected actions are carried out. As concluded in an audit made by the BCFPB (1999), "The positions and shapes of a substantial number of cutblocks approved in forest development plans... were modified to a moderate or maximum degree in subsequent cutting permit submissions". The apparent weaknesses of forest development planning in addressing uncertainty and accurately forecasting forest interventions challenge not only forest managers, but also other stakeholders in the forest system. Traditional planning is being questioned. The BCFPB (2000) concludes in its Review of the Forest Development Planning Process in BC:

> The reliance on major amendments to obtain approval of planned development and harvesting may not ensure that forest resources are being adequately managed and conserved... The effort spent in preparing and reviewing a detailed original FDP may not be the best use of limited resources, given that major amendments will drive forest harvesting"... the cost of the major amendment process was identified as an inefficiency by some districts and licensees working in highly dynamic environments... in highly dynamic environments (e.g., bark beetle

infestations and natural disturbances such as ice storms), FDPs cannot meet the intent of providing an orderly plan for development of roads and harvesting and a meaningful opportunity for public review and comment....

In spite of these observations, the actual magnitude of the effect that uncertainty is having on forest planning has not been quantified Province-wide. Neither have sources of this uncertainty and their features been investigated.

4.3 Province-wide Quantification of How Uncertainty is Affecting Forest Planning in BC

Given that uncertainty is strongly affecting forest planning efficacy in BC, it was considered relevant to quantify its effect on the part of licensees preparing FDPs and on the governmental agencies that review the plans. The approach taken was to directly survey FDP producers and reviewers, asking them to identify and comment on issues that are related with the effects of uncertainty on planning. The results provide an overview of the current situation at the provincial level.

4.3.1 Methods

Between September and October of 2001 an email survey (Appendix 2) was conducted throughout BC. The objectives of the survey were:

1) To determine the number of FDP submissions and amendments per year in the Province, and to obtain an estimate of the average cost of producing them and reviewing them; and
2) To identify uncertainty promoting amendments to FDPs, and strategies used by licensees to deal with it.

The survey was sent by email to the six BCMOF Forest Regions (Cariboo, Kamloops, Nelson, Prince Rupert, Prince George, and Vancouver). In some cases, officials asked the survey to be directly sent to some of the forty BCMOF Forest Districts province-wide. The survey was also sent to five randomly selected licensees operating throughout BC (Slocan Forest Products Ltd., Gorman Bros Lumber Ltd., Kalesnikoff Lumber Company, Riverside Forest products Ltd., and UBC Research Forests). The survey consisted of two different sets of questions. Similar questions were asked to both licensees and the BCMOF, with some special questions for each party. BCMOF Regions/Districts were asked:

1. How many FDP's are submitted annually to your Region/District?
2. What is the estimated cost in the Region/District for reviewing an FDP?
3. How many times are approved FDPs amended (major and minor) -on average- by licensees in the Region/District? and What are the main causes of these amendments?
4. What is the estimated cost for reviewing amendments to FDPs? (total $, $/m^3, or $/ha).

Licensees were asked:

- What is the estimated cost of producing an FDP?
- What are the main causes, and costs, of amendments (major and minor) to your FDP?
- Is uncertainty actually compromising the implementation of your FDP approved blocks and cutting permits?
- Do you assess FDP implementation?
- Do you track forest planning performance?

- Do you have any strategies to deal with uncertainty affecting FDP implementation?

All forty BCMOF Forest Districts responded directly or through regional officials that compiled the information for the region[11]. The five licensees surveyed also responded. These answers were compiled and categorized. Due to the difficulties acknowledged by BCMOF officials and licensees on relating budgets to FDP preparation and revision, estimations of costs were made with caution. However, rough estimates of total costs involved in FDP processes made by each BCMOF region/district did not differ greatly (Appendix 2).

4.3.2 Results

About 301 FDPs are reviewed each year province-wide by the BCMOF[12]. A regional split shows variance among forest regions (Figure 4.2).

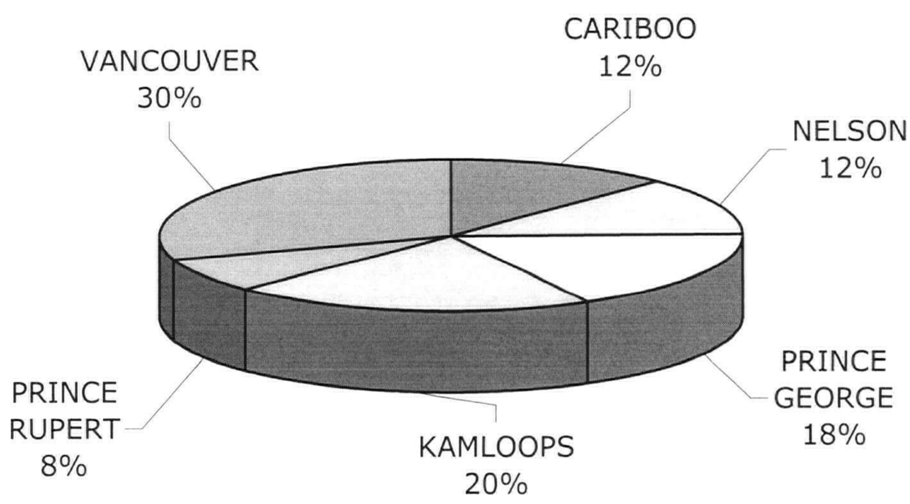

Figure 4.2 Percentage of FDPs reviewed by BCMOF Forest Regions.

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[11] In some cases these responses did not include answers to all questions.

[12] According to the BCMOF Forest Practices Branch 500 FDPs are reviewed per year in BC. From the information collected through the survey, 300 FDPs are reviewed per year. A cause for this discrepancy, as manifested by many BCMOF regions, can be that most of FDPs are now getting 2-year approvals, and therefore, are not reviewed each year.

The review of each FDP involves staff time and capital costs (e.g. offices, computers, software, air photos). The total cost for reviewing each FDP is about $11,000. If there is the need of extra field assessment, as occurs in about one third of revisions, this cost increases to $25,000 (for helicopters to access remote sites, vehicles, accommodation, etc). Annual costs involved in reviewing FDPs in BC are therefore approximately $ 5.8 million. Adding other costs involved in FDP review (e.g. appeals, monitoring, BCFPB audits) this annual cost rises to about $ 6.6 million. For licensees to produce a FDP costs between $30,000 and $50,000. Adding costs of the review process (e.g. public participation, publishing, field assessments), licensees estimate that these costs are at least double. Annual costs involved in producing FDPs in BC would be approximately $25 million.

About 2700 amendments to FDPs are reviewed each year by the BCMOF. Individual FDPs have an average of 2 major amendments (under Section 41(1) of the BCFPC Act) per year. These amendments range from reshaping cutblock boundaries in a way that environmental attributes can be affected (e.g. new boundaries incorporate a stream not originally considered), to deleting or adding whole cutblocks. In BCMOF Forest Regions of high contingency (e.g. with beetle epidemics) an individual FDP can have ten major amendments. For the BCMOF, the review of each major amendment costs between $2,500 and $7,000. For licensees to put together a major amendment, and to comply with the required public participation and First Nations consultation that major amendments require, costs between $4,000 and $6,000. In some instances major amendments are equivalent to a new FDP, in which case the cost of such amendment is closer to that of the original FDP.

According to the BCMOF and licensees, the principal causes of major amendments to FDPs are natural disturbances, changes in timber markets, and lack of higher level plans, social conflicts and policy changes (Figure 4.3).

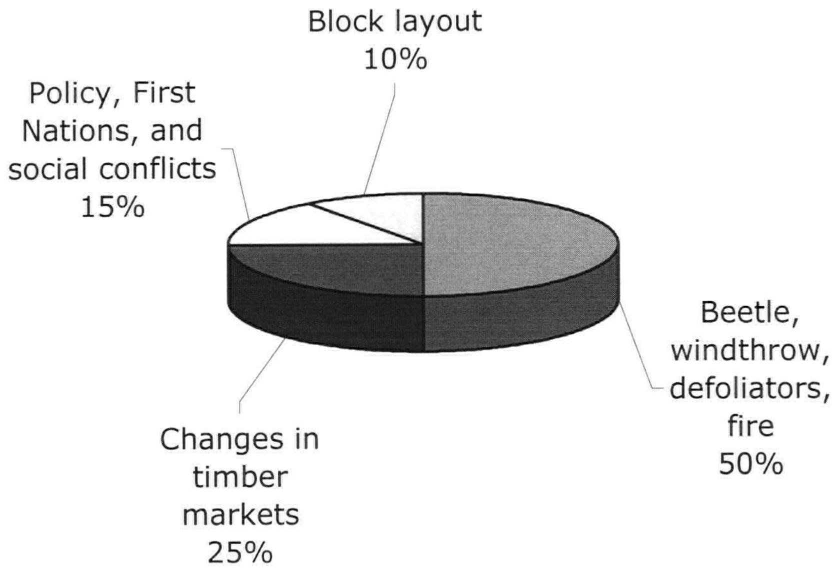

Figure 4.3 Principal causes of major amendments to FDPs in BC.

As an example, a BCMOF District official in the Cariboo Forest Region states:

> We are currently dealing with a pine beetle epidemic in the district so most licensees submit numerous amendments every year. We have processed in the order of 300 FDP amendments each year for the last three years... we amend each FDP between 50 and 100 times per year. In addition to the 300 FDP amendments we also process as many harvest authorities that are exempt from FDPs (minor salvage operations that do not need to be amended into and FDP before they can be logged)...

Another District official in the Vancouver Forest Region reports:

> Lack of Higher Level Plans and objectives provokes amendments. As we establish higher-level objectives for wildlife habitat areas, ungulate winter range areas, old growth management areas, etc, theoretically the task of balancing resource interests will be easier...

A District official in the Prince George Forest Region adds:

> As First Nation issues also don't always fit into the operational planning timeframes, so some development proposals may have to be amended later once consultation has been concluded.

Individual FDPs have an average of 6 to 10 minor amendments (under Section 43(1) of the BCFPC Act) per year. These amendments include small changes to cutblock boundaries, in a way that environmental attributes are not affected (e.g. changing the access to the cutblock, accommodating boundaries to fine-scale features of the landscape). For the BCMOF, the revision of each minor amendment costs between \$250 and \$2,500. For licensees to produce each minor amendment costs between \$400 and \$2,000.

According to the BCMOF and licensees, most minor amendments are due to "fine tuning" during the layout of cutblocks in the field. Other causes are expedited salvage and reshaping of blocks to accommodate social concerns (Figure 4.4).

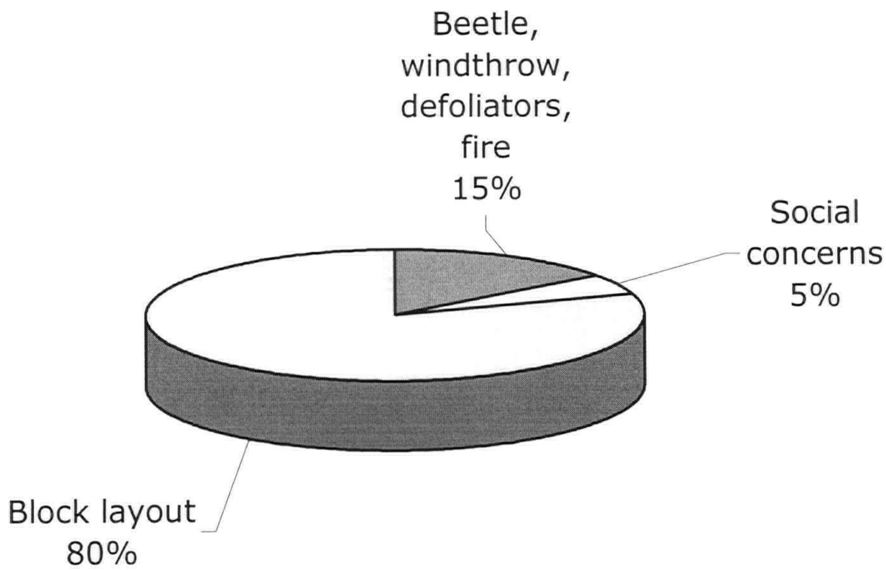

Figure 4.4 Principal causes of minor amendments to FDPs in BC.

As an example, a District official in the Cariboo Forest Region states:

> ...the number one cause (of minor amendments) is that licensees submit an FDP having only done a map analysis. After the blocks are approved, they lay them out in the field and apply for an amendment to approved road and block changes. They are reluctant to do too much fieldwork up front because of the cost. If they invest too much money and do not get approval, it is a loss... At least ninety percent of the CP applications that come in are accompanied with at least a minor amendment.

Uncertainty is not expressly dealt in producing FDPs. FDPs are seen as living plans to be amended as information is improved. As a licensee states:

> The purpose of (licensee) FDPs is to provide opportunities for harvest, with the assumption that it is a coarse filter for weeding out those blocks where the harvesting opportunity is very limited from a social perspective.

Uncertainty is dealt with indirectly through two main strategies used by licensees. The first is to "get ahead on planning", so that a sufficient supply of annual allowable cut in FDP is ensured by maintaining a stock of FDP approved and CP issued blocks. Licensees are typically keeping a stock of 3 to 5 years of area approved for harvesting in their FDPs. One licensee reports having 10 years of FDP approved blocks. Another licensee states:

> (On having a stock of approved wood), if we propose development in a sensitive area, we can plan at a slower rate and spend more time educating the public on our proposals with the hopes of eliminating fear and suspicion around our development.

The second strategy is to shorten the period between cutblock proposal in an FDP and cutting permit issuance. This allows licensees to pass as soon as possible the situations in which, at least in formal terms, cutblocks can be rejected or restricted. As a licensee states:

> With the development status we have (only) some certainty as these blocks can still be pulled back by the agencies. So we try to know what rules are we playing with and once we start development (intense field work and assessment) on a block try to get it to the permit stage as quickly as possible.

No licensee reported tracking performance in FDP implementation.

4.3.3 Discussion and conclusions from survey results

Forest development planning represents considerable costs to both planners (licensees) and reviewers (BCMOF). Although costs of assembling and reviewing original FDPs are important, in certain districts of the Province they can eventually be less significant than the total costs of amendments (e.g. Cariboo BCMOF Forest Region).

The total annual cost of producing and reviewing FDPs in BC is about $ 31 million. The total annual cost involved in producing and reviewing amendments (major and minor) is about $ 12 million. Clearly, a way of reducing costs for the forest development planning process as a whole would be to reduce the number of amendments to FDPs. The results of the survey support the BCFPB's concerns about the efficacy of FDPs in areas of high contingency discussed in Section 4.2.

There is a lack of incentives to address uncertainty in forest development planning through direct methods, such as scenario planning, contingency models, etc. Minor amendments represent a lower cost for licensees than assembling accurate FDPs, which should include some complicated and expensive field assessments. A licensee states:

> Many of the assessments required at the FDP stage require a great deal of up front work and risk in order to entertain approvals... you cannot develop accurate and effective assessments -Visual Impact Assessment, for example- unless your cutblock design is implemented in the field.

Rather, licensees prefer to keep a large stock of approved blocks in their FDP, to have room to deal with uncertainty. This however would not be the best alternative from a social perspective. The BCFPB (2001b), concerned about potential constraints to future high level planning, reports:

> ...(although) there is no restriction on including more cutblocks than can be logged in the period of the plan, (approvals of more cutblocks than can be logged in the

> period) may restrict future options for strategic planning and forest resource management.

Furthermore, the Board suggests that the government:

> ...initiate changes to the (BCFPC) Operational Planning Regulation to limit the number of cutblocks that can be protected to be approximately five years' worth of volume unless an approved landscape unit plan allows protection beyond five years.

A final conclusion relates to the fact that no licensee reported tracking forest planning performance (e.g. efficacy), even though some of them expressed interest in knowing it. Plans surpassed by contingencies are seen as a "fact of life". As stated by a licensee:

> ...the over-riding influence on forest development planning here in recent years has been the ongoing Mountain Pine Beetle epidemic. The beetle is essentially determining where operations are conducted - if not for 100% of the cut, certainly for close to all of it.

This seems closely related with the lack of incentives for accurate planning. The present context for decision-making works in a way that accurate planning by strengthening the information channel can signify bigger costs to licensees versus salvage. Since salvage rates are lower, is a cost-effective alternative. This compromises their willingness to adopt innovative ways to improve planning performance. If motivated to do so, better efficacy would not only enable licensees and the government to save resources/time, but also would benefit other stakeholders in the forest system.

4.4 Conclusion

The current planning approach in BC is not efficacious. Planning costs are higher than they could be, and the private and public budgets would be better spent under a reformed planning system. Current planning is based on too narrow a view of forests as systems and does not directly incorporate uncertainty. Forest systems in BC are extremely complex, and more comprehensive planning approaches are needed to build realistic plans that account for the dynamic nature of these systems. The use of tools that help acquiring knowledge about the dynamic of the forest system (e.g. fire, beetle, and windthrow hazard models; innovative public participation schemes; economic forecasting) could be better directed to address specific sources of uncertainty previously detected. Eventually, plans should be more specific in their targets, allowing for more flexibility and discretion in processes.

CHAPTER V. A METHOD FOR SPATIALLY ANALYZING FOREST PLANNING EFFICACY AND UNCERTAINTY (SAFEPLAN METHOD). A CASE STUDY

5.1 The Need for the SAFEPLAN Method

Private and public budgets, and public and consumer confidence are being significantly affected by the failure of forest planning in BC to address uncertainty. Agreement on the need to redirect efforts towards innovative forest planning is broadening, making planning processes more flexible, result-oriented, and accountable to the public.

More detailed information about outcomes of forest planning and explanations for those outcomes will be needed in a context in which licensees need to dramatically improve performance to reduce costs, and government officials are even more pressed to provide justification for harvest authorizations. In a more flexible context for planning, the public is expected to ask for more certainty that the environment is not being damaged and demand more accountability of planners. The demand for managers to produce reliable plans and to better explain unexpected outcomes will rise.

The method for **S**patially **A**nalyzing **F**orest **PLAN**ning efficacy and uncertainty (SAFEPLAN) was developed in response to these needs. It is based on the basic concepts for better planning introduced in chapters two and three.

5.2 Goals and Objectives of the SAFEPLAN Method

SAFEPLAN is a GIS-based process for continuous evaluation of forest planning performance, and the relationship of this performance with sources of uncertainty. Desired outcomes of forest management, specifically which areas are to be harvested, and which are to be left undisturbed are in plans. Comparison of planned with actual harvesting outcomes reveals the efficacy of performance. Where discrepancies have occurred, corrections to planning procedures and future plans are proposed. Throughout this cycle sources of uncertainty are identified and addressed.

Matching planned harvesting is only one of the possible desirable outcomes of forest management. Other kinds of outcomes are profitability, employment, protection of environmental values, social support for forestry, etc. Monitoring of forest management performance on accomplishing these outcomes is widely reported, though (e.g. BCMOF, 1994; BCFPB, 2002). Planning efficacy on harvesting as planned is much less reported. The BCFPB has pioneered monitoring performance of planning with respect to location of harvesting in BC (BCFPB, 1999). The lack of methods to do so in a more systematic and cost-effective way has compromised monitoring performance in a broader temporal and special scale.

The specific objectives of SAFEPLAN are:

1) to assess forest planning efficacy through comparing planned and actual harvesting;

2) to identify factors –components of the forest system- that contribute to discrepancies between planned and actual harvesting;

3) to evaluate associations between factors contributing to discrepancy and physical attributes of the landscape; and

4) to provide feedback within the planning process, improving the information channel and adding new knowledge.

5.3 Description of the SAFEPLAN Method

The SAFEPLAN method consists of five consecutive steps:

Step 1. Compilation of information. Maps of planned and actual harvesting are compiled in ArcView®. In the current scheme for forest planning, planned harvesting is represented by proposed cutblocks contained in a map attached to an FDP submitted for approval to the BCMOF.

Once digitized, these proposed cutblocks form layer number 1. Digitizing cutblocks from successive FDPs produces layer number 2, 3, and so on. Actual harvesting is represented by cutblocks harvested in a given year. These cutblocks are identified from BCMOF forest cover maps, high-resolution digital orthophotos, aerial photos, and field inventories. Once digitized, these actual cutblocks form layer 1a. Digitizing cutblocks harvested in successive years produces layers 2a, 3a, and so on (Figure 5.1).

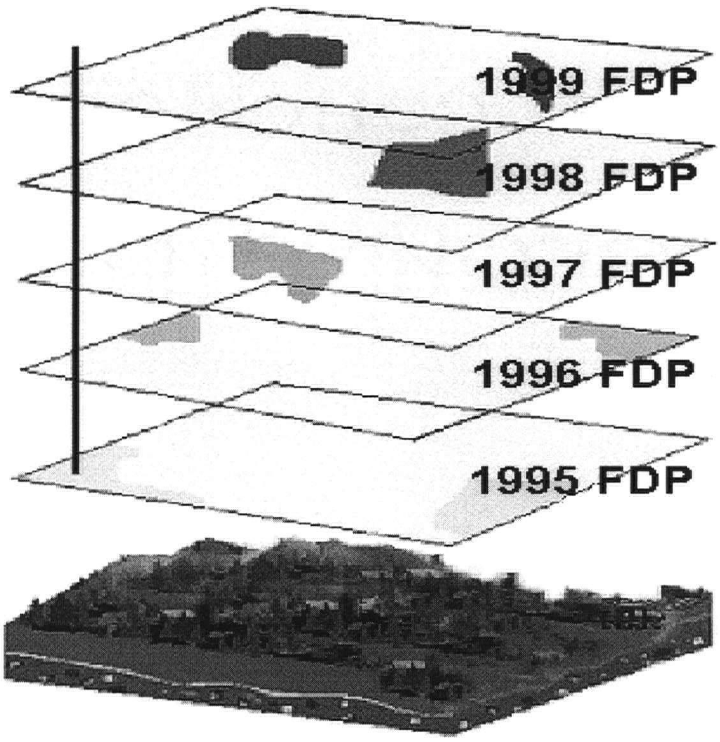

Figure 5.1 Compilation of planned and actual harvesting in ArcView®

A data-table describing legal and biological features of cutblocks is associated with each resulting layer. Layers of annually planned cutblocks link to data tables with cutblock ID, cutblock category ('A proposed', 'A approved', 'Salvage', 'Cutting Permit'), current year, and year in which harvesting is expected. Layers of annual harvesting link to data tables with cutblock ID and current year.

Step 2. Preparation of grid cells and centroids. Geographic boundaries of the area of planning are digitized in a new layer. This layer is then gridded (100*100 metres) using the 'convert to grid' tool in ArcView® Spatial Analyst extension (McCoy and Johnston, 2001). The result is a raster map of 1ha cells. Finally, the whole raster is converted to a point shapefile using the ArcView® Raster to Vector Conversion script which makes use of the asPointFtab, asPolyLineFtab, and asPolygonFtab avenues to convert a grid to either a point line, or polygon shape file (McVay, 1998). Each 1ha cell inherits a centroid (Figure 5.2).

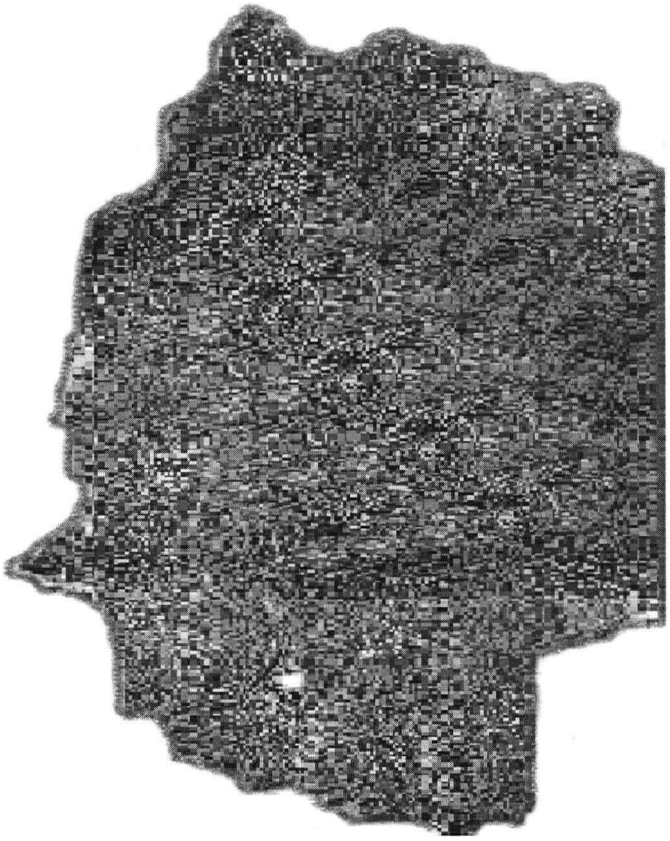

Figure 5.2 Preparation of grid cells and centroids

Step 3. Attachment of feature data. Image layers and data tables resulting from Step 1 are joined to the 1 ha cells resulting from Step 2 using ArcView® Assign Data by Location function. This function provides the ability to perform a spatial join between two selected themes (ESRI, 1998; Ormsby and Alvi, 1999). As a result, clicking on any central point within the area of planning displays a window describing planned and actual harvesting, legal history and biological features of the cell (Figure 5.3).

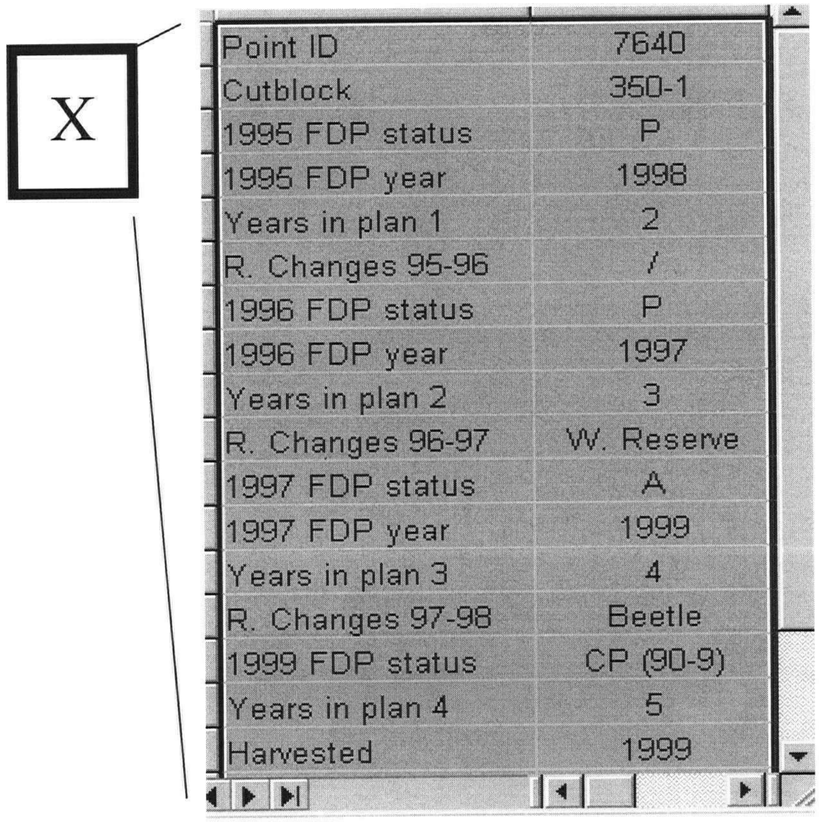

Figure 5.3 Attachment of feature data to cells

Step 4. Querying data. The data table resulting from Step 3 is queried using ArcView® Query Builder. This tool allows creation of an equation to examine particular themes and to answer specific questions (ESRI, 1998). Potential questions to analyze using ArcView® Query Builder include: Which cells were proposed for harvesting? Which of these were approved for harvesting and for which cutting permits were issued? Which are harvested? How long did it take to harvest approved cells? Where were approved cells deleted without being harvested? Where are cells that are not-approved for harvesting cut? (Figure 5.4).

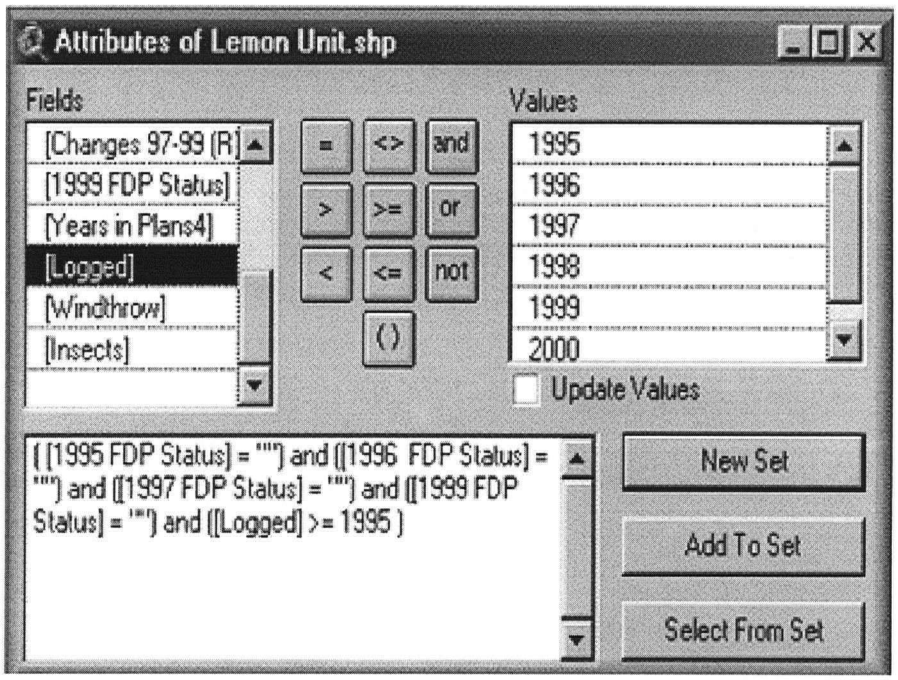

Figure 5.4 Data query. In this example, cells that were harvested without been proposed in any FDP, are identified.

From the answers to these questions, indicators of forest planning uncertainty are calculated. Through ratios these indicators quantify the magnitude of uncertainty affecting the different stages of the planning cycle. The higher the ratios, the deeper the way in which efficacy of planning has been compromised by uncertainty. These ratios are:

- P/H, the ratio of the set of cells proposed (planned harvesting) to harvested cells (actual harvesting).
- P/A, the ratio of the set of cells proposed to approved for harvesting cells (approved harvesting).
- A/H, the ratio of the set of cells approved for harvesting to harvested cells.

- A/CP, the ratio of the set of cells approved for harvesting to cells with cutting permit issued ("ready to go" harvesting).
- CP/H, the ratio of the set of cells with cutting permit issued to harvested cells.
- Time between P and H, the average period of time in years between the proposal of a cell and its harvesting.
- Time between A and H, the average period of time in years between the approval for harvesting of a cell and its harvesting.
- Time between CP and H, the average period of time in years between the issuance of cutting permit for a cell and its harvesting.

These indicators of planning uncertainty can be calculated yearly (i.e. 1995, 1996, 1997, 1998, 1999, 2000), or for a period of time (i.e. 1995 to 2000). As FDPs in BC are submitted yearly or every two years, and they propose harvesting with a horizon of five years, periods of time for analysis can be considered in many ways. One FDP can be considered alone and indicators can be estimated for its specific five years horizon of planning. Several successive FDPs can be considered individually, or considered together overlapping their horizons of planning. Either way, trends in uncertainty can be estimated. The planning area can be stratified according to characteristics of interest and indicators of uncertainty can be calculated and then compared for different planning areas.

Step 5. Investigating causes of unexpected outcomes. For areas of discrepancy (planned harvesting does not occur or unplanned harvesting does occur), or where indicators of forest uncertainty are too high, causes are investigated. Natural disturbances (i.e. windthrow, beetle outbreaks, fires), social concerns (i.e. community watersheds, visually sensitive areas, old-growth forests) and ecosystem attributes (i.e. forest types, wildlife ranges, streams) within the planning area are added as new layers into the Arcview® view.

Patterns of association between these disturbances, concerns and attributes, and areas of discrepancy are investigated by visual scrutiny of the displayed orthophotos and themes, and by analysis of the results from querying the data tables, and contingency tables and Chi square tests if needed.

Some patterns of association can be fairly obvious (e.g. most non-planned harvesting can occur in beetle outbreak areas, or an A/H ratio can be especially high in an area with low value timber and costly access). Other patterns, though, are less obvious, and more research has to be done. Using the ArcView® Query Builder, new questions are posed (e.g. cells that were approved for harvesting and were not harvested that are located in community watersheds). Information from FDP documents, cutting permits submissions, BCMOF's approval and rejection letters, and comments from the public complement the GIS analysis in this step. Forest managers and officials are interviewed to determine the reasons for specific outcomes. On these interviews orthophotos are displayed, allowing for easier visualization. Contingency tables can be used to confirm association between variables and outcomes.

Results from this analysis lead to conclusions and recommendations. Conclusions refer to what is going wrong and what is going well in the planning process, and what are the causes for those (e.g. deficiencies of the information channel, challenges in the context for decision-making). Recommendations provide feedback to the planning process to improve what is going wrong and to reinforce what is going well (e.g. improve maps, databases, and identification of where tools, research, and new processes are warranted to reduce uncertainty).

5.4 Data Requirements for the SAFEPLAN Method

Implementation of the method does not require generation of spatial data other than that required for traditional planning in BC. This consists of:

- FDP maps (1:20,000 - 1:50,000) showing cutblocks by status (proposed, approved, and with cutting permits issued). Cutblock attributes (e.g. legal history, natural disturbances, harvesting) are in databases linked to the maps;
- forest cover (1:20,000), which follows the BC Geographical System (BCGS) of mapping. This cover stratifies the landscape into polygons and for each one of these, stand attributes and general disturbance history are described (BCMOF, 1998a);
- orthophotos for the planning area. Scale depends on the issues to be dealt with. As examples, the BC Land Use Coordination Office (LUCO) uses 1:250,000 aerial photographs to identify Landscape Units and Biogeoclimatic Zones; 1:63,000 aerial photographs to elaborate regional hazard maps for landslides, snow avalanching, areas of active erosion, and active floodplains; and 1:15,840 for forest inventory (BCLUCO, 1999). On the other hand, Mitchell et al. (2001) recommend using 1:15,000 scale color aerial photographs for windthrow detection;

- specific legal information for each cutblock. Submissions for approval and permits, approvals, rejections, issues on public consultation and agency review. Documents that contain the rationale for changing plans for proposed or approved cutblocks.

Most of this data is already in the possession of licensees; however there may be problems with accuracy and dated information (Sierra Systems, 2001).

5.5 Test of the SAFEPLAN Method in the Lemon Landscape Unit

5.5.1 Introduction to the Case Study

The Lemon Landscape Unit (Lemon) is located within the area covered by the Arrow IFPA within the Arrow Timber Supply Area. The 41,000ha unit is set in a mountainous area in the southwest portion of the Nelson Forest Region, immediately adjacent to the town of Slocan in southeast BC (Figure 5.5).

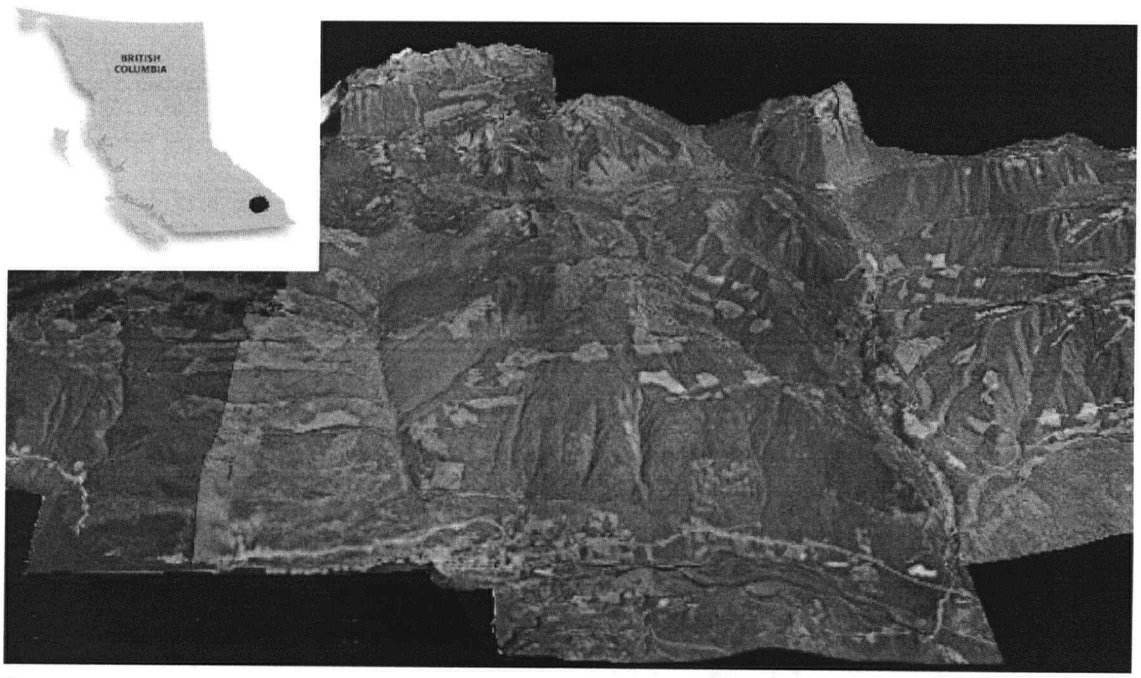

Figure 5.5 Aerial view of Lemon Landscape Unit and location of Lemon in BC.

Forestry activities occur throughout the unit at lower and mid-elevations, and environmental, social and economic values are key drivers of forest management. The forest system includes diverse ecosystems including interior cedar-hemlock and Engelmann spruce-subalpine fir forests (Arrow IFPA, 1999), wildlife ranges and a variety of natural disturbance regimes, such as fire, windthrow, insects and other pathogens, and landslides (BCMOF, 2001c). Forest resource availability is diverse in these ecosystems. Different sites present particular yield, economic potential, and social sensitivity for timber, wildlife ranges, water quality, and visual attributes. Multiple stakeholders are very active in demanding participation in forest decision-making and appreciate numerous non-timber values, such as recreation areas, and community and domestic watersheds (Arrow IFPA, 2000). These concerns, and the attitudes, values and behaviour of people are being surveyed by the Collaborative for Advanced Landscape Planning at the University of British Columbia (Meitner et al., 2001). The high level of public concern means that this area "under the microscope", as reported by McDonald (1999), is one of the environmental "hot spots" in BC.

Policy in Lemon also has a particular relevance in shaping the forest system. The BC Chief Forester in the rationale for AAC determination in Arrow Timber Supply Area (TSA), within which the Arrow IFPA occurs, acknowledged "for this determination I am mindful of the difficulties of locating harvesting operations in the Arrow TSA as a result of the various pressures exerted on the land base" (BCMOF, 2001c). This recognition led to the Arrow Forest License Group being awarded an Innovative Forest Practices Agreement (IFPA) in 1998 to help "increasing the wood supply for forest licensees while at the same time ensuring the most advanced and sustainable forest practices possible" (Arrow IFPA, 1999). As part of the Arrow IFPA, forest management activities in Lemon are carried using an ecosystem management approach. The IFPA's working definition of ecosystem management includes "a process of decision-making, that uses an understanding of local and regional information about ecological and human social processes, functions, structure and composition, and the interconnections between them" (Arrow IFPA, 1999). Scenario planning is a fundamental component in this management process. Different future scenarios are forecasted and their sustainability is assessed based on criteria and indicators of forest management sustainability.

The Lemon Landscape Unit was selected as a case study due to the complexity of the system in which forest management occurs. Another factor was the explicit focus on improving forest planning approaches that are being taken in the area. As manifested at the governmental and licensee level, what is being looked for in the Arrow IFPA is a more flexible and accountable approach to planning (Arrow IFPA, 1999). Scenario planning and criteria and indicators projection based on models, need to include underlying uncertainty.

5.5.2 Objectives of the Case study

The SAFEPLAN method was applied in Lemon with the general objective of evaluating the performance of harvest planning during the period 1995-2000, and the sources of uncertainty affecting it. Specific objectives were:

- to describe planned and actual outcomes of FDP proposed harvesting between 1995 and 2000;

- to identify ecological, social, economic, and policy sources of uncertainty, which contribute to discrepancies between these planned and actual outcomes;
- to evaluate associations between sources of uncertainty and ecosystem or geographic attributes, and to review the process of cutblock approval and cutting permit issuance, identifying the social/regulatory issues that occurred, how they were resolved, or if un-resolved the causes and potential solutions;
- to identify where -and how- information sources and predictive tools could be used by managers to reduce uncertainty in planning; and
- to describe the supportive role that SAFEPLAN could have with respect to better planning in Lemon.

5.5.3 Methodology of the Case study

Application of the SAFEPLAN method in Lemon consisted of the five consecutive steps described in section 5.3. Some features, however, were specific to this case study.

Paper and digital maps for Lemon were obtained from various sources. Orthophotos, forest health surveys, forest covers, and salvage permit maps, with ecosystem attributes and disturbances, were obtained from the BCMOF. FDPs submitted in 1995, 1996, 1997 and 1999, aerial photos, cutting permits, application and approval letters, and maps of community watersheds and visually sensitive areas were obtained from Slocan Forest Products Ltd. (SFP)[13]. This material was

[13] Slocan Forest Products was the only Licensee submitting FDP's during 1995-1999 for harvesting in Lemon Unit.

supplemented with the FDP texts received from the BCMOF and SFP, and clearcut edge windthrow mapped from the 1998 aerial photographs. Interviews with forest managers and BCMOF officials provided information for specific outcomes.

Maps showing proposed and actual harvesting between 1995-2000 in Lemon were added as themes in ArcView®. Further information on proposed harvesting was obtained from the FDPs submitted during 1995-1999. Actual harvesting was taken from the BCMOF 1998 and 2000 forest cover maps, which were checked and corrected using August 2000 orthophotos. Data-tables containing cutblock identification, area, development status, years in plans, planned harvesting year, actual harvesting year were attached to these maps. The aggregated digital information consisted of five layers: Layers 1 to 4 described proposed cutblocks in the 1995 FDP, 1996 FDP, 1997 FDP and 1999 FDP respectively. Layer 5 described actual cutblocks on the landscape for the period. Just as the sources of these layers varied, so did the quality of their data. Duplicate maps existed –maps for the same FDP year from the BCMOF and the licensee- for some years. Data from the two sources was compared, and double-checked with 1-meter pixel resolution 1998 digital orthophotos for Lemon. The high resolution of these orthophotos allowed identification of activities on the landscape. In 30% of cases, cutblocks in successive plans had the same shape but were shifted relative to each other or to the cutblock on the orthophoto (Figure 5.6). These were considered to be obvious mapping shifts and were re-located to match the cutblock locations on the orthophotos to avoid influencing subsequent analysis. Data quality, though, was a primary source of uncertainty for planning in Lemon. Its consequences are discussed below.

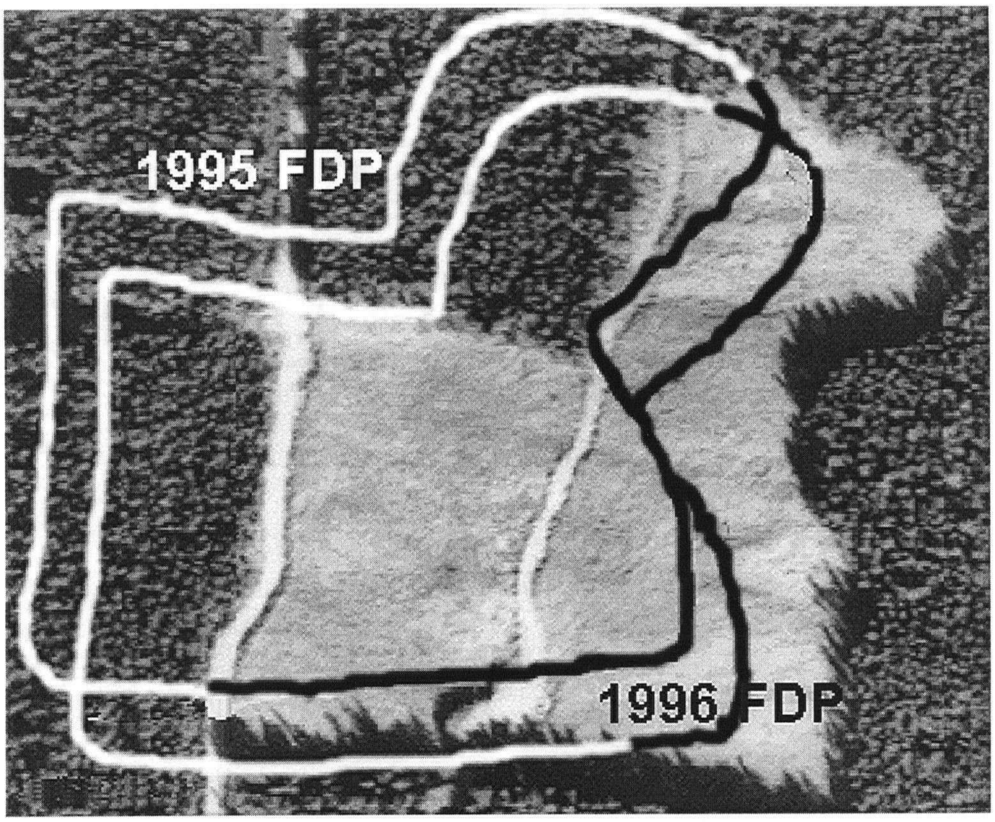

Figure 5.6 An example of obvious mapping shifts.

The area within the borders of Lemon was gridded (100*100 meters), resulting in 40,981 1-hectare cells. This grid theme was converted to a point shapefile. On attaching feature data, the data was linked to each one of the 40,981 points at the centre of the cells. A click on anyone of the points within the boundaries of Lemon opens the history of the cell between 1995 and 2000.

On querying the point data table, a number of questions were answered, such as: How many ha were proposed for harvesting between 1995-1999 in Lemon? How many of them were approved? How many cutting permits were issued? How many of them were actually harvested? How many years passed between the proposal and the harvesting areas? Were there delays? Why were blocks deleted, re-shaped, made larger or smaller? For each query, each cell was counted once. If a cell was proposed for harvest in consecutive FDPs, it was attributed to the year when first proposed. Results were displayed in charts to help the visualization of distributions and trends in the data. The results of these queries enabled calculation of the indicators of planning uncertainty described in section 5.3. These indicators show how uncertainty affected planning efficacy in Lemon between 1995 and 2000.

Where areas of discrepancy occurred, and indicators of uncertainty were high, causes of discrepancies and uncertainty were investigated. Printed ortophotos for Lemon were displayed to managers and reasons for specific outcomes were asked. Discrepancies were spatially related with themes featuring windthrow, fire, and beetle outbreaks, community watersheds, visually sensitive areas, forest types, and old growth forests. The pattern of association of these features with cells showing unexpected outcomes was evaluated.

5.5.4 Results and Discussion of the Case Study

The SAFEPLAN method was applied for a single 5-year time span. The data, therefore, was in some cases limited in scope. The analysis, therefore, used special precaution in analysing results, and additional data was obtained for some stages of analysis. When results were unclear, they were clarified with interviews and bibliographical research. Yearly analysis can be done for 5-year –or other time span- moving frames, which would enable identification of stronger trends.

5.5.4.1 Proposed and Approved Harvesting

In the four FDPs submitted between 1995 and 1999 a total of 1,914 ha were proposed for harvesting in Lemon. The area proposed each year dropped between 1995 and 1999 (Figure 5.7).

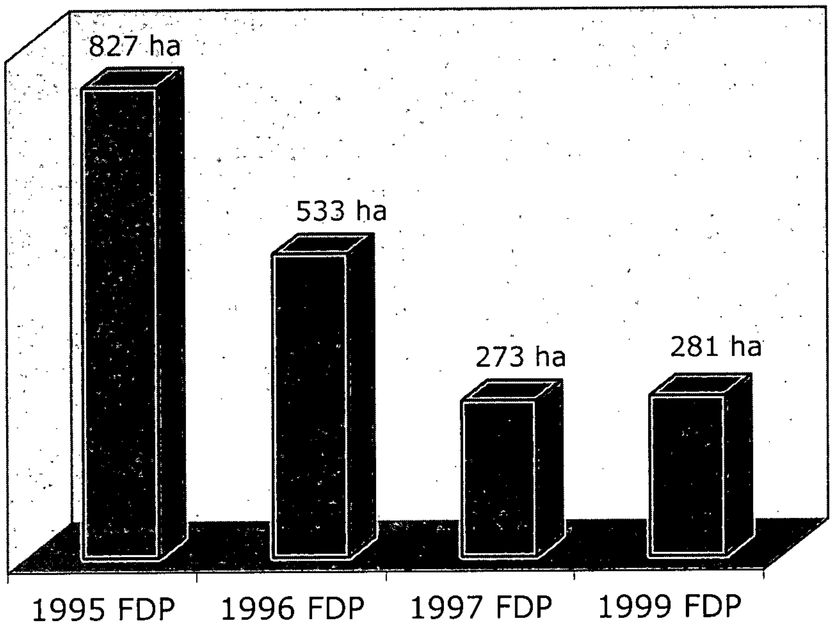

Figure 5.7 Proposal of harvesting in FDPs between 1995-1999.

One year after the submission, 44% of ha proposed for harvesting was dropped, and 14% were approved. 80% of dropped ha were within blocks that were wholly discarded and 20% were within blocks that were reshaped.

During the period 1995-2000, 513 ha (27% of proposed) were approved. Although they had been approved, 25% of the ha were dropped before the next plan. Of these, 25% were within blocks that were discarded and 75% were in blocks that were re-shaped.

Very few of the blocks proposed in the 1995 FDP appeared as approved in the 1996 FDP. Of the 827 ha proposed, 40% were dropped and only 9% were approved one year after the submission. From this 9% of approved ha, nearly half (45%) of them were dropped before the 1997 FDP. Proportionally, approved status ha were dropped more frequently than proposed status ha (Figure 5.8).

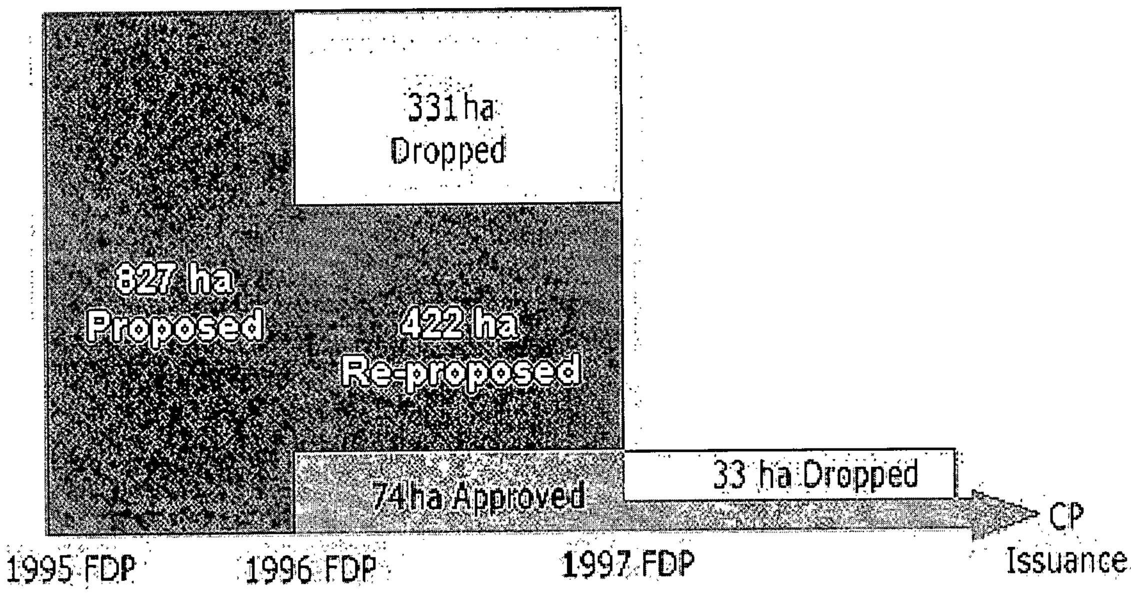

Figure 5.8 History of ha proposed in the 1995 FDP.

5.5.4.2 Cutting Permit Issuance

From the total area of 1,914 ha proposed for harvesting between 1995-1999, cutting permits had been issued for only 384 ha (20%) by March 2001.

Including blocks proposed before 1995, and blocks proposed through amendments to FDPs during 1995-1999, cutting permits were issued for 886 ha between 1995 and 2000. Sixty three percent of these ha received a cutting permit within two years after submission. From the 827 ha proposed in the 1995 FDP, only 24% got a cutting permit within the next 5 years after submission. For Lemon, the stock of area under cutting permit varied from year to year, more than doubling in recent years (Figure 5.9).

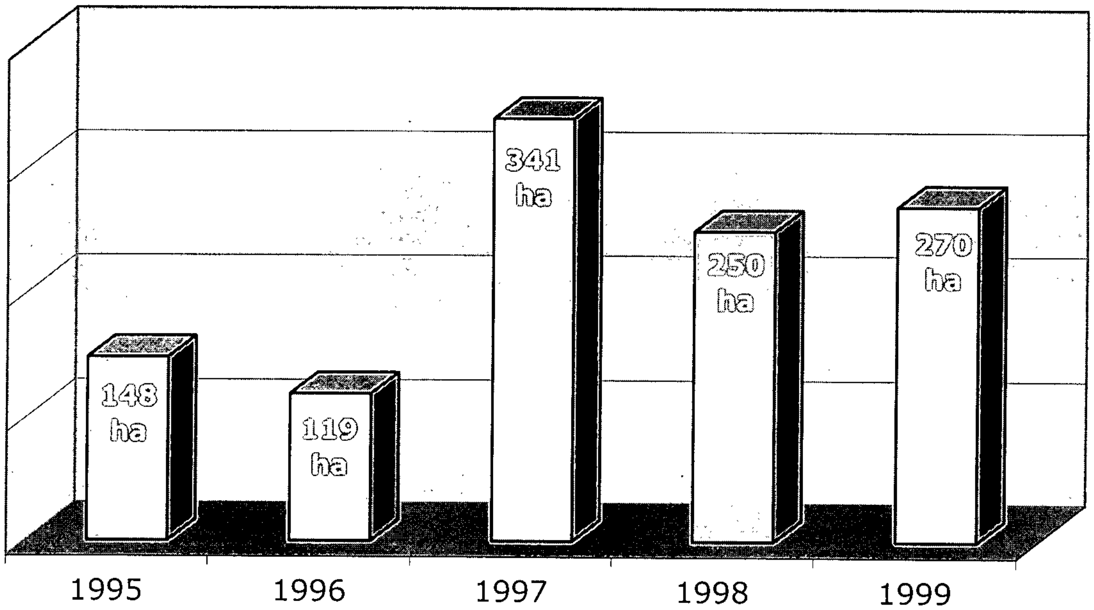

Figure 5.9 Area under CP in Lemon between 1995-1999

5.5.4.3 Harvesting

During the period 1995-2000 a total of 608 ha was harvested, which represents less than 1.5% of the gross area of Lemon and 3.8% of its harvesting land base.

From the total area proposed for harvesting between 1995-1999 (1,914 ha), 27% was harvested[14]. An additional 80 ha was harvested without being proposed in any FDP, either because of minor salvage, or because of boundary modifications prior to CP issuance that did not appear in any FDP. From the 513 ha that obtained approved status,

[14] The blocks proposed for harvesting previous to 1995 were not considered in this percentage.

46% were harvested. From 220 ha that received a CP prior 1998[15], 68% had been harvested before March 2001 (Figure 5.10). After receiving a cutting permit, 37% had been harvested after one year, 56% after two years, and 83% after three years.

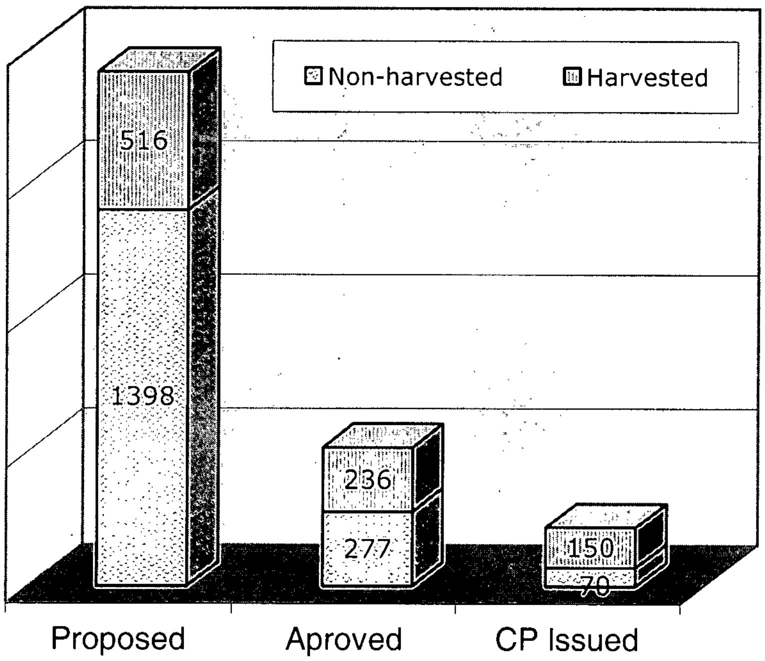

Figure 5.10 Harvesting for proposed, approved and CP issued ha.

Prior to 1998, FDP's were required to include a detailed harvest schedule[16]. Of the 827 ha proposed in the 1995 FDP for harvesting during the next 5 years, only 17% were cut according to the proposed schedule. For the 1996 and 1997 FDP's these rates were 8% and 12% respectively.

5.5.4.4 Indicators of Forest Planning Uncertainty

Quantification of discrepancies between planned and actual outcomes of planning in Lemon allowed for estimation of indicators of uncertainty. These indicators refer to the level in which uncertainty affected the efficacy of the planning process (Figure 5.11 and 5.12).

[15] Only CP issued before 1998 were considered for this estimation.
[16] This requirement for FDPs was dropped by the 1998 BCFPC amendments

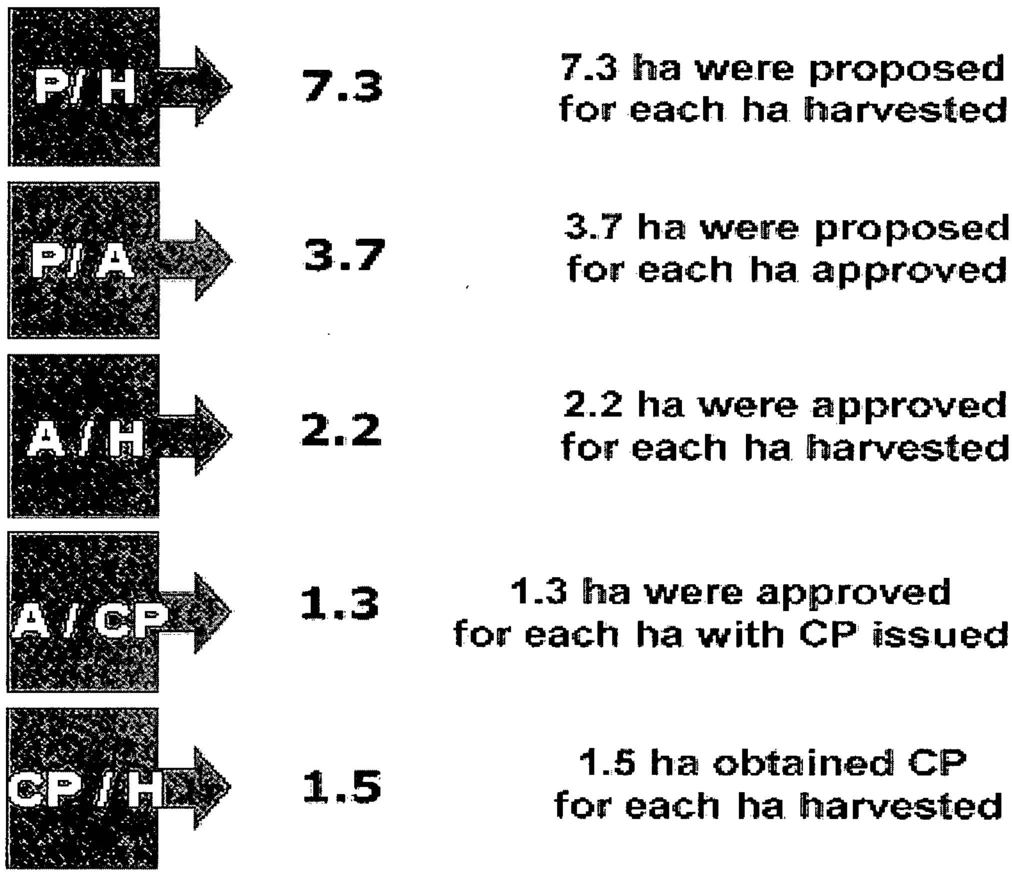

Figure 5.11 Indicators of forest planning uncertainty (effort made to complete planning) for Lemon Landscape Unit

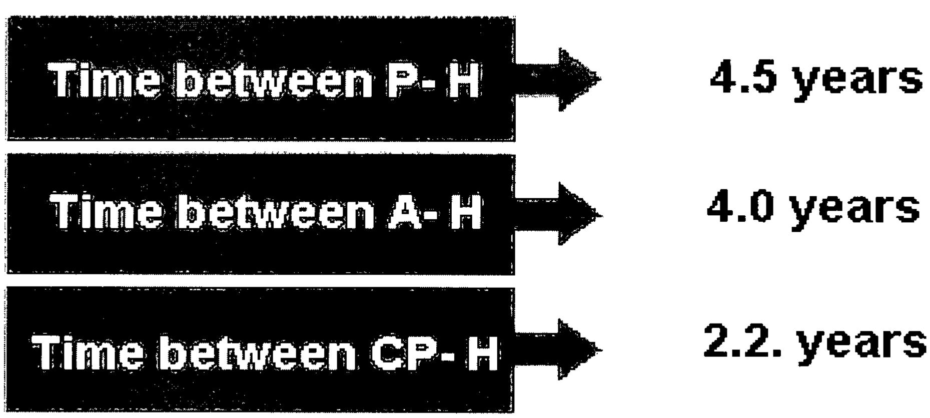

Figure 5.12 Indicators of forest planning uncertainty (time required to complete planning) for Lemon Landscape Unit

5.5.4.5 Analysis of Sources of Uncertainty Affecting Planning

5.5.4.5.1 The Forest System as a Source of Uncertainty

From one year to the next, the number of ha proposed varied greatly. Entire cutblocks were discarded, and new ones were added. Other cutblocks were re-shaped, reduced or increased in size. Of the ha that were proposed and discarded before the next FDP, or approved and discarded before the next FDP, about half of the cases were due to rejection by governmental agencies. Complexity in the policy subsystem was a key determinant in planning. Rules changed, they were not clear, and the licensee had to respond to this new reality. After the enactment of the BCFPC in 1995, the BCMOF asked the licensee to submit a 1996 FDP substantially compliant with the new regulations, especially with the ones referring to biodiversity. This accounted for the majority of the approved blocks discarded from the 1995 FDP. The licensee completed considerable fieldwork during 1995 and 1996 (including terrain mapping, hydrology, fish and wildlife, visual impact, and operational assessments), and re-worked the FDP to be consistent with the newly imposed biodiversity regulations. The effects of the BCFPC were fully reflected in the 1997 FDP. Several new areas were proposed, and many of the areas proposed and approved in earlier FDP's were completely discarded. While it was a major factor disrupting the continuity of the planning process during the first half (1995-1997) of the period of study, policy change was not the only source of uncertainty in Lemon.

Identification of the main sources of uncertainty was completed for the 226 ha that obtained FDP approval for harvesting status and were discarded in consecutive FDP or had not been harvested after 3 years[17]. For 20% of these ha no reasons were reported or could be ascertained. From FDP documents, BCMOF correspondence, public participation and interviews with managers, it was possible to evaluate sources of uncertainty for the remaining 80% of the cases. These sources were economic and operational, social, legal and ecological (Figure 5.13).

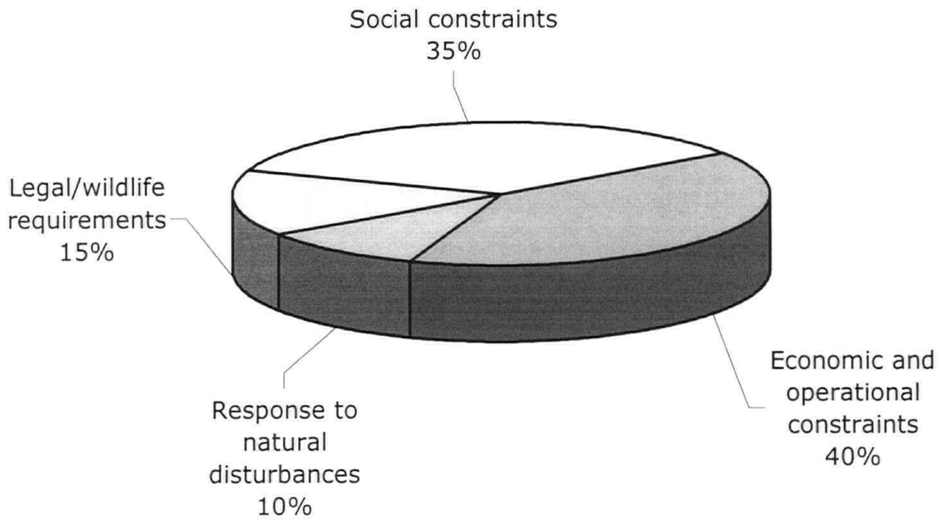

Figure 5.13 Sources of uncertainty for discarded and non-harvested approved ha.

Economic and operational reasons explained 40% of cases. Stands with marginal merchantability were not harvested because they either could not be harvested economically due to low pulp prices or they contain mostly non-commercial tree species.

Social constraints explained 35% of cases. These approved ha were not harvested after social pressure (e.g. threat of appeals to courts, boycotts and blockades from people expressing their disapproval). Even when the licensee had been granted approval status for

[17] For this particular analysis, harvesting during 2001 was recorded and approved cells that obtained CP were not considered.

harvesting, these areas were set aside either because of the impracticality of actually harvesting or to prevent more social conflicts and prevent further damage to company's image.

Legal/wildlife requirements explained 15% of cases. These approved ha were not harvested as a direct result of requirements arising from the enactment of the BCFPC. Some entire blocks were discarded, and others were reshaped to accommodate BCFPC requirements for reserves.

Response to timber damaged by natural disturbances explained 10% of the cases. These approved ha were discarded after the field layout work showed that beetle infestations and windthrow had reduced merchantability. These areas were discarded and not salvaged due to low value wood and other harvesting priorities.

In some cases, uncertainty had more than one source. As an example, the 1999 FDP submitted by the licensee describes how:

> A previous hemlock looper attack is evident in the area on Wragge Face which is bounded by Valhalla Park and Slocan Lake... (the licensee) had intended to have a salvage program for this area in 1993, however due to public concern regarding the visual modifications, the program was cancelled [18].

Uncertainty affected the planning cycle not only at early stages (e.g. between the proposal and the cutting permit issuance). Even after FDP approval and CP issuance, revisions to ha were common. Of the ha

[18] The results described are the main source of uncertainty in cases where there is more than one source. In this particular example, cell-ha were counted under social concerns.

under cutting permit, 32% were not harvested during 1995-2001[19]. Most of this percentage was due to cutblock re-shaping or re-sizing. Of this 32%, 11% had not been harvested by 2001 but intentions were to proceed as in the original cutting permit. For 15% of the ha no reasons were reported. From FDP documents, BCMOF correspondence, public participation and interviews with managers, it was possible to evaluate sources of uncertainty for the remaining 74% of the cases. These sources were:

- economic and operational reasons, especially unforeseen low pulp prices, for 55% of cases;
- new legal/wildlife requirements, resulting from enactment of the BCFPC, for 29% of cases;
- natural disturbances, especially pine beetle outbreaks, in 6% of the cases; and
- unresolved social issues, especially concerns due to drinking water quality, in 10% of cases.

For 20% of approved and 15% of CP issued ha that were not harvested, a key issue was considered to be block layout in the field. The fine scale used in this analysis (1 ha) allowed to track differences between final layout and proposed boundaries of cutblocks. Interviews with managers supported this assumption, and analysis of the information channel discussed below seems to confirm it.

As stated, some 80 ha were cut without being proposed in any previous FDP. Endemic pest problems that occurred in Lemon during 1995-2000 are mountain pine beetle, douglas fir bark beetle, spruce

[19] For this particular analysis, harvesting during 2001 was recorded.

bark beetle, grey spruce looper, white pine blister rust and root disease. Mountain pine beetle reportedly affected just 72 ha in Lemon during the period, while windthrow along clearcut boundaries affected 74 ha. Of this total area of 146 ha, just 6 ha were harvested as salvage, 3 ha of which were proposed in FDP's.

5.5.4.5.1.1 Spatial Association of Uncertainty and Landscape Attributes

The 181 FDP-approved ha that were discarded in consecutive FDPs, or had not been harvested after 3 years, and to which sources of uncertainty were attributed, were mapped. Their association with landscape attributes was examined.

The BCMOF defines "problem forest types" as stands which are physically operable and exceed low site criteria and yet are not currently utilized or have marginal merchantability (BCMOF, 1998a). According to the licensee, these stands grow sub-alpine fir, pure hemlock, lodgepole pine, hemlock-leading and sub-alpine fir -spruce stands greater than 140 years, or deciduous broad-leaved species. These areas were identified from the 1998 BCMOF forest cover.

Fifty six percent of total approved ha was located in "problem forest types". From the 72 ha not cut due to economic and operational reasons 87% of these were growing "problem forest types". In addition many were located in high altitudes and in areas of steep slopes. Access is challenging and is primarily by helicopter, which involves high operational costs. As a result of low pulp log prices, these stands were not used because they could not be harvested economically (Figure 5.14).

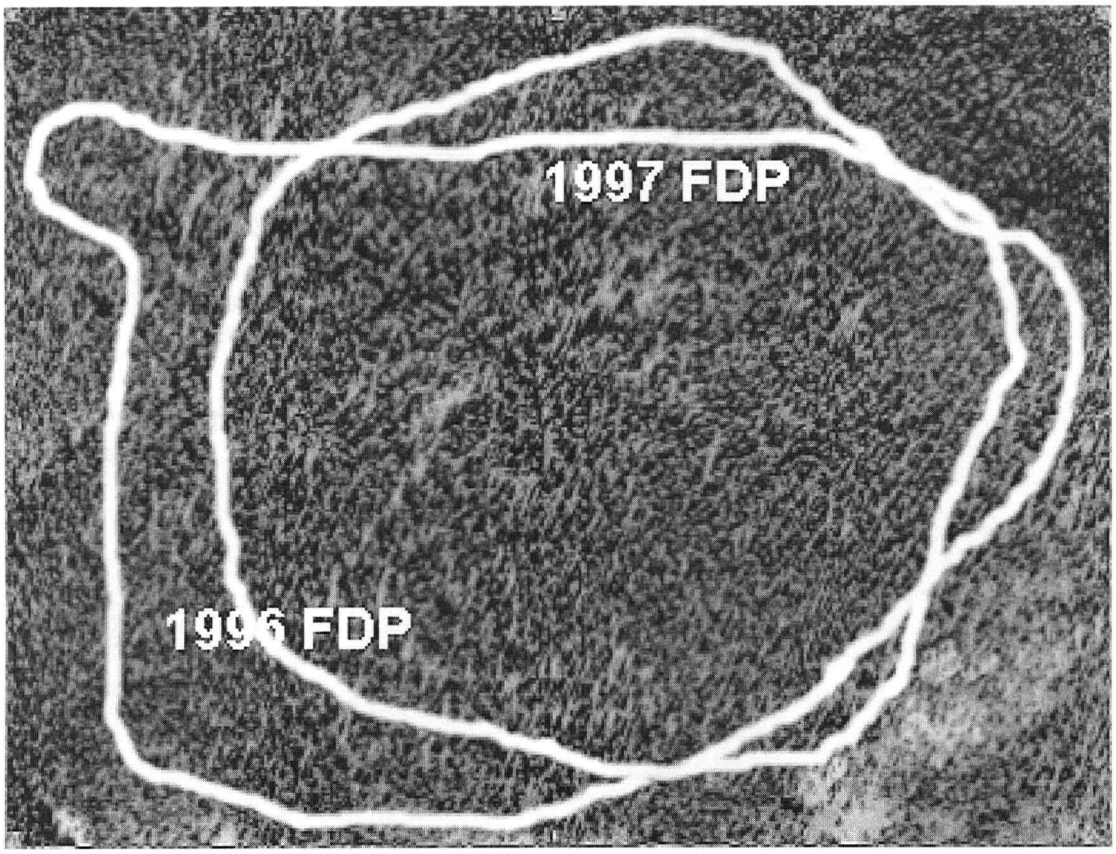

Figure 5.14 Example of ha approved in 1996 and 1997 and then dropped due to their location in low quality stands.

Sixty percent of total approved ha were located either in visually sensitive areas and/or in community watersheds. Of the 63 ha not cut for social reasons, 73% of these were located within scenic areas classified as to be 'visually sensitive'[20]. Seventy-eight percent of the 63 ha were located within community and domestic watersheds. Visual and water quality issues together accounted for 90% of ha not harvested due to social reasons (Figure 5.15).

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[20] In the Arrow TSA, scenic areas were officially made known by the District Manager in June 1998. Visual Quality Objectives have not been established.

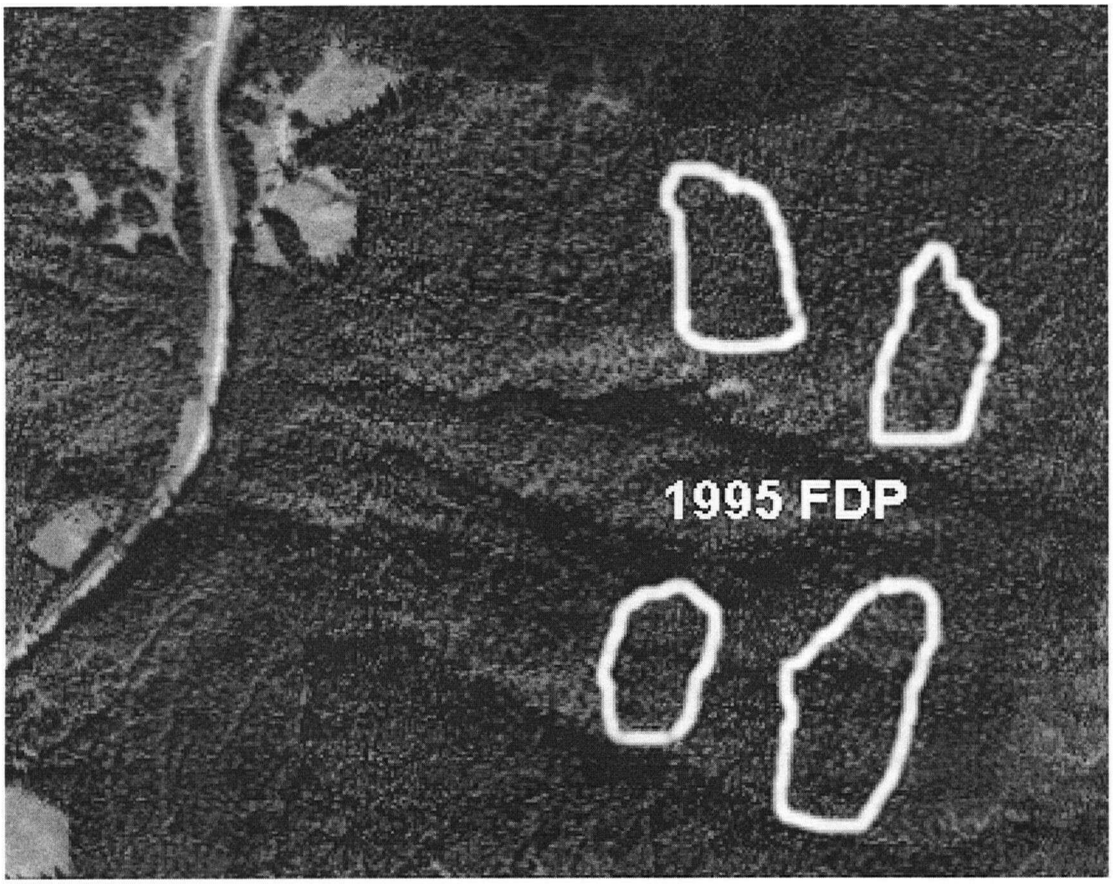

Figure 5.15 Example of ha approved in 1995 and then dropped due to concern for visual values.

27 ha not harvested due to legal/wildlife uncertainty were evenly scattered throughout Lemon, and the BCMOF forest cover showed no common pattern among these areas. No correlation between legal/wildlife reasons that affected planning and attributes of the landscape was observed, including proximity to streams[21] (Figure 5.16).

[21] Winter range maps were not available to be included in this analysis

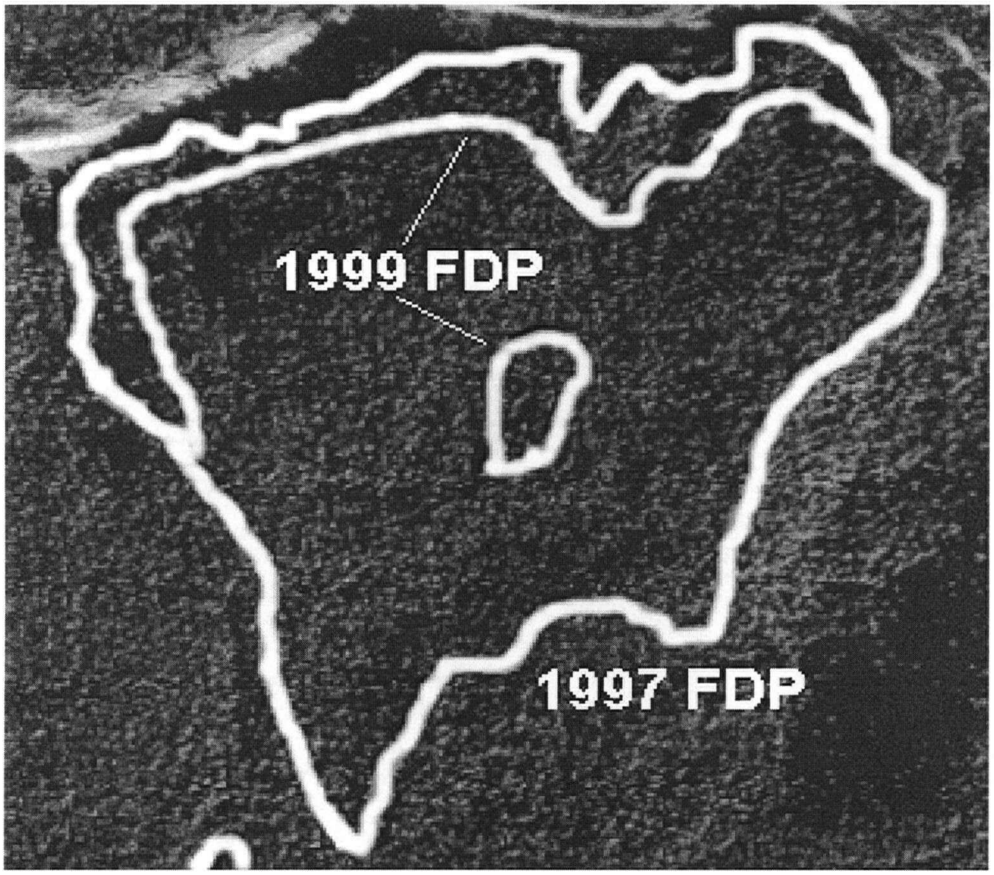

Figure 5.16 Example of ha approved in 1997 and 1999 and then dropped due to BCFPC requirements for wildlife reserves.

Fifteen percent of total approved ha was located either in areas of beetle outbreaks and/or windthrow. The 18 ha not harvested due to timber damaged by natural disturbances were compared with 1998 and 1999 beetle outbreak maps. 70% were located in one of these outbreak areas (Figure 5.17). Another 20% of areas were located adjacent to old cutblocks within windthrow polygons mapped from aerial photos. From BCMOF forest cover, beetle outbreak areas did not relate with any one of the features of individual polygons but species composition. All windthrow occurred in the edge of polygons where harvesting had already taken place.

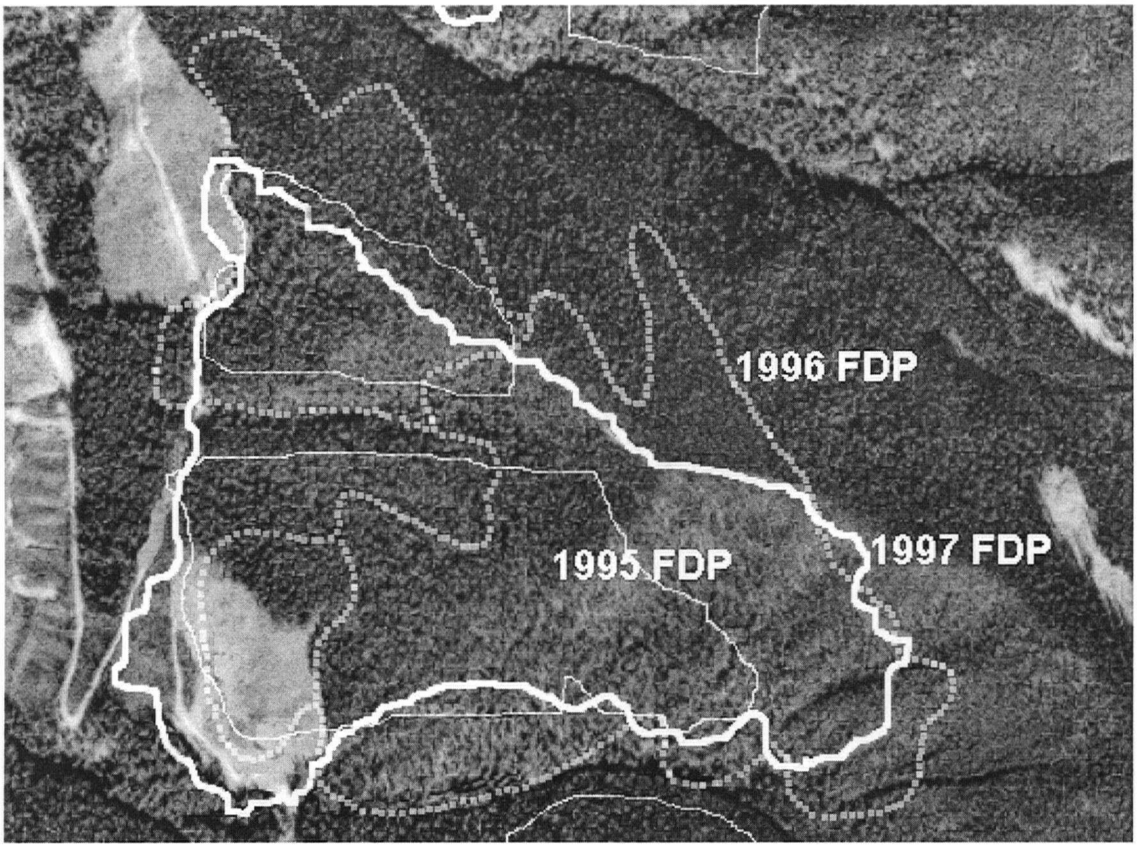

Figure 5.17 Example of ha approved in 1995, 1996, and 1997 and dropped due to beetle outbreaks. Proposed ha were "chasing beetle".

5.5.4.5.2 The Information Channel as a Source of Uncertainty

The capability of the information channel to fully transmit forest system attributes is limited. Most of the information used in planning in Lemon was produced outside of a GIS environment, therefore a number of corrections had to be made prior to analysis. Frequently, the shapes of harvested polygons do not coincide with the cutblock shapes on the orthophotos. Examination of digital FDP maps revealed other mapping discrepancies. Almost 20% of proposed cutblocks were shifted and did not correspond to the actual locations on the orthophotos. In many cases non-correspondence was found between the same block in consecutive FDP's. In a few cases, blocks were proposed for harvesting in areas that were already cut.

The BCMOF 1998 and 2000 forest cover maps lack some current information. Some areas do not show as harvested, even when harvesting has occurred. Other areas show as harvested, even when harvesting has not yet occurred. Natural disturbances are also not well documented. As acknowledged by the BCMOF[22], problems with existing forest databases are numerous. Major problems are that BCMOF forest cover files do not meet the requirements of modern geographic information systems and most existing files do not meet the standards of quality now defined for the Province. These problems are reported also by Sierra Systems (2001). The BCMOF (1999b) specifically recognizes the need for improvements in the:

> ...quality of the ministry's geographic information, the standardization, rationalization and consolidation of the ministry's geographic information (spatial and attribute) datasets, the development and maintenance of spatial and attribute integration links and the integration of the business processes and applications that use geographic information.

As Thrower & Associates (1999) report, the BCMOF is implementing several initiatives to improve collection, storage, and handling of spatial and attribute data. Eventually these initiatives will lead to better knowledge on the BC forest systems, helping management. But in the meantime, managers have to cope with a context of information data in a dynamic transformation.

[22] Memorandum 6640-20/INCO sent by John Ellis, Director BCMOF Information Systems Branch, to Regional and District Managers in July 1997 with reference: "What is INCOSADA and why are we doing it".

Data accessibility was also an issue. Where information was produced within a GIS environment, it came in three different formats: Pamap®, ArcView®, and Arc/Info®, and early FDP maps were created using MicroStation®. Data needed for planning is often contained in paper maps, non geo-referenced digital images and maps. Digital data is easier to assemble and filter than paper records, provided the formats are compatible with the GIS software and the hardware in use. Digital geo-referenced map-based files can be easily incorporated into Arcview®. As reported by the BC Land Use Coordination Office (1999), forest digital map-based data in BC is stored in PAMAP GIS, MOEP Binary Compressed, SAIF/ZIP, Microstation CAD, ARC/INFO and Arcview® formats. While these problems sort themselves as agencies and licensees move to fully digital data and reconcile software, to translate files into useable data is time-consuming, and can affect the accuracy of the data.

Another challenge concerned the scaling of the data. Stine and Hunsaker (2001) comment on generation and propagation of error by combining data with different *grain* and *extent*. Cutblock layout (e.g. the precision of proposed cutblock boundaries) in the FDP was not as fine scaled as other features that forest covers described for the landscape, such as streams and existing clearcuts. Natural disturbance map scales were coarse when compared with community watershed maps and even coarser when compared with stream classification maps. As the EPA-California (1998) states, "while spatial data of all map scales (e.g. 1:1,000,000 to 1:1200) can be displayed in the same view by a GIS, their relative positions with respect to one another will vary greatly due to their accuracy". A challenge, discussed by Edwards and Fortin (2001), is that techniques to transfer data from one scale to another are frequently complicated.

Significant new information about landscape features was obtained during the period 1995-2000. The licensee completed at least 20 assessments and inventories, such as an archaeological overview assessment, terrain stability assessment, recreation inventory, and visual impact assessment, among others. Most of this information, however, referred to the present state of the landscape, and neither acknowledged uncertainty nor predicted future states.

During the period studied, the licensee not only met the regulatory requirements for public participation (BCFPB, 1998b), but also implemented new ways of sharing decision-making with the public. However, this new knowledge of the "pulse" of the public did not materialize in any tools to forecast future social concerns or behaviors, nor result in maps showing constraints for harvesting due to social concerns. The numerous assessments, inventories and public participation initiatives carried out during the period by the licensee signified a good basic knowledge of the forest system being managed. However, most of this new knowledge was to comply with newly enacted regulations and did not identify significant changes to the planning processes for increasing certainty.

5.5.4.5.3 The Context for Decision-Making as a Source of Uncertainty

Decisions made in Lemon are constrained by numerous procedural, social and administrative factors. As an example, in preparing the 1998 FDP the licensee had to respond to the following:

- The BCFPC Act, regulations and guidebooks.

- Other features objectives or things made known by the District Manager prior to April 30, 1998.
- The Kootenay Boundary Land Use Plan and its implementation strategy.
- The 1998 FDP Memorandum of Understanding between BCMOF and BCMELP.
- The District Manager's instruction for preparing the 1998 FDP.

The procedural and administrative framework is rigid, and was especially so during the period 1995-1998. The licensee has a very good record on acting within this framework, as reported by the BCFPB (1998a; 1998c). The Board concluded:

> ...(the licensee's) practices complied with the Code in all significant respects. There is a high degree of compliance in an operating area with eleven community watersheds and steep terrain.

In the same audit it is suggested that the licensee goes further than complying with legal requirements. In spite of complying with this framework, however, the resulting plans still did not obtain a social license.

The FDP process during the first half of the period (1995-1998) required a schedule of harvesting. The requirement to specify the year of harvest was eliminated in 1998, but the requirement for describing specific location of blocks remains. The level of detail of information requested at the FDP stage generates uncertainty. The licensee cannot have complete knowledge about issues that location of harvesting will generate until the very last stage of planning. The discussion about management approaches, block design, wildlife management strategies, etc. continues to the cutblock layout and prescription phase, instead of being dealt with during higher level planning.

The assessments of landscape attributes completed by the licensee during 1995-2000 required a great deal of up front work. Accurate and effective assessments and simulations of cutblock impacts on such things as visual quality or habitat supply cannot be developed unless cutblock design is complete. This creates an adversarial climate in which the licensee must take on the risk of completing the majority of the design work in the field and then presenting the information to the government and the public for review. In a rigid scheme that requires very precise location of harvesting, once blocks are laid out on the ground, it is costly to the licensee to make changes requested by the reviewers and the public. Rather than focusing all of the planning effort on individual cutblocks, it would be preferable for licensees to engage the public and agencies in planning for desired forest conditions. These conditions should be negotiated for the landscape unit and sub-unit scale. The test for operational plans becomes their consistency with these desired conditions.

Legal requirements are not the only ones framing decision-making in Lemon. Unfulfilled social expectations create legal challenges and add complexity to this context. As reported by the BCFPB (2001a):

> The Board finds that, at that time (1996), watershed assessments did not have to be done unless the district manager specifically required them. If an assessment was required, there was no legal requirement for water-user representation. Although the Code's Interior Watershed Assessment Procedure guidebook, the Kootenay-Boundary

Land Use Plan and local practices created some public expectations for water-user participation in watershed assessments, they were not legally required.

Even though the stages in the FDP and CP approval process are sometimes viewed as one-way 'gates' (e.g. with increased certainty as each gate is passed), unresolved social issues and changing regulations along with responses to market fluctuations lead to amendments and deferral of harvesting. The rigidity of FDP processes does not allow for simple amendments to FDPs once some of these factors arise. Numerous amendments practically constitute whole FDPs, and are proposed in advanced stages of the planning cycle. The licensee gets certainty through flexibility, from keeping a stock of approved cutblocks and issued cutting permits. There is no restriction on including more cutblocks than can be harvested in the period of an FDP. However, as discussed, the BCFPB (2001b) has reported the drawbacks of this approach. Furthermore, self-discarding of approved areas by the licensee can lead to better compliance with new regulations and better response to social concerns, but at the price of wasted effort.

5.5.5 Conclusions and Recommendations from the Case study

Application of SAFEPLAN method for analyzing planning outcomes revealed the efficacy of planning and the principle sources of uncertainty in Lemon Landscape Unit in Southeastern BC. The case study confirms apprehensions surrounding current planning processes identified in the provincial survey described in Chapter IV. From this application of the method on a small scale it was possible to make numerous recommendations to improve planning in Lemon. The recommendations also include measures that should be taken to improve the policy context in which planning is currently conducted in BC.

Planning in Lemon appears to be reactive. Instead of a strategic rationale derived from a higher-level plan driving harvesting proposals towards given targets, various contingent factors influence what is harvested and what is not harvested. These factors included:

- the enactment of new regulations in 1995 that dramatically changed the context in which forestry was practiced in Lemon;
- low wood prices which put large areas of Lemon below the economic margin;
- unresolved social concerns;
- bark beetle outbreaks and some windthrow; and
- the requirement for additional resource information.

The net effect of these factors was substantial revisions in plans from year to year, including removal of substantial numbers of FDP approved blocks from the plans, and a large number of amendments to FDP's. A number of conclusions and recommendations result from this case study. These refer not only to improvements in planning by the licensee, but also to improvements in the context in which planning occurs in BC.

A first conclusion is that planning efficacy is significantly affected in Lemon by unaddressed uncertainty. As the indicators of uncertainty show, only 1 out of 7 hectares proposed in FDPs was harvested. The major loss of hectarage occurs between FDP proposal and approval, but 25% of FDP approved hectares are dropped prior to the CP stage.

From the licensee's perspective it could be argued that these high ratios indicate adequate effectiveness because they show that they are being responsive to social expectations and ecological conditions of the landscape. Since the system is dynamic, having large stocks of approved blocks, for example, will lead to the need to revisit them and improve management. This will make easier to reach legal objectives. These ratios, however, show how uncertainty has constrained efficiency of the planning process. Furthermore, they show how in the current context for planning in BC, the more effective are licensees, the less efficient is their planning, and the less efficacious is the planning process as a whole for other stakeholders.

Calculating these indicators yearly, and for different operating areas would allow trends in performance to be identified and compared.

There is a spatial pattern in planning outcomes in Lemon. Social uncertainty is higher within community watersheds and in scenic areas. Economic uncertainty was higher within "problem forest types". Broader studies of the associations of social and environmental factors with unexpected outcomes within the Arrow TSA would identify where predictive models would be useful, and facilitate the development or calibration of these models. Where sources of uncertainty are driving FDP's, the incorporation of the most adequate predictive modeling (e.g. beetle hazard models and windthrow risk models where beetles and wind are major agents of disturbance) and innovative approaches to uncertainty (e.g. creation of instances for expert judgment, and possible future scenarios) should be a high priority for improving the information channel.

Natural disturbances were present as a major contributor to uncertainty within the period of interest, but did not have major direct incidence on unexpected outcomes (e.g. several blocks were added to the FDP because of bark beetle, in what constituted a sort of "salvage through FDP" strategy; occurrence of landslides not related with forest operations was a key component of social concern and subsequently non-harvested approved areas).

Social concerns should be identified and incorporated into the higher level planning process, as a way of addressing them early in the FDP process as targets to reach. This has been also suggested by the BCFPB (1998b). Social values surveys of the kind of Meitner et al.'s (2001) at the higher level planning stage can help to identify these social targets for management.

The average time between proposal in FDP approval and CP issuance was relatively short (2.2 years) for harvested blocks. This would appear to reflect a time efficient planning process, but this may actually reflect the dropping of blocks with more difficult operational/social issues from the plan. Over time this means areas that are contributing to calculation of AAC, area in fact deferred from harvesting. This concentrates the harvest in 'available' portions of the landbase. The realism of harvesting and deferred areas should be addressed, and AAC adjusted where necessary.

The two main aspects of the context for decision-making, which helped to reduce efficacy, were lack of flexibility and lack of certainty. Small modifications to proposed blocks re-opened discussion of the entire block. In some cases the incorporation of new information rather than resolving issues, opened new issues and lead to the areas being dropped. Frequent amendments of approved and authorized activities reduced the trust of all parties who contributed to the FDP process including the public. As the BCFPB (2000) suggests, some of the contents of FDPs, such as objectives for the full range of forest resources, should be moved to higher level plans (e.g Landscape Unit Plan). These objectives would represent social agreements. As the BCFPB states, this would reduce "the costs and time required to prepare, review and approve FDPs, eliminating unnecessary duplication". The degree of cutblock modification warranting FDP review should be clarified for all parties in the planning process.

The stages in the FDP-CP approval process are sometimes viewed as 'gates'. As blocks pass each gate, the confidence of the parties involved in the planning process that the block will be harvested should increase. The uncertainty ratios indicate that CP issuance added certainty, however, unresolved social issues and changing regulations, along with responses to market fluctuations, still lead to amendments and deferral of harvesting. Mechanisms should be in place to give certainty to CP issued blocks. If policies change such that these blocks do not conform, there should be a mechanism for review and amendment, however there should also be compensation for added costs. The government should stand behind the results of the planning process and support the licensees in resolving situations where social activism prevents harvesting of CP's.

The stock of issued CP's may appear sufficient, but includes blocks in areas with low economic value or unresolved social objections. Where CP approved blocks are not in fact available for harvest, there is increasing pressure to rapidly process new proposals, and the integrity of the planning process is jeopardized. It would be preferable for the stock of CP's to include a balance of economic opportunities representative of the landbase included in the timber supply. CP's should be valid for a fixed term.

Within the forest industry, there is a tendency to use GIS only for producing and updating maps. The SAFEPLAN method illustrates how GIS can be used for problem analysis, spatially and non-spatially. Forest planners should use the full capabilities of GIS to relate uncertainty to mappable areas in the landscape. This spatial knowledge can be used to identify areas with special challenges for planning, assist with the design of specific future conditions, and give direction to plans. GIS can be used to routinely assess the performance (e.g. efficacy) of planning, and to detect information weakness.

Under the Arrow IFPA, a new scenario planning approach is being tested (Arrow IFPA, 1999). These scenarios identify potential future stand and landscape conditions which meet specific management objectives. These scenarios will have to account for factors that will certainly occur, but they also have to take in consideration uncertain and probabilistic events. The GIS-based methodology presented in this study could play a supporting role in analyzing the sensitivity of forecasted scenarios to these sources of uncertainty.

5.6 Conclusion

A method to address uncertainty through better forest planning in BC is proposed. Results obtained for southeastern BC confirm apprehensions respect to current planning processes, and show how the adoption of this method could increase the efficacy of forest plans, and improve the cost-effectiveness of the whole planning process.

CHAPTER VI. FUTURE DIRECTIONS FOR FOREST PLANNING IN BRITISH COLUMBIA. A NEW CONTEXT FOR THE SAFEPLAN METHOD

6.1 Forest planning in BC in a time of transition

As discussed in Chapters II and III, complexity of the BC forest systems makes uncertainty an ever-present issue. This together with the difficulties of planning described in Chapters IV and V, have led to the growing demand to change the context in which forest decision-making is done. The government has recognized that "increased certainty has been a key goal for industry, as companies need to coordinate personnel, equipment, suppliers, markets and financing on a multi-year basis" (BCMOF, 1999c). The forest industry has voiced the need for a new planning process that is more flexible and adaptable, enabling them to avoid losses and take advantage of unforeseen opportunities. Licensees recognize, though, that regulatory changes are just part of what is needed. Slocan Forest Products (2001) acknowledges:

> While our business environment changes daily, climate and biodiversity change over many centuries. We understand that nature defines the ultimate limit of what's possible in our business environment.

Riverside Forest Products (2000) points out:

> Forestry in this province involves constant change. Everything from environmental considerations to aboriginal land claims affects us. We have two options. We can sit back and wait and see what happens, or we can get involved and help shape change...

Coulson Group (2001b) states:

> ...there are several variables within the wood products marketplace that are out of our control, but what we can control is our daily performance....

Allowing for improvements in performance, however, implies changes in the context for decision-making. As the government acknowledges, "For too long, the forest industry has been captured in an inefficient and ineffective legislative maze..." (BCMOF, 2002c). The BCFPB (2000) suggests:

> A more flexible approach may be needed to plan for the development of roads and harvesting, recognizing the short lead time and the dynamic nature of operations in (highly dynamic environments) circumstances... from government, we must have an adaptable, results-based regulatory framework that makes companies responsible for outcomes but allows flexibility to apply innovative technologies and approaches.

The forest industry (COFI, 1999) agrees:

> ...implementing a results and incentive based approach to regulating forest practices that is in line with other jurisdictions and substitutes new certification systems for existing monitoring and auditing.

Innovative Forestry Practices Agreements (IFPAs) and Results-Based Forest Practices Code Pilot Projects are major initiatives that the BC Government has taken to answer to these requests (BCMOF, 1997). Further, profound changes to the BCFPC towards more result-based forest practices are being discussed, and implementation of new legislation is expected in April 2003 (BCMOF, 2002a). In the meantime, more than 44 million hectares of forest land have been certified in BC as being managed sustainably (BCMOF, 2002b). Neither of these two innovative approaches, the IFPA and Pilot projects, includes explicit evaluation of plan outcomes in terms of achieving the specific goals of harvesting. Monitoring efficacy of plan implementation is not discussed. Both initiatives use detailed sets of indicators to track environmental and social performance. Both initiatives present potential for addressing uncertainty in forest planning, through improvements in the information channel (IFPA) and in the context for decision-making (Pilot Projects). The principles for addressing uncertainty and better planning upon which the SAFEPLAN method is built apply in each one of these initiatives.

6.1.1 Innovative Forestry Practices Agreements (IFPAs). Addressing Uncertainty by Improving the Information Channel

IFPAs are tenure agreements that are awarded to holders of volume-based licenses that enable to test new and innovative forestry practices to improve forest productivity. On providing evidence that forestry practices will increase sustainable timber supply while addressing all other resource values, IFPA holders would increase the harvest levels under their existing licenses (BCMOF, 2000). IFPAs ensure flexibility in forestry practices. Practices that allow for flexibility, however, are limited, and include harvesting methods or silvicultural systems, activities that result in free-growing stands, silviculture treatments, collection of data, and activities that will enhance and protect non-timber resource values (BCMOF, 1997). No flexibility for operational planning processes is introduced.

Currently, seven IFPAs are at different stages of implementation in BC. Arrow IFPA, in the Nelson BCMOF Forest Region, was awarded the IFPA in 1998 (Arrow IFPA, 1999). After 4 years, it is a good example of some of the advantages of collective working in a complex environment, but also gives a sense of how changes in BC should go further to allow for flexibility. A key requirement for being awarded an IFPA is the proposal of a forestry plan that manifests the objectives and strategies of licensees for the area. The Arrow IFPA forestry plan is based on:

> ...the need for an innovative and balanced solution to address forest resource issues in the Arrow TSA including downward pressures on short and long term timber supply, as well as environmental and social values (Arrow IFPA, 1999).

This forestry plan is joint proposal by the five licensees operating in the area. It sets strategic and management objectives, and introduces the ecosystem management approach undertaken. It also introduces initiatives to be carried out to improve the knowledge of the area. As acknowledged by the licensees, they are not seeking and do not expect an immediate increase in AAC. Rather, they expect that "the Province's Chief Forester takes the IFPA's planned practices and expected results into account determining an AAC for the Arrow TSA" (Arrow IFPA, 1999). On putting together this forestry plan, licensees have received input from other stakeholders in Arrow, what has allowed for agreement on certain targets at the tactical level. The fact that this forestry plan is not directly related with the FDPs that each licensee has to submit to the BCMOF, however, compromises the opportunities of significantly improving planning processes. Social sources of uncertainty still arise in the proposal of cutblocks in conflictive areas (e.g. community watersheds), and in some cases licensees have problems harvesting blocks with issued CP. FDPs are still going through frequent amendments after approval. The context for decision-making remains pretty much the same and is still rigid.

What makes Arrow IFPA an interesting experiment is its potential for improvements in the information channel for planning. Licensees are sharing their needs for knowledge, and are coordinating to find ways for improving it. The Arrow IFPA's Five Year Work Plan (Arrow IFPA, 1999) describes many initiatives being carried out under the umbrella of a sustainability project, which provides the context for the IFPA ecosystem management approach. Most of these initiatives, in one way or another, imply the acquisition of new knowledge for understanding the natural, social, and economic components of the forest systems under management. Good examples of the relevance of this new knowledge are the clarification of social values (Meitner et al., 2001), and patterns of natural disturbances (Dorner, 2001) for Arrow. This new knowledge is allowing for the discussion of targets and alternative future scenarios, and the simulation of different strategies for dealing with these.

The SAFEPLAN method was tested in Arrow with support from the IFPA (Chapter V). As described, application of the method to one licensee's operations provided useful knowledge about the forest system under management. Application of the method to sample landscape units from Arrow IFPA as a whole would identify with more clarity the knowledge needed to make planning and plans more efficacious, and better strategies to get it (e.g. specific models, forecasting efforts, visualization tools).

A key component of innovative management in Arrow is the concept of planning towards more than one possible future scenario (Arrow IFPA, 1999). Through SAFEPLAN, inputs from individual licensees and other stakeholders can be gathered to assess alternative future scenarios (e.g. due to level 2 and 3 uncertainty, as described in Section 3.2.1). These can be spatially compared, uncertainty can be described, and most probable scenarios can be linked to tactical and operational planning. On identifying sources of uncertainty (e.g. people's concerns), and spatially relating them with features of the landscape which would constraint location of harvesting, licensees can have a broader support for justifying changes to the AAC in Arrow.

6.1.2 Results-Based Forest Practices Code Pilot Projects. Addressing Uncertainty by Improving the Context for Decision-Making

Results-Based Forest Practices Code Pilot projects are exploring new ways to regulate and enforce BC forest practices to increase efficiency and save costs for both industry and government (BCMOF, 1999d). There are seven pilot projects, which are at various stages of development, around the Province. One of these, Stillwater Pilot Project, is the most ambitious current initiative.

Stillwater encompasses 180,000 hectares near Powell River, BC, managed under Weyerhaeuser's Tree Farm License 39. According to the licensee, "the Pilot Project will reinvent the forest management approval process" for the area (Weyerhaeuser, 2001a). Flexibility is introduced to the context for decision-making on allowing the licensee to replace the sequence of FDPs being submitted year by year, by a single plan termed the "Forest Stewardship Plan". This plan defines agreed forest management strategies and measurable targets for the system managed. Immediate benefits of this shift in the number of plans are: focus on landscape planning instead of block planning, incorporation of public participation in early stages, a permanent community advisor board, and flexibility to adapt to changing conditions in the system (Weyerhaeuser, 2001a). These issues will allow for a more adaptive management, and will result in clear benefits for the licensee and the BCMOF, such as reducing cost of producing and approving plans by a minimum of 50%, and getting cutting permit approvals within 24 hours. Stakeholders will directly benefit by the maintenance or improvement of environmental standards for forest management

However, as another example of the controversy surrounding forestry in BC, Stillwater is not exempt from criticisms (Weyerhaeuser, 2001b; West Coast Environmental Law, 2001). These criticisms refer mainly to the fact that pilot projects focus almost exclusively on allowing the proponents to reduce or remove the need for public consultation and government involvement, with little or no changes to the actual practices being carried out. Critics (e.g. Forest Caucus of the B.C. Environmental Network) argue that forest planning instead should use the precautionary principle where there is uncertainty or imperfect information. In contrast to these views, however, the licensee intends that Stillwater will be closely monitored and evaluated in terms of its environmental and public participation performance, and economic efficiency. This controversy shows how in a context of more flexibility, with fewer instances at the operational level for public participation, managers have to gain the trust of stakeholders.

All the potential for acquiring certainty that a more flexible context offers can be jeopardised if people do not trust what is being done.

Accountability, therefore, becomes one of the cornerstones of the planning process. The SAFEPLAN method can help managers in Stillwater to spatially evaluate uncertainty during plan development. By retrodicting performance of past plans, some undesirable outcomes anticipated and confronted. Uncertainty (e.g. possible beetle epidemic) can be discussed with the public and agencies, and potential scenarios can be worked out together (e.g. if a Douglas-fir bark beetle epidemic occurs, should salvage be allowed in visually sensitive areas?) in advance. Present uncertainty can be refined in the landscape. When amendments to the FSP have to be made, they can be better explained both to agencies and to the public through mapped uncertainty using documentation developed through SAFEPLAN. Future amendments will be reduced selecting better predictive tools and ways of acquiring knowledge. On tracking plan implementation, uncertainty can be detected in an incipient state (e.g. a social issue that has the potential for expanding and being introduced into the forest policy agenda).

6.1.3 A Result-based BCFPC and Better Planning

Reducing complexity of the BCFPC is becoming one of the key issues in the transition in forest policy in BC. Although the form that new policies will have is not clear yet, it is fair to suppose that management will be more oriented towards achieving certain targets, or outcomes, than following rigid and mandatory processes. As proposed by the BCMOF (2002c), in this context social, economic and ecological targets would be agreed on through the establishment of landscape level zones and objectives, and managers would be responsible for managing towards these targets. Areas of development (e.g. development units) that pursue the strategic objectives of higher-level plans would replace specific location of cutblocks in plans. Management in these areas would require a Resource Development Permit (RDP). The RDP contains sufficient information and meets BCMOF tests that the proposed management respects legal rights, complies with land use zoning, and incorporates public input.

The framework for forest practices being described in the "Result-Based Code Discussion Paper" (BCMOF, 2002c) and "Sustainable Resource management Planning: A Landscape-level Strategy for Resource Development" (BCMSRM, 2002) documents recently proposed constitute a very serious attempt for making management - and planning- more efficacious in BC. Furthermore, they describe a context with possibilities and risk to licensees, and other stakeholders. They also provide an opportunity for strengthening the principles that better planning should follow. These principles, reviewed throughout the chapters of this dissertation, are:

1) The forest system comprises more than forest ecosystems. Planning should consider ecosystems (extraction, conservation), resources (harvesting techniques, silvicultural measures), stakeholders (participation, negotiation), and policy subsystems.

2) Multiple components and interactions make forest systems complex. Planning should acknowledge that knowledge will always be incomplete, and that ignorance and uncertainty will not only be present in the planning process, but will pervade through the whole implementation cycle.

3) An uncertain future represents both constraints due to risk of losses and potential opportunities. Planning should aim not only to avoid these losses (risk-adverse), but also capturing unforeseen opportunities (risk-taking).

4) Uncertainty manifests itself in different forms, and affects in various ways forest management. Planning should recognize and characterize uncertainty, and propose the best way of addressing each form of it. Planning should be open not only to probabilistic predictions, but also to guesses, judgments, and scenarios.

5) Setting adequate objectives and selecting best ways of achieving them in a complex system filled with uncertainty has to be learned by practical experience. Planning should be based on constant learning, as a way of making incomplete knowledge more complete. Planners have to acknowledge the most efficient way to learn, from their own personal experience (pragmatists, theorists). The planning process should include a process where feedback on past outcomes informs future plans; and

6) Efficacious forest plans are the ones that reach their goals (effectiveness), and do so with less inputs (efficiency). Planning should include mechanisms to routinely evaluate plan performance. If goals are not being reached, or do so with excessive inputs, planning should include mechanisms to address these weaknesses.

From this new context for planning, however, arise new challenges for both managers and agencies. Agreement on ecological, and socio-economic targets is not an easy task. When specific processes for managing forests are not specified, to have targets toward which to aim becomes fundamental. Questions remain: Who will assume the responsibility for assuring that targets are in place? In the absence of agreed targets, does management occur without restrictions? Or does management occur at all? If targets are in place, how their accomplishment will be certified? Where natural events conflict with the accomplishment of targets, are licensees released from managing towards those targets? How responsible will managers be for including information that leads to predicting disturbances? Will the targets acknowledge the return periods of "infrequent" events? How frequently will targets be amended to cope with shifts in social values?

None of these questions are easy to answer. Although changes in policy are expected to be in place by 2003, these questions will remain for a long time. They reinforce the need for a holistic view of the forest system and a systematic method for addressing uncertainty in planning.

6.2 Conclusion

Forest planning in BC is in a time of transition. IFPAs and Pilot Projects are major initiatives to test for improvements in current management and planning processes. New forest legislation towards a more flexible framework for planning is expected by 2003. In this new context, principles for better planning, and applications of the SAFEPLAN method, help on addressing uncertainty, controlling performance, and accounting of outcomes.

VII. CONCLUSION

A forest is a complex adaptive system made up of dynamic ecosystem, resource, stakeholder and policy subsystems. Sufficient knowledge is required for planning and implementing management actions that are the best ecologically, economically and socially for the present and future. The complexity of the forest system, difficulties in characterizing it, and a context that impedes acquisition of knowledge means that uncertainty pervades forestry. Planning should be a constant learning process. When plans fail, improvements can be made if these failures are detected. SAFEPLAN enables spatial evaluation of planning outcomes, calculation of indicators of uncertainty, and allows investigation of the association of uncertainty with attributes of the landscape.

From the application of SAFEPLAN in Lemon Landscape Unit in southeastern BC it was possible to make numerous recommendations to improve planning. These include measures that the Licensee should take, such as selecting new tools for modeling natural disturbances, improving economic forecasting, and implementing new public participation schemes. The recommendations also include measures that should be taken to improve the context in which planning occurs in BC. These include placing greater emphasis on defining target conditions, to give more certainty for approved harvesting, and moving more of the contents of FDP's to higher level plans.

The results obtained for the southeastern BC case study were consistent with results obtained in the provincial survey of planning performance. Provincially, frequent amendments to forest development plans demonstrate that the current planning approach is not efficacious. Planning is based on too narrow a view of forests as systems, and unaddressed sources of uncertainty affecting planning include natural disturbances, shifts in social concerns, market cycles, and changes in policy. Planning costs are higher than they could be, and the private and public budgets would be better spent under a reformed planning system.

Forest planning in BC is in a time of transition. Major initiatives to test improvements in current management and planning processes are under way. New forest legislation that provides a more flexible framework for planning is expected by 2003. It is hoped that this new framework addresses the complete forest system. The value of the SAFEPLAN method in a new planning context remains the same, to monitor outcomes, to attribute these outcomes to sources of uncertainty, and to provide feedback for subsequent plans.

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APPENDIX 1. GLOSSARY

Chaotic process: process that is unpredictable due to non-measurable shifts in initial conditions (Denny and Gaines, 2000).

Complexity: condition of consisting of parts or elements not simply coordinated, but some of them involved in various degrees of subordination; complicated, involved, intricate; not easily analyzed or disentangled (Oxford English Dictionary).

Contingency: an event the occurrence of which could not have been, or was not, foreseen (Oxford English Dictionary).

Criteria (Criterion): A category of conditions or processes by which sustainable forest management may be assessed. Criteria are characterized by a set of related indicators which are monitored periodically to assess change (The Montreal Process, 1995).

Deterministic process: process in which exact laws are followed, so that what will happen in the future is necessary consequence of states at any given moment in the past (McGraw-Hill Dictionary of Scientific and Technical Terms).

Eco-forestry: approach to maintain and restore full functioning, natural forest ecosystems in perpetuity, while harvesting forest goods on a sustainable basis. The essence of ecoforestry is to learn to perceive what the forest can supply without altering its basic ecological functions and intrinsic values (Drengson and Taylor, 1998).

Ecosystem management: approach by which, in aggregate, the full array of forest values and functions is maintained at the landscape level. Coordinated management at the landscape level, including across ownerships, is an essential component. (Society of American Foresters, 1993)

Effectiveness: contribution towards a certain outcome (Hodgetts, 1982).

Efficiency: inputs required for reaching a certain outcome (Hodgetts, 1982).

Efficacy: power or capacity to produce an effect (Oxford English Dictionary). The Merriam-Webster Dictionary relates efficacy with capableness, productiveness, adequacy, capacity, and sufficiency.

Equilibrium: staying in the vicinity of a given state over a relevant temporal scale (DeAngelis and Waterhouse, 1987)

Extent: size of an area mapped or analyzed (Stine and Hunsaker, 2001).

Feedback: a modification, adjustment, or control of a process or system by a result or effect of the process (Oxford English Dictionary)

Grain: resolution of any given landscape feature, as it is perceived through the source of data used (Stine and Hunsaker, 2001).

Holistic forestry: approach that defines the forest as a diverse, interconnected web which focuses on sustaining the whole (all life forms), not on the production of any one part (e.g. timber) (Hammond, 1991).

Homeostasis: certain stability in a system (Beishon and Peters, 1972)

Ignorance: lack of knowledge (Oxford English Dictionary).

Indicator: a measure of an aspect of criteria (criterion). A quantitative or qualitative variable which can be measured or described and which when observed periodically demonstrates trends (The Montreal Process, 1995).

Instinct: act that appear to be rational, but is performed without conscious design (Oxford English Dictionary).

Knowledge: the sum of what is known; fact, state, or condition of understanding (Oxford English Dictionary).

Modification: change in respect to some qualities in a system (Oxford English Dictionary).

New forestry: approach that defines forest management with timber production as a by-product of its primary function: sustaining biological diversity and maintaining long-term ecosystem health (Franklin, 1990).

Non-linear interactions: the rules of interaction change as the system changes and develops (Levin, 1998).

Optimal operating point: state of development that takes full advantage of the available energy and resources (Kay, 1997).

Precautionary principle: in the face of uncertainty, society should take reasonable actions to avert risks where the potential harm to human health or the environment is thought to be serious or irreparable (President's Council on Sustainable Development, 1996).

Social forestry: a broad range of tree and forest related activities undertaken by rural landowners and community groups to provide products for their own use and for generating local income (Gregersen et al., 1989).

State: quantity stored in, or condition of, a system (Odum, 1994).

Stochastic process: process governed by probabilistic laws (McGraw-Hill Dictionary of Scientific and Technical Terms).

Type one error: rejecting a null hypothesis when it is true (Ritchie and Marshall, 1993).

Type two error: failing to reject a null hypothesis when it is false (Ritchie and Marshall, 1993).

Uncertainty: incompleteness of knowledge (Smithson, 1989).

Understanding: the degree of match between reality and theory (Pickett et al., 1994).

APPENDIX 2. PROVINCE-WIDE QUANTIFICATION OF HOW UNCERTAINTY IS AFFECTING FOREST PLANNING IN BC

1. Revision of Forest Development Plans in BC

BCMOF FOREST REGION	FDP REVIEWED/YEAR	FDP AMENDMENTS/YEAR
CARIBOO	38	523
NELSON	38	200
PRINCE GEORGE	53	281
KAMLOOPS	60	444
PRINCE RUPERT	24	285
VANCOUVER	88	1005
TOTAL PROVINCE	**301**	**2738**

2. Estimated Costs of Revision of Forest Development Plans in BC[23]

Staff time (Office review, field review, meetings with stakeholders)[24]	$ 11,000 / FDP	301 FDP/year	$ 3,311,000
Vehicles, accommodation in camps, helicopter time, etc.	$ 25,000 / FDP	100 FDP/year	$ 2,500,000
Appeals, reviews, and board audits	$ 30,000 / FDP	26 FDP/year	$ 780,000
TOTAL PROVINCE			**$ 6,591,000**

[23] Based on answers of 25 out of the 40 BCMOF Forest Districts

[24] Based on an average of 40 full man-days per FDP at $ 275/day. These averages were given by District officials.

3. Causes of Major and Minor Amendments to Forest Development Plans in BC[25]

BCMOF FOREST REGION	Main Causes for Minor Amendments to FDPs	Main Causes for Major Amendments to FDPs
CARIBOO	1) Beetle 2) Block Layout 3) Windthrow	1) Beetle
NELSON	1) Block Layout 2) Beetle 3) Windthrow 4) Fire	1) Changes in Policy 2) Beetle 3) Social conflicts
PRINCE GEORGE	1) Block layout 2) Beetle 3) Fire	1) Timber market changes 2) Fire 3) Beetle
KAMLOOPS	1) Block layout 2) Beetle and defoliators	1) Block layout 2) Timber market changes 3) Changes in policy 4) Beetle and defoliators
PRINCE RUPERT	1) Block layout 2) Windthrow	1) Block layout 2) Windthrow
VANCOUVER	1) Block Layout 2) Timber market changes	1) Timber market changes 2) First Nations consultation 3) Block Layout

25 Based on answers of 34 out 40 BCMOF Forest Districts and 4 out of 5 licensees.