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# A Strategy for Habitat Supply Modeling for British Columbia

## DRAFT Volume I

***Vision — Decision-makers and practitioners in British Columbia will use habitat supply modeling effectively as a part of a suite of tools to evaluate options for the sustainable management or restoration of habitats, and to predict the potential implications of development alternatives on habitat supply.***

*Prepared for —*

**Habitat Modeling Steering Committee**

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Final Project Report — March 2002

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# EXECUTIVE SUMMARY

This strategy has been prepared in response to a request by the Ministry of Water, Land, and Air Protection (MWLAP). The project concept and guidance came from the Habitat Modeling Steering Committee, an inter-ministry steering committee with members from MWLAP, the Ministry of Forests (MOF), and the Ministry of Sustainable Resource Management (MSRM), all of whom are involved in habitat supply modeling (HSM). The purpose of the strategy is to indicate where efforts and investments are most needed within government, the forest industry, academia, and non-government organizations to improve analysis and forecasts of habitat and ecosystems so that more informed decisions can be made about sustainable resource use. The strategy complements and supports a strategy developed by the Biodiversity Working Group, Forest Productivity Council of BC, in 2001.

Beginning in July 2001, the nine months over which the strategy was developed represents a period of unprecedented change and uncertainty within the provincial government and, more broadly, in the forestry and natural resources sector. Within government these changes are having a dramatic impact on mandates, organizational structure, roles and responsibilities, budgets, resources, and priorities. Further program delivery changes and resource reductions are planned over the next couple of years. These changes will continue to have a strong influence on responses to this strategy.

The strategy development process included a current situation analysis; an assessment of the future context for HSM; information analysis, feedback, and synthesis; and final reporting. To assess the current situation, interviews were held with 28 resource professionals and 18 HSM modelers. The strategy components included an HSM "system" representation; a Decision Type classification; a list of key HSM functional capabilities; a model characterization and evaluation framework; a catalogue of currently available modeling approaches; an HSM vision and five strategic objectives; near-term and longer term implementation plan options; and nine recommendations. The model characterization and evaluation framework also was developed to serve as a draft model registry and model evaluation tool. Once tested more fully, these tools can be used to identify and compare available modeling approaches.

Some of the key technical barriers to HSM identified included a lack of knowledge about habitat–species relationships, thresholds, and baseline information; insufficient detailed biophysical inventory and successional information; and inadequate HSM training and extension. Organizational and cultural barriers identified included unclear mandates regarding the conservation and protection of habitats; poor communication between biologists and decision–makers, resulting in confusion over the value and use of habitat information; absence of a corporate ministries-wide vision and strategy for HSM; and a need for consistent and approved HSM standards and protocols.

A scan of current modeling approaches indicated that most are able to address both static non-temporal and spatial–temporal analyses. A significant barrier continues to be the time and costs associated with data preparation. All modeling approaches are able to use site series information and can deal with spatially nested habitat areas. The majority of approaches allow users to define specific species–habitat relationships, often through a user interface. Most models do not have an integrated population analysis component, although this can usually be handled using post-modeling procedures. Most of the modeling approaches are able to generate forecasts of future

conditions. A broad range of indicators are used in HSM; however, forest inventory and stand structure attributes are by far the most common features used.

A summary table of modeling approaches presented in relation to the six Decision Types indicates that 31 of the 32 modeling approaches (projects) are able to address landscape-level habitat questions (Decision Type A); thirteen are able to address ecosystem-level habitat questions (Decision Type B); twelve are able to address stand-level habitat questions (Decision Type C); twenty-two are able to address single species–guild, specific life requisite questions (Decision Type D); eight are able to address single species–large area home range, all/most life requisite questions (Decision Type E); and nine are able to address single species–small area home range, all/most life requisite questions (Decision Type F).

From the interviews with resource professionals and modelers, it was clear that all resource professionals agree there is a need for improved HSM capability, more up-to-date information on what models are available, and guidance on how models can best support the resource management decision-making process. It was also evident that the state of HSM cannot be improved by using the current fractured and uncoordinated approach. All three natural resources ministries have clear business drivers in their new Service Plans that point to the need to do a better job of HSM. Government, industry, academia, First Nations, private sector firms, and non-government organizations all will need to contribute to improving HSM through a partnership of effort and support. Any one participant should not control this more coordinated HSM effort. Rather, these efforts should be based on a shared and equal partnership arrangement involving all key stakeholders who will receive a benefit from the resulting improved products and services.

The vision for HSM is as follows:

**Decision-makers and practitioners in British Columbia will use habitat supply modeling effectively as a part of a suite of tools to evaluate options for the sustainable management or restoration of habitats, and to predict the potential implications of development alternatives on habitat supply.**

Five strategic objectives are identified to support the vision. Objectives 1, 2, and 3 aim to enable more coordinated model development and increase model-building capacity in the province. Objectives 4 and 5 address the establishment of HSM standards and protocols, and the enhanced understanding and use of models. The five strategic objectives are:

1. To ensure the development, full documentation, and availability of at least one fully complete modeling approach for each of the six Decision Types.

2. To accelerate model development and increase modeling capacity by assembling a high-caliber, multi-disciplinary development team.

3. To identify critical knowledge gaps regarding both habitat–ecosystem thresholds and linking habitats to population response.

4. To organize and maintain the modeling "toolbox," including the development of modeling protocols and standards to ensure consistency, quality, and broad access.

5. To increase user and decision-maker capacity through the development and delivery of general and specialized training and demonstration packages.

The implementation plan provides two options. Option 1 has a near-term focus (six months to one year) and employs an incremental approach. Option 2 takes a longer-term view (two to three years) and advances a bolder agenda for addressing the strategic objectives. The two plans are referred to as options, but could be viewed as being somewhat sequential.

With an emphasis on the Option 1 implementation plan, the strategy makes nine recommendations:

1. The provincial government (MWLAP, MSRM, and MOF) and the forest industry should sponsor a Habitat Supply Modeling Strategy Workshop as soon as possible, in order to communicate and obtain feedback on the proposed strategy directions, implementation options, and recommendations.

2. HSM should be a standardized analytical procedure that is used to assess habitat supply and habitat values in a manner parallel and at least equivalent to the approaches being used for timber supply analyses.

3. When reporting on analysis results, HSM approaches should incorporate the use of ecological benchmarks and environmental thresholds.

4. A cooperative agreement needs to be established between the natural resources agencies (MWLAP, MOF, MSRM and possibly others) regarding the coordination of HSM-related activities within government.

5. The provincial government should form an Inter-Agency Habitat Supply Modeling Technical Committee with representatives across the provincial natural resources agencies.

6. The provincial government should establish a high calibre, technical HSM team, led by a dedicated manager and champion, that can focus on priority model development needs, offer expert advice, and provide technical leadership.

7. The provincial government should establish a set of HSM protocols and standards to ensure consistency, quality, and broad access to existing models.

8. The provincial government should establish a habitat supply model registry that includes a standard and required set of features to be used for characterizing existing and new models.

9. Under the direction of the Inter-Agency Habitat Supply Modeling Technical Committee, the provincial government should develop and deliver general and specialized training and demonstration packages for HSM.

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*The completion of this strategy was very much the result of a real Team effort. I wish to express my gratitude to my colleagues for their high level of commitment in seeing the strategy through to its final conclusion. It was fun working with you and a continual positive learning experience.*

*The Team would like to thank the Habitat Modeling Steering Committee and the habitat supply modeling community for allowing us the opportunity to explore this vision for new directions with habitat supply modeling. Finally, to the decision-makers, resource managers, and modelers, we extend our appreciation to you for generously providing us your time, experiences, and insights during the interview process.*

*Keith Jones, R. Keith Jones & Associates, March 2002*

# ABBREVIATIONS

| | |
|---|---|
| AAC | Allowable Annual Cut |
| BEC | Biogeoclimatic Ecosystem Classification |
| BWG | Biodiversity Working Group |
| EFMPP | Enhanced Forest Management Pilot Projects |
| ENGO | Environmental Non-Government Organization |
| FDP | Forest Development Plan |
| FPC | Forest Practices Code |
| GIS | Geographic Information Systems |
| HSI | Habitat Suitability Index |
| HSM | Habitat Supply Modeling |
| IFPA | Innovative Forest Practices Agreements |
| KBLUP-IS | Kootenay Boundary Land Use Plan – Implementation Strategy |
| LRMP | Land and Resource Management Plan |
| LU | Landscape Unit (Planning) |
| MELP | Ministry of Environment, Lands and Parks (formerly) |
| MOF | Ministry of Forests |
| MSRM | Ministry of Sustainable Resource Management |
| MWLAP | Ministry of Water, Land and Air Protection |
| OGMA | Old Growth Management Area |
| RIC | Resource Inventory Committee |
| SDM | Statutory Decision Maker |
| SLUP | Strategic Land Use Plan |
| TFL | Tree Farm License |
| TSA | Timber Supply Area |
| TSR | Timber Supply Review |
| UBC | University of British Columbia |

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NOTE: ALL APPENDICES ARE IN A SEPARATE VOLUME II

# 1 Introduction and Context

This strategy report has been prepared in response to a request by the Ministry of Water, Land, and Air Protection (MWLAP). While the contract was with MWLAP, the project concept and guidance came largely from the Habitat Modeling Steering Committee, an inter-ministry steering committee with members from MWLAP, the Ministry of Forests (MOF), and the Ministry of Sustainable Resource Management (MSRM), all of whom are involved in habitat supply modeling (HSM).

In the original request for proposal, the following goals for the strategy were stated:

- To indicate where efforts and investments are most needed to improve analysis and forecasts of habitat and ecosystems, so that these best inform decisions about sustainable resource use.
- To provide recommendations and outline some of the immediate steps that can be taken in modeling initiatives within government, the forest industry, academic institutions, and non-government organizations.
- To address both short- and long-term strategic direction, and specify the tasks that are the highest priorities in the immediate future.

Furthermore, it was stated that the strategy needed to reflect the views and capabilities of those that use, or could use, predictive models to support decisions that affect environmental values.

The main body of the strategy appears within this Volume I, while all of the appendices are contained within a separate Volume II document. The State of Modeling report prepared in December 2001 has been incorporated within this strategy report, the equivalent sections of this volume being Sections 1–5 plus Appendices A, B, and C of Volume II.

Within this introductory section (1), we will first establish some perspectives and definitions. An important conceptual discussion and illustration of what we are calling the HSM “system” follows. This helps to set context and show the inter-relationships of key components of the HSM system as they have been considered in the strategy.

In Section 2, we will provide further context for habitat supply models by covering the topics of why we need habitat supply models; what kinds of individuals need to be involved typically in habitat supply model work; and how habitat supply models fit into resource management planning and decision-making overall.

In Section 3, we advance a classification of Decision Types. This provides a common framework for many of the strategy components. The six Decision Types embrace the full spectrum of resource management questions or issues regarding habitats and ecosystems and their interpretation for biological populations and biodiversity. They serve as a common reference set for characterizing habitat supply model features and for evaluating the present set of modeling approaches being used in the province. Section 3.3 provides a table for characterizing and evaluating modeling approaches. It cross-references the functional capabilities of models with the six Decision Types and indicates a preferred “performance level” for each functional capability.

Section 4 describes the range of perspectives that resource management decision-makers and their support staff have on HSM. These views are based on a set of interviews conducted in the fall of 2001. From these findings, we have identified important barriers to the acceptance and use of habitat supply models. These barriers were considered in developing the strategic objectives, implementation plan, and recommendations in Sections 7, 8, and 9, respectively.

Section 5 provides a scan of modeling approaches and projects in BC and elsewhere. This overview was based on the findings of interviews with modelers. Table 5.1 presents a summary of these modeling approaches and projects in relation to the Decision Type classification. Appendix C in Volume II lists detailed responses for each of the 18 interviews; these responses were reviewed by the modelers to ensure the information was interpreted correctly.

In Section 6, there is a summary of the future context from three viewpoints: organizational, technical, and market. In these times of significant change it was important to understand probable trends, so that the strategy and near-term implementation plan could be as realistic as possible.

The core of the strategy is contained begins in Section 7. It lays out a vision and a set of five strategic objectives with supporting rationales. In the form of two implementation options, Section 8 provides a description of what are felt to be some of most important near-term steps (Option 1) and longer-term steps (Option 2) towards implementing the strategy.

With an emphasis on the option 1 implementation plan, Section 9 lists nine key recommendations. Section 10 provides a list of references cited in the strategy.

## 1.1 Methods

This assignment has spanned nine months of activities, and over this period an unprecedented level of change and uncertainty has prevailed within the natural resources sector, both public and private. This reality created a unique challenge for developing the strategy.

At the outset, the consulting team took a multi-disciplinary approach to all aspects of the strategy development. Each team member brought a unique set of capabilities spanning a rather wide range of technical, domain, and organizational knowledge. Given the nature of the topic area and project requirement, this breadth in experience and skills was advantageous. The approach used in the developing the strategy was divided into five main processes: current situation assessment, future scenario assessment, analysis, analysis feedback and final synthesis and reporting. These processes were somewhat iterative, particularly the current situation assessment.

The current situation assessment involved a review of a range of pertinent documents and websites, and a set of interviews with 28 decision-makers and 18 modelers. The first set of interviews was conducted in the fall of 2001 and provided valuable insight into a number of issues, barriers, and opportunities regarding HSM, from user and decision-maker viewpoints. With these discussions as background, a team analysis meeting was held in late November 2001. At this two-day session, some key foundation components were sketched out which subsequently set in place a framework for the overall strategy. These components included the HSM System construct, a Decision Type classification, a model evaluation tool, and a detailed list of functional capabilities, model features, and system requirements. This latter output provided a consistent structure for the interviews with the modeling community.

These components, in addition to the interview findings, formed the basis for a State of Modeling Report prepared for the Habitat Modeling Steering Committee (HMSC) in December 2001. In mid-December, a day-long meeting was held with the HMSC to review this report. With an overall positive response from the committee, the assignment focus moved to completing the strategy.

About mid-way in the assignment, a future context document was circulated among the team. It was gradually augmented and updated until the completion of the strategy. Important inputs to this process included the following: the government New Era Agenda materials; discussions from a fall symposium on sustainable forest management sponsored by the Innovative Forest Practices Agreement (IFPA) holders; informal discussions with our respective networks; and the summary Service Plans released in mid-January 2002 for MWLAP, MSRM, and MOF.

Due to the continuing state of change, it was decided to focus the strategy and implementation plan more on identifying activities (how) than on the responsibilities (who) for actions. The strategy also has indicated where it is aligned with and supports the strategy and implementation plan for the Biodiversity Working Group, Forest Productivity Council.

A draft strategy report incorporated input of the above processes, including feedback from a strategy workshop held with the HMSC and other key HSM players in the February–March 2002 period. Further review by the HMSC and others provided important feedback for this final report.

## 1.2 Perspectives

Models are an abstraction of knowledge. Knowledge, in turn, can be thought of as a part of a data–decision continuum. From the viewpoint of decision support, Figure 1.1 shows a knowledge progression starting with data and theory as the foundation (modified after Moon et al. 1997). To be useful and provide meaningful information, data must be organized and analyzed. Theory also comes into play to guide the overall assessment of the situation of interest[1]. For example, data is often organized into classes, scanned to determine patterns, or analyzed to generate statistics. Progressing along the continuum, information components are subjected to interpretation and integration, typically through some kind of modeling process that results in a forecast.

These predictions, naturally, are only as good as the accuracy of the underlying data, the guiding theory and our understanding (knowledge) of and assumptions about the relationship between the various information components. In other words, if our predictions are inaccurate, it may be that the data and information are inadequate, the overarching theory is incorrect, or our current knowledge of relationships is in error. To determine sources of error when using models for direct interpretation or forecasting, it is important to recognize the explicit lineage of this knowledge continuum. Without the appreciation of this continuum, it will not be possible to effectively increase predictive accuracy and precision.

To complete the continuum, predictions[2], when used against a set of decision criteria and an associated decision process, provide a means to support decision-making. Note that we have used the expression "means to support" because these predictions realistically can and should lead only

[1] Also referred to as a guiding paradigm (Hudson 1992).
[2] Once tested appropriately.

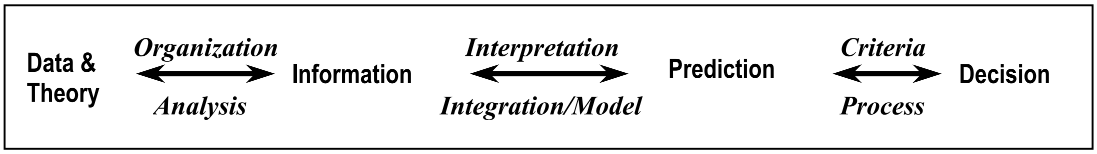


**Figure 1.1 Models are a part of a data/theory–decision continuum, with the ultimate purpose of better informing resource management decisions.**

to more informed decision-making. A critical aspect of decision support is the format in which the predictive information is portrayed to the decision-maker(s) — does it convey the message in such a manner that the user can understand the nature and magnitude of the risks, consequences, and opportunities that are forecasted? The arrows in Figure 1.1 are bi-directional, but in practical terms resource management decision needs are the main driver that specifies the requirement for prediction and knowledge, information, and data.

With HSM the prediction is about habitats (for species or groups of species, or as surrogates for biodiversity) and their quantity, quality, and distribution, geographically in the future. Models come in many shapes and sizes and there are many debates about what constitutes a model. Models may comprise a single simple function or they may be made up of a set of functions as components. More complex models might be in the form of a series of inter-related or inter-dependent models, perhaps combined into an integrated modeling package. Some modeling packages can also include sophisticated user interfaces that help the user link different inputs with particular models, model settings (parameters), and standard output reports.

For practical reasons, the heart of habitat supply models contains or holds a set of case-specific relationship knowledge. The circumstance defining the case depends on many factors, in particular, the species or species groups of interest, together with their relationships to the dynamics of the spatial and temporal biophysical setting being examined. This set of conditions and relationships can be very broad; for example, the knowledge or assumption that biodiversity will be best served by maintaining particular patterns through time and space. Models normally comprise procedures and functions that incorporate relationship knowledge about different information components (typically inputs about a current state of conditions) and then predict or forecast a future state of conditions. In the case of HSM, it is a forecast of the quantity of various habitat qualities present in both spatial and temporal terms.

Since the late 1980s, information and decision support technologies have advanced considerably. They currently offer significant opportunities to characterize, forecast, and visualize the state of natural resources far into the future. In the early part of this period, for example, under the federal Green Plan, a Forest Management Decision Support System initiative invested some $7 million in early-stage spatially explicit forest and wildlife habitat modeling tools. Since then, so-called forest estate modeling approaches, usually centered around timber supply analysis objectives, have matured considerably, as have their enabling technologies of GIS, databases, application programming tools, data acquisition technologies, statistical packages, inferencing methodologies, and so on. Today, these spatial and temporal tools are being used increasingly for developing scenarios of future forest-landscape conditions, and as a basis for interpreting habitat for individual or groups of species and biodiversity.

While these developments are encouraging, the focus of much of this modeling has been on timber supply analysis and the associated growth and yield models that drive these analyses. Over the past five years these now widely accepted modeling protocols have worked despite many challenging technical and institutional barriers. In the area of HSM, a similar effort to that undertaken with timber supply analysis needs to be undertaken, so that habitat, species, and biodiversity values can be considered on an equal footing to timber and other resource values.

## 1.3 Definitions

In this strategy, the term habitat is a concept used to refer to “the place, including physical and biotic conditions, where a plant or animal usually occurs” (Johnson and O’Neil 2001). More specifically, habitat is “an area with the combination of the necessary resources (for example, food, cover, water) and environmental conditions (temperature, precipitation, presence or absence of predators and competitors) that promotes occupancy by individuals of a given species (or population), and allows those individuals to survive and reproduce.” (Morrison et al. 1992 as cited in Johnson and O’Neil 2001). By this definition, a habitat is always with reference to a particular species, group of species, or an expression of biodiversity.

Habitat supply refers to the quantity, quality, and geographic distribution of habitat present over time. Again, the supply of habitat is relative to a particular organism, group of organisms, or elements representing biodiversity. Habitat supply may also be expressed with reference to a season such as a winter range, a life stage such as “reproductive”, or a habitat element such as a particular food source (adapted from Page 2001).

Models are representations of real-world situations (Holister 1984). In the broadest sense, “models are built to define problems, clarify ideas, organize concepts, communicate information, develop and test hypotheses, and to make predictions.” (Roloff et al. 2001). Habitat models are an abstraction of our current state of knowledge about habitat relationships. They involve procedures to represent and process this relationship knowledge about various data components (inputs) to predict future conditions (outputs), all normally within a temporal, or spatial and temporal, framework. Habitat supply models, therefore, are purposeful because they are designed to inform resource management decision-making. They are used to “characterize how animals [and other organisms] respond to their abiotic (for example, landform, soils, climate) and biotic (vegetation, species interactions) environment.” (Roloff et al. 2001). Drawing from these definitions collectively, habitat supply modeling attempts to model or represent and forecast habitat supply.

## 1.4 The Habitat Supply Modeling System

The modeling of natural resource systems is typically complex, and potentially confusing to the novice. To help bring some clarity to the HSM Strategy, we have developed a schematic (Figure 1.2) that shows how HSM relates to a number of other similar or supporting processes. While we are calling the contents of the entire figure the *habitat supply modeling system*, it provides primarily a technical and habitat perspective of key functions, processes, and relationships. As was described in Section 1.1, data and information systems underpin and feed these functions.

**Environmental, Economic and Social Values**[3] are the starting point for describing the system, and have therefore been placed at the top of Figure 1.2. These values are translated into a set of **Resource Management Principles, Goals and Objectives**. At the highest level, for example, they represent the goals of the provincial government and the three natural resources ministries. For example, the government has stated two pertinent principles: (1) to ensure open government and accountable decision-making, and (2) to ensure effective and sustainable use of the provincial land base. At the ministry level, the MSRM has as one of its goals to "prepare comprehensive strategic land and resource plans that promote sustainable use and management of the province's natural resources." Likewise, MWLAP has a goal to "conserve and restore the natural biological diversity of landscapes and terrestrial and aquatic ecosystems." Allied principles, goals, and objectives similarly occur at the regional, sub-regional, and stand levels regarding the full spectrum of environmental, economic, and societal values.

**Levels of Planning, Management, Decision-Making & Monitoring** — A number of legislative tools exist and are being developed to protect the range of values present and to help achieve resource management objectives. Many of these tools or instruments are engaged across a range of levels (or scales) for planning, management, decision-making, and monitoring. For example, the Prince George Land and Resource Management Plan (LRMP) has a strategic objective for biodiversity for the entire LRMP planning area which states: "to manage for biodiversity by maintaining a pattern of mature and old growth forest at the landscape level." For this area, at the stand level, the planning for habitat supply and biodiversity is being proposed for future Type III silviculture analysis and modeling, with the eventual goal of having quantifiable objectives and measurable targets for habitat supply or habitat enhancement. Section 2.2 of the current document describes these different levels of planning, management, decision-making, and monitoring in greater detail.

These resource management goals and objectives, exercised through the various legislative instruments, require initial and on-going resource analysis. The initial analyses can help to establish and test policies and regulations. Subsequent analyses support regular planning, decision-making, and monitoring processes that can be matched against the original set of objectives. Generally, modeling projects arise from specific **Habitat Supply and/or Timber Supply Information Needs or Questions**. The modeling exercise is usually then focused through the **Selection of Appropriate Criteria or Indicators** that are monitored to answer the questions in a cost-effective manner.

By far the most developed analysis process in Figure 1.2 is that representing determination of the **Predicted Timber Supply** (i.e., Timber Supply Analysis). **Management Regime Options/Alternatives** explore the effects of different forest management strategies, harvest flows, uncertainties in forest inventories, and growth projections on timber supply. This analysis is used to inform decisions regarding the Allowable Annual Cut (AAC) for a particular management unit, as well as related land use and management decisions. Currently, timber supply models are used to conduct these analyses at the management unit level (for example, TSA). Timber supply models in Figure 1.2 are within the circle labeled **Disturbance Scheduler and Stand & Forest Estate Prediction Models**. An example of a timber supply model system used by the MOF is a program called FSSIM that simulates how the forest is harvested decade by decade, controlled by resource management practices and growth and yield models to simulate how the forest grows (for example, Variable Density Yield Prediction – VDYP and Table Interpolation Program for Stand Yields – TIPSY). These kinds of analyses allow alternative management regimes to be compared as to their effect on the flow of timber and forest structure.

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[3] This font type will be used to reference the elements within Figure 1.2.

The overall objective of this modeling — i.e., Timber Supply Output — is to estimate harvest flow in a way that is consistent with current land-use plans, forest management practices and forest inventory data. But as a model, it is dependent on not only the reliability of current forest inventory data, but also on the modeler's ability to accurately capture all of the factors affecting future forests, be they natural (**Natural Disturbance Regimes and Succession**) or management-related (**Management Regime Options/Alternatives**).

Both spatial and aspatial timber supply analysis approaches are being used in BC. Aspatial approaches are increasingly developing techniques to allow for the incorporation of more detailed spatial representation of the analysis units. For some strategic analysis questions, such as those at a broad provincial or whole region level, explicit spatial representation has certainly not been essential. However, with the growing need to have a direct alignment of strategic planning with operational planning levels, the maintenance of spatial relationships has become more important. Fortunately, increased computing power and modeling approaches are showing considerable promise in this direction, and many of the emerging next generation timber supply models are able to predict detailed stand-by-stand condition schedules that exceed one or two rotations (**Predicted Future Stand & Ecosystem Conditions**).

By and large, habitat, biodiversity, and other ecosystem values need to be considered within a spatial context. For this reason, more contemporary HSM approaches are drawing upon the outputs of spatial scheduling models, normally used for timber supply analysis, in order to obtain spatial and temporal predictions of future forest conditions (see **Predicted Future Stand & Ecosystem Conditions**).

These outputs, in turn, serve as key inputs to many HSM approaches. In some cases, the habitat supply model is appended directly to the "Disturbance Scheduler and Stand and Forest Estate Prediction Model." This is most likely to occur when predicting coarse-filter type indicators that are closely associated with typical stand or forest factors. In other cases, the outputs are used as predictors of future forest and ecosystem conditions that feed other stand-alone habitat supply models.

The future forest conditions are often predicted in time steps (for example, one decade) and characterize a limited number of stand variables, such as primary tree species and average age, height, and diameter. Habitat modeling could be made more effective by the addition of outputs for stand and ecosystem characteristics such as crown closure, canopy layers, snags, coarse woody debris, and understory. These outputs, in turn, are the kinds of attributes that **Coarse and Fine Filter Habitat Supply Models** use as inputs to interpret various forms of habitat quality and abundance.

The habitat supply model contains the structured knowledge of what constitutes habitat, and an analytical strategy to evaluate and predict its future supply. As with all models, it is important that these models are peer reviewed, evaluated, and validated. It is the understanding of species and their habitats — **Habitat Relationships** — that is paramount for predicting species' responses to past, present, and future land uses within a managed landscape (Johnson and O'Neil 2001), and that forms the essence of the knowledge base within the models. At this point in Figure 1.2, the habitat supply model usually excludes the consideration of population dynamics or animal-plant interactions. The output from a habitat supply model is a predicted set of future habitat (stand or forest) conditions geographically and over time — **Predicted Future Habitat Conditions**. HSM is becoming a "freestanding" activity with its own set of specialized tools and approaches. Consequently, it is important to show it as separate from the Disturbance Scheduler and Timber Supply Models.

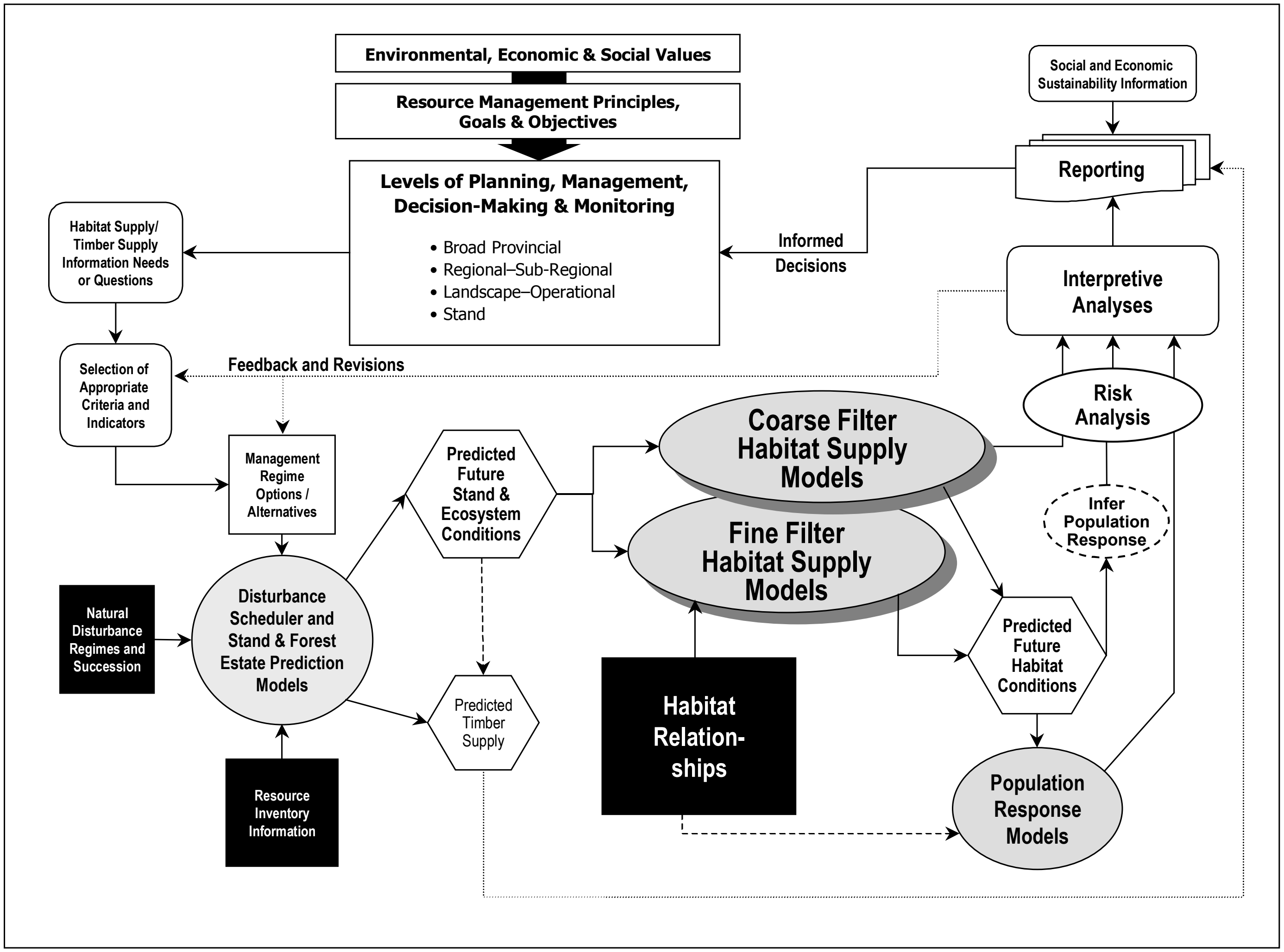


**Figure 1.2 Habitat supply models in the context of spatial timber modeling, population response models, and decision-making.**

Most commonly (especially with fine-filter habitat modeling) the predicted future habitat outputs allow biologists to **Infer Population Response** for a particular species, group of species, or guild. In the case of coarse-filter HSM, the focus may be the predicted presence of specific ecosystem attributes themselves (for example, seral stage distribution) rather than populations of individual species.

At the next important stage, **Interpretive Analyses** and **Risk Analysis** can be conducted to determine the impact of the predicted habitat supply and population trends on ecosystems / biodiversity or species. Results of these analyses should be used to evaluate and potentially revise the indicators and management options selected for evaluation at the beginning of the process. The final step in the process — **Reporting** —summarizes the results and prepares presentation materials that convey the results of the modeling in a form that is readily useable by decision-makers. To close the loop, these interpretative reports feed back into and inform the planning, management, decision-making, and monitoring processes.

For completeness, we have included the pathway to **Population Response Models**. These models can link population dynamics information with habitat supply features in order to obtain an estimate of population. At this time, except for a few examples, this analytical pathway in the HSM system is less well-known and is exercised infrequently.

# 2 Present Context for Habitat Supply Models

Since this assignment is focused principally on developing a strategy for using habitat modeling to assist the MOF, MWALP, and MSRM in meeting their goals related to habitat management, the following discussion focuses on **the role of habitat modeling in supporting decisions that affect habitat quality, quantity, and distribution.**

## 2.1 Application of Habitat Supply Models

In an ideal world, where decisions are based on the best available information, all HSM ultimately fulfils a decision-support role. In practice, HSM is undertaken today for a variety of reasons. In general, these can be grouped under three broad functional areas as outlined below.

### *2.1.1 Decision Support*

Habitat supply models provide decision-makers with information about the potential habitat-related impacts of various land-use management options, including trends into the medium- and long-term. For example, habitat supply models are used for

- Evaluating and comparing alternatives within planning processes;
- Evaluating potential management options when experimental management and field testing is too risky (for example, affecting red-listed species);
- Sharing and consolidating knowledge from various sources and individuals about habitats and their management;
- Predicting change through forecasting of future habitat conditions; and
- Assisting resource managers to understand and see habitat as another important forest output in the same the way they have come to see timber values — i.e., viewing habitat not as a timber constraint, but rather as another forest value that can be managed for in the same way as we now manage for timber.

### *2.1.2 Monitoring and Assessment*

Habitat supply models are important tools to support adaptive management. On the "front end" of the process, they provide a basis for predicting and portraying anticipated results, and in helping decision-makers choose which scenarios are the most practical to explore. At the "back end," they offer an analysis framework for organizing, storing, analyzing, reporting, and interpreting monitoring results, including testing our understanding of species–habitat relationships. Within the adaptive management cycle, this information in turn feeds back into the decision process to close the loop — i.e., the "adjust" step of the adaptive management cycle.

Models also provide a means of incorporating the results of individual monitoring initiatives into a broader context for analyzing the overall effectiveness of resource management objectives. Within this same context, models offer a way of projecting short-term monitoring results into long-term trends.

### 2.1.3 Research

Habitat supply models provide researchers with a framework to capitalize on, synthesize, and abstract existing knowledge about the habitat requirements of particular species, species–habitat relationships, and the distribution of particular habitat components through time and space. With this kind of application, they also help to identify gaps in knowledge (learning opportunities) and data, and assess their significance through sensitivity analyses and a comparison of outputs. Finally, modeling activities encourage researchers and practitioners to organize and apply the often-vast amounts of empirical data available.

## 2.2 Planning, Management, Decision & Monitoring Levels

Individuals in various positions make habitat-related decisions at a variety of management/geographical levels across a wide range of agencies and organisations in BC[4]. The levels can be divided generally into four groups[5]:

- Broad provincial (for example, FPC regulations, land use targets)
- Regional–subregional (for example, LRMPs, TSAs)
- Landscape–operational (for example, Landscape Unit planning, FDPs, SLUPs)
- Stand (for example, Type III Silviculture Plans, Pre-harvest Silviculture Prescriptions)

Table 2.1 shows the relationships between the different decision-level scales and the typical issues or decision points, the range of typical project area sizes, and example analysis units (entities and size range).

The potential entry points for habitat modeling into the decision-making framework related to habitat management are primarily located within the ongoing operations of the MOF, MSRM, and MWLAP, and within activities and processes undertaken by the forest industry and other groups or organisations to interact with a ministry's operations (for example, forest industry plan submissions and lobbying efforts by ENGOs).

In part, the various levels of planning, management, monitoring, and decision-making reflect the complexities of analyzing habitat itself. For many vertebrate species, habitat quality is often a stand- and ecosystem-level issue, while habitat quantity and distribution are often landscape level issues. Many species have life requisites that include various types of habitat at different points in their life cycle, sometimes at quite disparate locations and sometimes including both terrestrial and aquatic habitats.

[4] The reader is also referred to substantial existing material that was already compiled to support the Resource Management Planning process. In particular, we refer to Section 2.4: Guideline for the Forest Resources Inventory Component dated June 30, 2000. In this report there are good descriptions of the full range of legislative authorities and business drivers relevant to wildlife, wildlife habitat, biodiversity and ecosystems. Please see http://www.for.gov.bc.ca/cpp/rmp/guidelines/200102/rmp_2_4.pdf for further information.
[5] The examples provided for each level may change significantly in the near- and medium-term as a result of the significant changes underway within government and the forest industry regarding these instruments and processes. They have been kept simply as a (past) familiar point of reference.

**Table 2.1. Relationships between different decision-level scales and issues or decision points, project area sizes, and analysis units (note also footnote 5).**

| Decision Level | Typical Issues or Decision Points | Typical Study Area | Analysis Unit Examples |
|---|---|---|---|
| **Broad Provincial Scale** | Provincial Legislation/ Regulations/ Management Strategy (e.g., FPC Regulations, Identified Wildlife Management Strategy) | Province or major area of province (e.g., coast/interior, species range) (250,000 – 950,000 $km^2$) | Region, BEC Zone, Ecosection, TSA, Landscape Unit (50,000 – 15,000,000 ha) |
| **Regional-Subregional** | Land Use Plans, (e.g., KBLUP-IS), Land and Resource Management Plans (LRMP, TSA) | Forest Region, Forest District, Timber Supply Area (TSA), Species Range (80,000 – 25,000,000 ha) | BEC Variant within Landscape Unit, Landscape Unit, Species Home Range (5,000 –200,000 ha |
| **Landscape-Operational** | Landscape Unit Plans, Regional Species Management Plans | Landscape Unit, Species Range (50,000 – 250,000 ha) | Grouping or individual site series or structural stage of a site series (5-200 ha) |
| **Stand** | Type 2/3 Silviculture Plans, Species/Guild or Stand Structural Component Management Strategies | Management Unit (e.g., TSA, TFL), BEC Variant within Landscape Unit (10,000-750,000 ha) | Structural stage of site series; forest cover type (0.5-200 ha) |

### *2.2.1 Broad Provincial Level*

Provincial level land-use and policy decisions affecting habitat are generally made at the cabinet level, or at least involve one or more ministers from MOF, MSRM, and MWLAP. These decisions often have far-reaching consequences (for example, locations of protected areas; the broad balance between habitat protection measures, risk to the environment, and estimated timber supply). These are decisions made by elected officials, and often involve striking a balance between perceived economic and social benefits that the decision-makers are familiar with, and habitat impacts, of which the decision-makers often have little or no direct knowledge. The decision-makers' sources of information usually consist of advice from senior ministry staff; limited background information in the form of highly condensed briefing notes; and conflicting lobbying from other interested parties. Habitat modeling results may be evaluated by senior ministry staff and influence their advice, or they may inform the cost/benefit analyses of various options.

### *2.2.2 Regional–Subregional Level*

Regional land-use planning (for example, LRMPs) may use habitat modeling to identify species or habitats of special concern. Habitat modeling, both coarse-filter and fine-filter, is also commonly used to evaluate the cost/benefit ratios of various land-use zoning and management regime options during the planning process. In some cases the Identified Wildlife components of the FPC have used habitat modeling to assist in formulating measures required for maintaining species' habitat.

### *2.2.3 Landscape–Operational Level*

Landscape-level planning looks at habitat supply on an area closer to the home ranges of all but the most wide-ranging species. At present, this level of planning is focused on coarse-filter planning related to locations of Old Growth Management Areas (OGMA), patch size, and the distribution of mature forest retention. However, as landscape level planning progresses to individual species management, fine-filter habitat modeling may also be incorporated. Regional and landscape-level planning are probably the areas where habitat modeling will play the most effective role at present.

Moving closer to an operational level, forest industry planners can use habitat modeling to assist with FDP preparation, especially in the absence of detailed habitat guidance from regional or LU level planning. MWLAP personnel, MOF decision-makers and ENGOs may also use habitat modeling information to evaluate proposed plans against approval tests.

### *2.2.4 Stand Level*

With the preparation of habitat-focused Silvicultural Plans at the management unit level, habitat modeling related to stand structural features is also being initiated. Where habitat issues are related to specific stand structures (for example, snags, coarse woody debris, large diameter trees), habitat modeling results can be applied to specific habitat management plans, and eventually to silvicultural prescriptions.

## 2.3 Legislative Authority, Regulations & Responsibilities

The primary legislative authority for habitat management is contained in the following: Forest Practices Code (FPC) of BC Act, FPC Operational Planning Regulations, Forest Act, Ministry of Forests Act, Ministry of Environment Act, Wildlife Act, Fisheries Act (Federal) and the Fish Protection Act[6].

Within the context of the legislation and regulations, the following specific processes may incorporate results of HSM:

- Strategic land use planning (protected areas and broad management zones);
- Establishment of wildlife management zones (for example, ungulate winter ranges, caribou management zones);
- Landscape unit planning (for example, designation of biodiversity emphasis options, old growth management areas);
- TFL, TSA, and IFPA management planning, including timber supply analyses and Sustainable Forest Management Plans;
- Watershed and riparian assessments;
- FDPs;
- Stand and cutblock level planning (preparation of silvicultural prescriptions and harvesting plans);

[6] With the recent restructuring of the provincial government a number of these provincial acts and their associated regulations will be changing.

- Impact assessments of major developments; and
- Effectiveness audits for the purposes of evaluating and reporting on the efficacy of existing legislation, regulations, or policies related to habitat management.

The responsibility for the enforcement of regulations and the implementation of processes related to habitat management is split among a number of government agencies and levels of government. MSRM is responsible for resource inventories (including habitat), land and water use planning and zoning, and environmental impact assessment of major projects. MWLAP is responsible for maintaining the biodiversity of the province, including fish and wildlife habitat and species protection and management; parks and protected areas; flood plain management; and air, land, and water pollution control. MOF is responsible for forest and range management, timber supply analysis, fire protection, forest research and the FPC (the main piece of legislation governing habitat management).

In general, on Crown lands, MSRM makes regional and landscape level decisions regarding land zoning which determine whether habitat will be protected, managed as a high priority, or compromised to meet other social and economic objectives. MWLAP evaluates the impact of past and current legislation, policies, and decisions on biodiversity; manages habitat in protected areas and parks and in areas where habitat is a high priority (for example, Wildlife Management Areas, Wildlife Habitat Areas); and provides input on habitat management in other areas. On forest and rangelands outside parks and designated wildlife areas, the MOF makes decisions regarding ecosystem- and stand-level habitat management (with input from MWLAP and MSRM). On private lands there are few limitations applied to habitat manipulation or destruction; some exceptions include areas on Managed Forest Lands and some critical nesting areas.

## 2.4 Habitat Supply Modeling in BC – Decision-Makers & Modelers

There are two often quite different perspectives and working environments to understand when evaluating the state of HSM in BC: the realities of the decision-maker and the world of technical modelers.

### *2.4.1 Decision-Makers*

The individuals making habitat-related decisions come from a wide range of backgrounds and experiences, and many of them have little or no expertise in species or habitat management, or knowledge of habitat modeling per se. These decision-makers potentially include elected members of the provincial Cabinet's Committee on the Economy and the Environment (CCEE); senior ministry officials (for example, deputy ministers, chief forester); regional and local decision-makers (for example, statutory decision-makers, district managers, designated environment officials); forest industry planners; silviculturalists; skidder operators and fallers; road engineers; and private land owners.

### *2.4.2 Modelers*

Habitat modeling is being completed by a variety of agencies and institutions. These include BC government biologists, analysts, managers, and researchers with MOF, MSRM, and MWALP; forest industry biologists; ENGOs; and university researchers and consultants acting on behalf of government agencies, industry and ENGOs. These groups at present are project focused and lack overall coordination.

It is estimated that about 40 percent of the modeling being undertaken is being done by consultants working on contract with government agencies or the forest industry. About five percent is being done by staff biologists in government or industry, with another 30 percent being conducted by researchers affiliated with universities, typically funded by government and industry. Approximately 20 percent of the modeling effort is being contributed by government researchers. Lastly, around five percent of modeling work is being provided by consultants funded through ENGOs.

# 3 Decision Types, Desired Model Features and Evaluation Framework

In the past, most modeling approaches have been developed to address a particular set of issues or decisions. When new issues or decisions arise, existing models are adapted to fill the new set of needs, or a new model is developed to suit those needs. There has been no attempt, to our knowledge, to develop a general classification of the various types of decisions or issues that benefit from HSM. Although there are classification systems for models or modeling approaches, they are based mainly on technical criteria rather than on their ability to inform specific types of decisions.

In this section, we first present a classification system for the different types of decisions that will benefit from habitat supply models. The classification is based on the scope and degree of habitat specificity required. We then discuss some of the trade-offs involved in model design and application. It is important to understand these trade-offs and features when evaluating the suitability of a modeling approach for a particular set of decision needs. With this as context, Section 3.3 provides a framework for model characterization and evaluation that allows for the matching of various modeling approaches to specific Decision Types. When used with a proposed model registry, the preferred functional capabilities and "performance levels" of the framework can be used by resource managers and decision-makers to help determine what modeling approaches will best serve their needs.

## 3.1 Classification and Characterization of Habitat Supply Decision Types

Approaches to providing habitat supply information to assist decision-making can generally be classed into two broad groups: *coarse-filter* and *fine-filter*. Where general habitat information is sufficient for decision-making, or where knowledge of species–habitat relationships, inventory data, and/or assessment resources are limited, a coarse-filter, or biodiversity-indicator-type approach, is often used. Where assessments are required to inform decisions regarding individual species at risk or featured species, a fine-filter approach is usually employed. Table 3.1 identifies three decision types that would benefit from HSM for each of the two broad approaches.

To fulfil the full range of potential coarse-filter Decision Types (A, B, and C), modeling approaches are required to address issues of quality and quantity of habitat or indicators of biodiversity at three scales — landscape, ecosystem, and stand.

For the coarse-filter Decision Types the supporting models may be quite simple, in that the predicted quality and quantity of a relatively few key indicators are required. The models for these indicators are often directly "attached" to the Disturbance Scheduler and Stand & Forest Estate Prediction Model component of Figure 1.2. This has contributed to the perception that habitat supply models are simply extensions of harvest schedule and growth engines, rather than legitimate separate models in their own right. It is important to note that, even for simple models that support Decision Types A, B, and C, an implicit (preferably explicit) set of relationships provide the rationale for why a particular factor (for example, patch size or number of snags) is used as an indicator or surrogate for biodiversity in a coarse-filter approach. It is important that the indicator selected to represent biodiversity is chosen because it is the best indicator rather than only because the Disturbance Scheduler and Stand & Forest Estate Prediction Model — i.e., the model — can predict it as an aspect of future forest conditions. When using indicators of biodiversity, the ecosystem–species relationships are of great importance, since relatively few indicators will be used to predict this level of habitat supply.

Within the fine-filter Decision Types, managers may require modeling approaches that either predict the supply of habitat to provide a specific life requisite for a single species or a species guild (for example, winter range in Decision Type D). Alternatively decision-makers may require models that predict the complete suite of habitats required to provide all or most of the life requisites for single species/population (often a species at risk or of special management concern).

In the cases requiring most or all life requisites for a single species, a further breakdown of Decision Types and their supporting models can be made, based on the size of the area that must be considered as "home range" (or geographic/ecological range for plant species). For some species, this area can be very large (for example, Decision Type E in the case of grizzly bears); however, the resolution requirements of the models that support Decision Type E may also be quite high, since site or stand-level habitat features must often be identified within that large home range. In addition, these models may need the capability to evaluate the juxtaposition of life requisites to determine availability of stand-level features within forests or landscapes of specified characteristics (for example, nest trees within areas suitable for foraging). Decisions regarding species with small ranges or home ranges (Decision Type F) often require models that can assess the quality and quantity of individual stand elements (for example, individual trees or stand structural components). These models must consequently be capable of detailed analysis of relevant study areas. For Decision Types D, E, and F the supporting models are often based on more complex species–habitat relationships and therefore more closely fit the graphic presented in Figure 1.2.

As with any simple classification, there will be some situations that may not easily fit into a single slot. There will also be more complex problems featuring multiple issues that require simultaneous investigation of habitat supply in two or more of the Decision Type classes (for example, seral stage distribution targets for an area including ungulate winter range, Decision Types A and D). It should also be pointed out that any of the Decision Types can be considered at a range of decision-making levels (see Figure 3.1 and Section 2.2). For example, stand-level habitat modeling (Decision Type C) or single-species habitat modeling for downy woodpeckers (Decision Type E) can be used to inform provincial level policy decisions regarding wildlife tree targets. In contrast, landscape-level habitat modeling for patch size distribution (Decision Type C) could be used to inform operational-level decision-making regarding cutblock layout.

**Table 3.1 Classification of Decision Types.**

| Filter | | Decision Type | Issues | Scope | Examples |
|---|---|---|---|---|---|
| COARSE | A | **Landscape Level Habitat**<br>Provision of habitat at the landscape level | Availability of landscape level habitat elements or conditions; presence or value of biodiversity indicators | Any landscape level habitat parameter | Seral stage, patch size distribution, connectivity |
| | B | **Ecosystem Level Habitat**<br>Provision of habitat at the ecosystem level | Availability of ecosystem level habitat elements or conditions; presence or value of biodiversity indicators | Variable, depending on type of ecosystem and habitat element | Ecosystem / plant community, OGMA representation, other site series / structural stage combinations, rare ecosystems |
| | C | **Stand Level Habitat**<br>Provision of habitat at the stand level | Availability of stand level habitat elements or habitat conditions | Variable, depending on type of feature and level of issue or decision | Various elements of stand structure, e.g., hollow logs, large diameter trees, wildlife trees |
| FINE | D | **Single Species—Guild Specific Life Requisite**<br>Provision of habitat to meet a specific life requisite of a single species or guild | Availability of a specific habitat element in a suitable condition, sufficient quantity and effective distribution | Specific life requisite at the landscape, ecosystem or stand level | Suitable nesting trees/snags for cavity nesters, mule deer winter range |
| | E | **Single Species Large Area Home Range, All/Most Life Requisites**<br>Provision of habitat to meet all or most of the life requisites of a species with a large home range or extensive range | Availability of suitable habitat elements in sufficient quantity and effective distribution | All / most life requisites | Woodland caribou, grizzly bear, whitebark pine |
| | F | **Single Species Small Area Home Range, All/Most Life Requisites**<br>Provision of habitat to meet all or most of the life requisites of a species with a small home range or limited range | Availability of suitable habitat elements in sufficient quantity and effective distribution | All / most life requisites | Woodpecker spp., bat spp., rodents, rare plant, lichen, moss or fungi spp. |

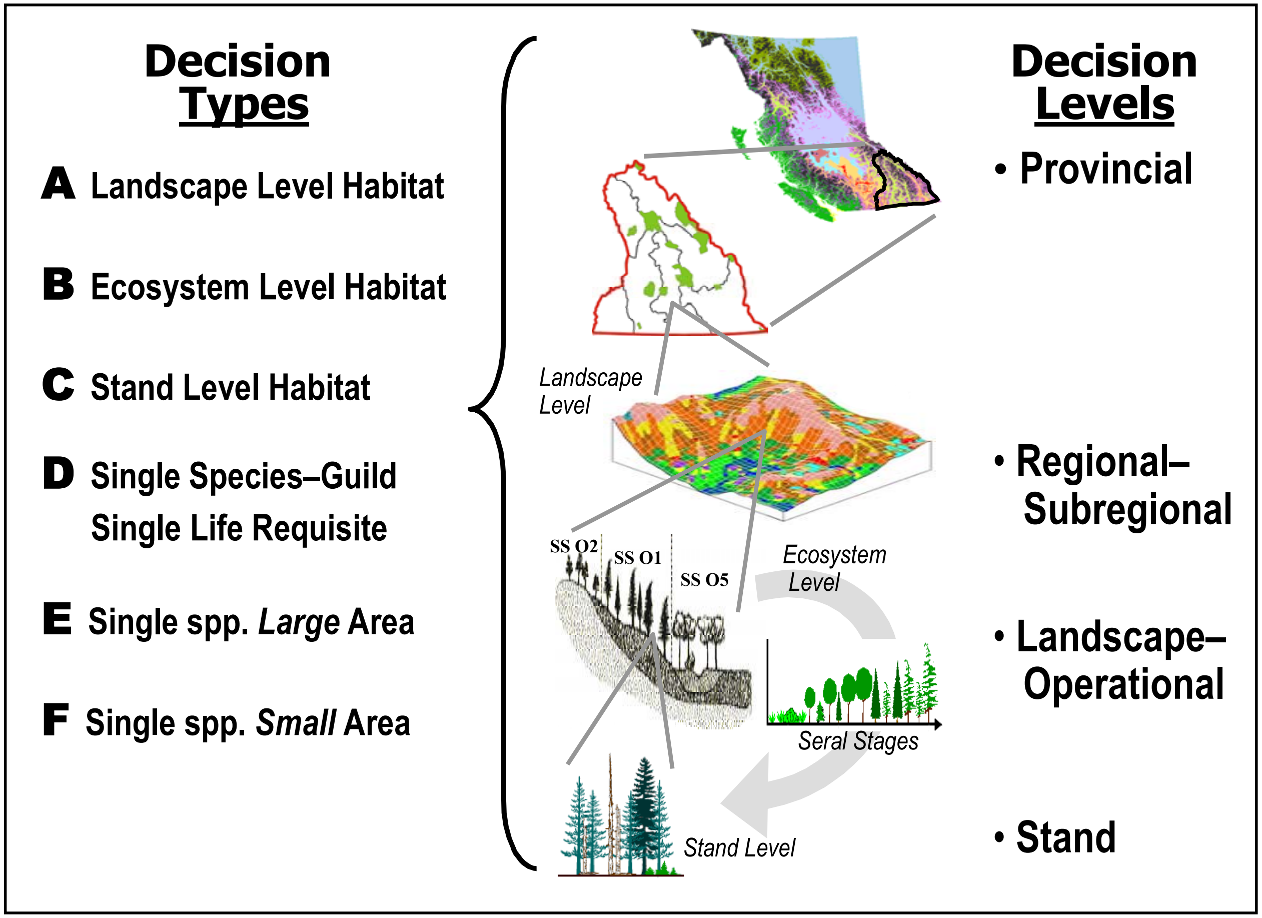


**Figure 3.1. The six Decision Types (left side) apply to habitat supply questions that arise across various scales of forest planning and management (right side). Decisions related to those questions are also made at various levels within the forest and land management administrative framework.**

## 3.2 Trade-Offs of Model Emphasis

All models are simplifications of reality. Habitat supply models attempt to capture the key relationships that are thought to be most influential in predicting habitat value. Despite the enormous increase in computational power, modelers still face decisions regarding the design characteristics of the model they will build (Levins 1966, Baskerville 1993). Modelers simplify reality in ways that aim to preserve the essential features of the problem being addressed and the desired solution. It would be ideal to develop models that maximize the generality of the application, realism and precision; however, this has not been practical to date, and tradeoffs between these critieria are always required. These tradeoffs are summarized as follows:

1. **Sacrifice generality in favour of realism and precision.** Precise measures are derived numerically from species–habitat relationship data for a particular case or area resulting in precise, testable predictions that are probably only applicable for the area for which data is available.
2. **Sacrifice realism in favour of generality and precision.** Set up general equations or relationships that are built upon general theory and that produce precise results. This approach sacrifices biological realism with the assumption that deviations from realism will result in small deviations in the conclusions. Furthermore, where evidence indicates that nature does depart from theory, further realistic "complications" can be included as the need arises.
3. **Sacrifice precision in favour of realism and generality.** Here the focus is on realistic relationships in order to determine qualitatively different types of results, and incorporate experience and opinion in a model that is robust. The realistic relationship may be poorly quantified due to a lack of area-specific data.

## 3.3 A Model Evaluation Framework

In order to compare and contrast models and modeling approaches that fulfill the requirements of the six Decision Types, a set of functional capabilities was constructed. Models that address certain issues, or are applied to inform certain decisions, must have capabilities relevant to the dimensions of the decision requirement. A large number of functional capabilities could have been used; however, the goal was to limit the list of capabilities to those that are most useful in characterizing and differentiating the modeling needs of the six Decision Types. This functional capability "checklist" can then serve as a means to compare different modeling approaches based on their ability to fulfill the requirements for each Decision Type.

These functional capabilities fall into four main categories:

- The ability to use spatial information (spatiality, proximity, and nested spatial information at different scales);
- Resolution and size of area that can be analyzed;
- The ability to accommodate user-defined input; and
- The ability to incorporate, or easily link to, population predictions.

In addition, although models that provide a snapshot of habitat availability at a single point in time may be useful for certain applications, in most cases the ability to predict habitat supply and availability over time is now considered an essential capability of habitat supply models. Other criteria can be used to further differentiate, define, describe, and characterize habitat supply models, and a number of these were used to describe the range of existing modeling approaches presented in Section 5 and Appendices B and C.

Table 3.2 provides a framework to evaluate habitat supply models in relation to the six Decision Types and seven important model functional capabilities. Within each cell of Table 3.2, a preferred level of performance is provided for each functional capability–Decision Type combination. The performance classes within Table 3.2 are defined below.

### *3.3.1 Example Use of Evaluation Framework*

The following example illustrates how the framework can be employed to evaluate and select various habitat modeling options available to a manager.

A forest manager is faced with making a decision regarding management of habitat for woodland caribou. Where time and resources are severely limited, the manager may choose to use a coarse-filter indicator approach to assessing the potential risk associated with various management options. He/she could decide to model the amount of old and mature forest projected to be present within the caribou habitat portion of the management unit (Decision Type A). If there is sufficient knowledge of habitat relationships and inventory information available to assess presence of old and mature on specific sites, the manager may choose an ecosystem-level modeling approach (Decision Type B). If partial cutting is being considered in order to encourage arboreal lichen production, stand-level modeling maybe appropriate (Decision Type C). However, if there are sufficient time and resources available for a more targeted approach, the manager may wish to consider a single-species model that looks at all life requisites for woodland caribou (Decision Type E).

Table 3.2 can be used by the manager to identify which model functional characteristics will be required to implement a habitat modeling project for each of the various Decision Types. Once a decision type is selected, Table 5.1 and Appendix C can assist in identifying modeling approaches that will potentially meet the project's needs. Alternatively Appendix C, Table 3.2, and Table 5.1 can be used to evaluate a model that has been proposed for a specific decision-type.

### *3.3.2 Spatiality*

Spatiality refers to the model's capability to explicitly use spatial information about habitat features — i.e., information that is typically geo-referenced within a GIS database. Two classes are defined, as follows:

**Often Desirable:** Spatial representation information for the analysis units may be required for specific species, stand, ecosystem, or landscape features.

**Mandatory:** Spatial representation information for the analysis units is essential and central to these kinds of analysis approaches. For example, the analyses may require information on where a particular condition occurs in relation to other conditions in a neighbourhood around a point-, line-, polygon-, or raster-based entity.

### *3.3.3 Resolution of Ecosystem Classification Input*

The resolution of the ecosystem information that the model is able to receive as input to interpret habitat features is an important consideration. Since BEC classes, rather than continuous information, are the standard in BC, we have used BEC to assess this functionality. Three classes are defined as follows:

**High:** Site series and usually structural stage information.

**Medium:** Groups of site series to BEC Variant level and occasionally structural/seral stage information.

**Low:** BEC Variant to Zone and/or Ecosection.

### *3.3.4 Size of Area that Can be Assessed*

The size of area that a model can handle can affect what kinds of Decision Types it can address. Sometimes this limitation is related to the computational power that the model is able to take advantage of. Note that it is assumed that the resolution of the model is set to evaluate the appropriate level of detail for the species/ecosystem component of interest, and that the whole area is analyzed at this resolution. Three classes are defined as follows.

**Small:** Typically less than 5,000 ha.

**Medium:** Typical landscape unit areas ranging from approximately 20,000 – 100,000 ha.

**Large:** Multiple landscape units ranging from approximately 100,000 – 1,000,000 ha.

### *3.3.5 Ability to Evaluate Multiple Scale Life Requisite/ Habitats & their Nested Spatial Relations*

For species that have overlapping habitat requirements at multiple scales, it is desirable to be able to analyze species–habitat relationships at a variety of scales simultaneously within the model (for example, a nesting habitat area embedded in a feeding habitat area). Three classes are defined as follows.

**Highly Desirable:** In most cases, the ability to analyze multiple scales and nested habitats will be a desired feature of this type of habitat supply model.

**Often Desirable:** Analysis of multiple scales and nested analysis may be desired; however, there are some cases when this capability would not be required.

**Not Required:** Analysis of multiple scales and nested analysis would not be a component of this type of habitat supply model.

**Table 3.2 Desired habitat supply model functional capabilities in relation to model Decision Types.**

| | MANAGEMENT ISSUES – DECISION TYPES | | | | | |
|---|---|---|---|---|---|---|
| | COARSE–FILTER | | | FINE–FILTER | | |
| | **A** Landscape Level Habitat | **B** Ecosystem Level Habitat | **C** Stand Level Habitat | **D** Single Species – Guild Specific Life Requisite | **E*** Single Species – *Large* Area Home Range– All/Most Life Requisites | **F*** Single Species – *Small* Area Home Range – All/Most Life Requisites |
| **DESIRED MODEL CHARACTERISTICS:** | General Application | Reasonably Precise; General Application | Reasonably Precise; Functional Realism | Reasonably Precise; General Application | Functional Realism; General Application | Reasonably Precise; Functional Realism |
| **FUNCTIONAL CAPABILITIES: ⇓** | | | | | | |
| **1. Spatiality** | Often Desirable | Often Desirable | Often Desirable | Often Desirable | Mandatory | Mandatory |
| **2. Resolution of ecosystem classification input** | Low | High (Medium) | High-Medium | High | High | High |
| **3. Size of area that can be assessed** | Large(Medium) | Small-Large | Small (Large) | Large (Small) | Large | Small |
| **4. Ability to evaluate multiple scale life requisite/ habitats & their nested spatial relations** | Not Required | Not Required | Not Required | Often Desirable | Highly Desirable | Highly Desirable |
| **5. Ability to incorporate user defined species – habitat relationships** | Usually Not Required | Usually Not Required | Usually Not Required | Highly Desirable | Highly Desirable | Highly Desirable |
| **6. Ability to interpret proximity information** | Often Desirable | Usually Not Required | Usually Not Required | Often Desirable | Highly Desirable | Highly Desirable |
| **7. Population response prediction** | Not Required | Not Required | Not Required | Usually Not Required | Highly Desirable | Highly Desirable |

* 'E' and 'F' may include predator-prey relationship components. Note that it is desirable that all models forecast future conditions.

### 3.3.6 Ability to Incorporate User-Defined Species–Habitat Relationships

It is sometimes desirable to have the ability to incorporate user-defined species–habitat relationships into the model. In other cases, the model can be run using standard relationships for the particular habitat component of interest. Two classes are defined as follows:

**Highly Desirable:** In most cases, user-definable relationships will be a desired component of this type of habitat supply model.

**Usually Not Required:** In most cases, standard rather than user-definable relationships would be sufficient for this type of habitat supply model.

### 3.3.7 Ability to Interpret Proximity Information:

For some decision needs it is desirable to be able to conduct proximity analysis as a key component of the modeling approach. Three classes are defined as follows:

**Highly Desirable:** In most cases, proximity analysis will be a component of this type of habitat supply model.

**Often Desirable:** Proximity analysis may be used; however, there are some known cases where it would not be required.

**Usually Not Required:** In most cases proximity analysis would not be a component of this type of habitat supply model.

### 3.3.8 Population Response Prediction:

For some decision needs, a population response prediction is desirable as a component of the output from the habitat supply model. Three classes are defined as follows:

**Highly Desirable:** Since the underlying issue is probably the potential impacts of habitat change on population level, a population response is desirable. Ideally, the model predicts population parameters based on habitat supply. Alternatively, model output can be linked to population levels or a population model.

**Usually Not Required:** Because only single life requisites are evaluated and the link between this factor and any particular population is difficult to establish, a population response is usually not required.

**Not Required:** Because the habitat components are the factor of interest, a population response is not required.

# 4 State of Modeling: Resource Professional Perspectives

To set the stage for developing a habitat modeling strategy, resource professionals from MOF, MWLAP and MSRM were interviewed. The majority of personnel interviewed fell into three groups: those responsible for making recommendations relating to habitat supply; statutory decision-makers (SDM); and designated environment officials. Examples included forest ecosystem specialists; regional managers with MWLAP; district managers with MOF; and LRMP project managers. A smaller number of individuals with roles to oversee development of strategic direction or related expertise were also interviewed. In total, 28 individuals were interviewed (for details, please see Appendix A).

In preparation for the interview process, the study team developed a general template for guiding both the interview discussions and our own thinking on the topic of current barriers to the use and incorporation of HSM information in the decision-making processes. Figure 4.1 outlines some of these key barrier points in the form of a schematic. While the interviews did not address all of these envisioned barrier points, the figure is included to provide additional context for this section.

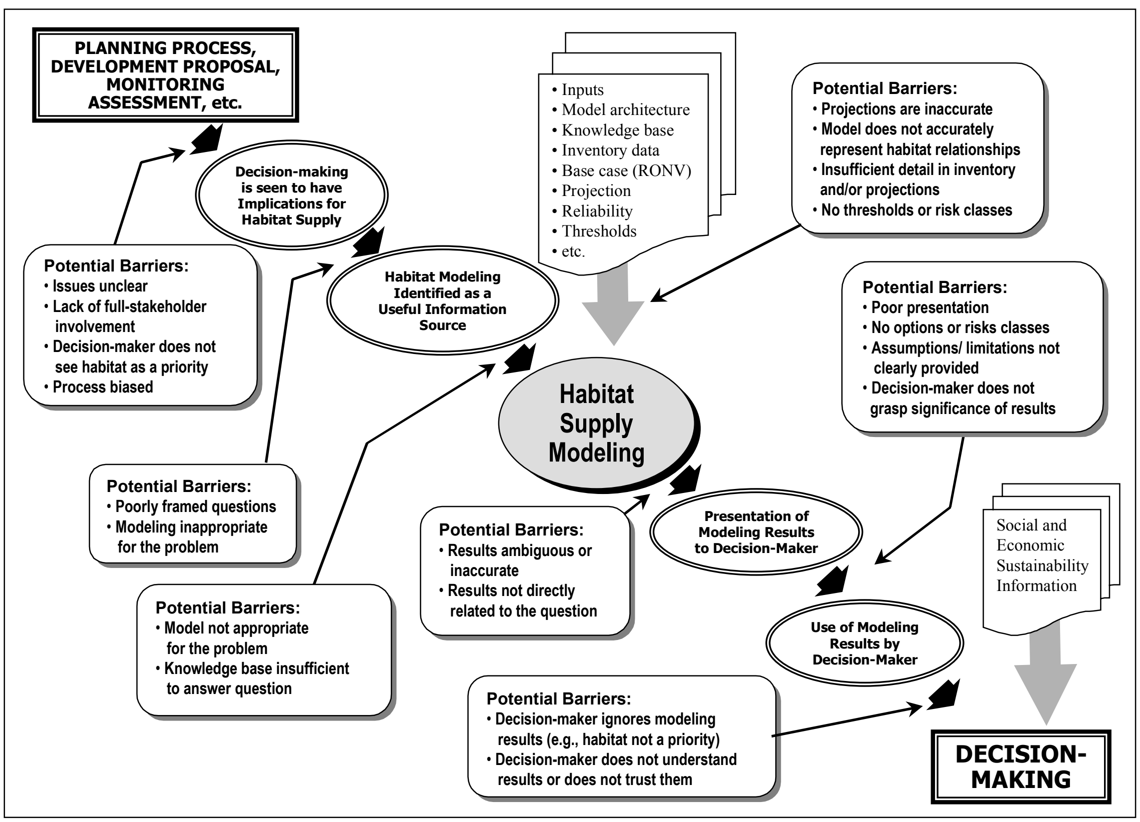


**Figure 4.1 Key barriers to the effective use of habitat modeling that may arise in a decision-making process (developed by consulting team).**

## 4.1 Setting the Stage for Discussions

Based on individual experience, the interviews were designed to identify the following:

- Decision areas of key concern that require or would benefit from HSM;
- Current availability and veracity of information from habitat supply models;
- Barriers to improving available habitat supply information;
- Current success of using HSM as a decision support tool; and
- Barriers to more efficient use of habitat supply information in decision support.

The tenor of the questions was modified to reflect the responsibilities of the person being interviewed, whether a decision-maker, advisor to a decision-maker, or a senior manager in government. Since many respondents had not used complex, forecasting habitat supply models, a fairly broad definition was used to set the bounds of the interview. This broad definition of habitat supply models included maps of habitat capability/suitability or ecosystem values through to species population models. People were encouraged to speak about their previous experience, but also to comment on potential implications arising from future government direction.

Most interviews began with a short discussion of what constitutes HSM. Many respondents were fairly unfamiliar with this term, although they often work with rudimentary habitat supply models. One respondent stated that most practitioners have "habitat supply models in their heads and use them all the time to input into decision-making." Forest development plans may be based on informal knowledge of habitat values for individual or multiple species. Similarly, many planning processes have included experts presenting information on the benefits and constraints of different scenarios on a particular value. These workshop processes have been used to formulate management frameworks for many species, but the effectiveness or robustness of assumptions has rarely been tested. These processes also tend to be temporally static, considering only the present time-frame. In this regard, most people spoke about non-forecasting models.

## 4.2 Application to Land Use Decision-Making

The BC land-use decision-making framework is outlined in Section 2 of this document. Within this framework, respondents were asked to identify the land-use decision-making activities that would benefit most from HSM.

### *4.2.1 All Land-Use Decisions Need Habitat Supply Information*

The vast majority of respondents consistently reported that the day-to-day activities of their job required or would benefit from HSM information. This was particularly the case for forest ecosystem specialists. Regional managers and district managers generally felt that all decisions pertinent to land use required or would benefit from more formalized habitat supply information.

HSM was identified as a tool with the potential to reduce land-use conflict by more explicitly addressing environmental values at a strategic level. It was noted that a number of strategic planning processes are failing because there is insufficient buy-in to the "plan" even after extensive public processes. In these cases, a more explicit assessment of impacts and gains to the environment would clarify the extent to which values are being adequately managed. This would either provide more certainty or would identify needed changes. Almost all respondents stressed an urgent need for improved habitat supply information, and felt opportunities were continually lost as a result of a lack of technical capability.

### 4.2.2 Priorities for Habitat Supply Information

In general, responses indicated that HSM tools should be applied to inform all planning decisions higher than those at the cutblock or stand level; that is, above silviculture prescriptions. The following planning, management, decision, and monitoring levels were highlighted as key areas that require or could benefit from HSM information.

**Forest Development Plans**

Many respondents noted that in order to meaningfully evaluate Forest Development Plan (FDP) proposals, both coarse and fine-filter habitat values need to be assessed, and that HSM at this level would be useful. Without this information, the appropriateness of block location and the silviculture prescriptions cannot be evaluated. Most respondents felt that a strategic assessment at the FDP level could inform decisions down through to stand level prescriptions, and that a strategic tool was needed to move away from block-by-block decision-making. Both SDMs and MWLAP staff expressed a strong need for this, although for slightly different reasons. The SDMs need this capability to streamline decision-making, while the MWLAP staff feel it would help deal with their lack of resources to review blocks individually.

**Landscape-level planning**

Generic landscape-level planning is incorporated within a suite of regulations, including the LU Planning Guide, Higher Level Plan Orders, and LRMPs. The specific requirements for incorporation of habitat information differs in each case. These planning frameworks are generally focused on coarse-filter strategies for maintaining biodiversity, although individual species are identified as coarse-filter/landscape level species, and are managed through budgets identified in these planning frameworks.

For example, the LU Planning Guide requires identification of old seral forest to meet targets, the objective being to "maximize the biodiversity gain" within the constraints set. A number of respondents identified a need to assess the relative benefits available from competing "suites" of potential Old Growth Management Areas for general coarse-filter biodiversity considerations, or for individual species interpretations managed under higherlevel plans. Similarly, existing land use plans identify strategies for maintaining single species like mountain caribou and marbled murrelet. Practitioners identified the need for HSM to inform effective on-the-ground implementation of these strategies.

**Development of LRMPs**

In areas where LRMPs are under development, HSM was identified as a key tool for assessing and reporting on the potential implications to environmental values of alternative strategic land use scenarios. Presentation of scientific information to the public was seen by all respondents as being key to a successful and informed process. SDMs are highly supportive of strategic planning initiatives that explicitly address habitat supply questions, because they take difficult decisions to the realm of a more in-depth public and accountable process. They also feel that habitat supply analysis may improve public acceptance of decisions by more explicitly dealing with these issues. However, concerns were raised regarding the new streamlined timelines for LRMPs with the new government, and whether these would be conducive to incorporating the necessary scientific modeling processes.

**Timber Supply Analysis**

A number of respondents viewed providing the opportunity to review potential implications of timber supply decisions on environmental values as an important phase in understanding implications of land-use decisions. The formal Timber Supply Review process currently allows a limited opportunity to present such information.

**Policy and Prescription Development and Monitoring**

The need to test the effectiveness of policies was also highlighted by many respondents. Some BC biodiversity policies include constraints based on reducing timber supply impacts, but they do not include an evaluation of the policies' effectiveness in maintaining or restoring environmental values. In order to use adaptive management effectively, the effectiveness of policies must be continually evaluated. The challenge of developing and using bona fide adaptive management mechanisms to incorporate new information as it arises was a large concern for many.

The need to provide information that informs the public was also raised. It was suggested that because of further funding and staff cuts, MWLAP's future role will be that of an information broker. HSM information, including its proper dissemination, may be a key element in the future for monitoring the status and potential impacts of policies on the environment.

### *4.2.3 Implications of Future Government Direction Uncertain*

Many respondents raised the issue of the uncertain effects of the new government mandate and the changes to regulatory frameworks currently underway on habitat-related decision-making. A fairly large percentage of individuals (approximately 25 percent) had recently changed ministries and were unsure of their future roles and responsibilities. Although wary of commenting on a future unknown framework, some individuals commented on the potential implications arising from possible future regulatory scenarios. Assuming a more streamlined government and streamlined processes for land use planning, many respondents emphasized the growing future need for strategic and operational planning tools to improve the scientific understanding of the implications of land use decisions for the environment. But again, the implications of reduced timelines and reduced resources in strategic planning processes raised key questions as to the feasibility of incorporating improved habitat supply information.

## 4.3 Model Availability and Veracity

### *4.3.1 Modeling Experience and Familiarity*

A small number of individuals had no experience with habitat supply models and were therefore unaware of the potential uses for such models. Although they expressed a desire for better information regarding habitat, they had not been sufficiently exposed to models to provide further commentary.

The majority of respondents expressed a general familiarity with habitat supply models but had little or no direct experience in their use. Many respondents commented that the extent of their practical familiarity with habitat supply information was limited to "values" maps for individual species or for coarse-filter biodiversity values, and that usually these maps and reports did not include a forecasting component. Examples of these include static values maps such as Forest Ecosystem Network maps, or map overlays of estimated habitat values for individual species. Some respondents were familiar with individual habitat supply models. Usually these were either a formal model relating to habitat use by a large mammal (for example, suitability/capability models rather than population models for grizzly bear, mountain caribou, or ungulates) or familiarity with the newly-developed ecosystem monitoring models that compare current and future landscapes to benchmark values.

In most cases, the agency person had been involved with a provincial expert or consultant who had produced a report for an individual species for their area. Frustration was expressed that often a model was developed, used to run single scenarios, and then the expertise was no longer available to continue to use that information throughout the longer time-period associated with decision-making.

Often, those who had used models in decision-making processes raised concerns that the models were inadequate for the task. One example was grizzly bear models developed in one region of the province being applied in other locales. Although building on the work of others is clearly necessary in developing approaches, it was felt universally that the inability to incorporate local variation was extremely detrimental in garnering support. This also made it difficult to improve the veracity of the models. On the positive side, there were a number of supportive comments for Habitat Branch's (MWLAP) new approaches to providing descriptive and easy-to-use effectiveness monitoring frameworks for landscape units.

SDMs expressed frustration that they, or the staff providing recommendations to them, were presented with reports that were too general in nature and provided information could not be fed directly into the decision-making process. General habitat supply information tended to be used as background or supporting information, but could not easily be weighed as the planning state changed (i.e., there was little or no hands-on assessment of scenarios). It was noted that although processes such as IFPAs were specifically developed to feed into decision support, results were either not yet available, or there was skepticism whether project outcomes would include useful decision support tools.

A number of staff, particularly Forest Ecosystem Specialists, stated that they had requested technical help through their agency on questions relating to habitat supply because they felt they had inadequate information to make decisions or recommendations. Although they had received support, they felt there were only limited tools and frameworks available for their use[7]. It was noted that documents such as the (former) MELP Environmental Risk Assessment document provide useful support for those looking for a new and more effective way to present information. However, practitioners often felt unable to link this approach to predictive scenario ranking, thereby reducing its utility. Additionally, the lack of knowledge around indicator relationships, thresholds, and devising risk categories restricts this otherwise useful interpretive capability.

### *4.3.2 Perceived Barriers to Model Availability*

A common statement from all those interviewed was that there are no absolute barriers to the increased development and use of habitat supply information. For example, in the past, funding, focus, and having a clear business driver resulted in the development and acceptance of the present timber supply modeling methodology. The view is that a focused effort and committed

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[7] A tool has recently been developed by MWLAP that assesses environmental effectiveness relating to landscape unit planning. A number of respondents were familiar with this and were positive about its becoming available for use by staff. Few specific comments were available because the tool is still being assessed in these early stages of its development. However, there was clear support for such a tool that was easily-to-use and that provided a common framework for presenting output to decision-makers.

resources could result in an equally robust and accepted HSM capability. However, concerns were raised about the feasibility of achieving this goal today, given the clear message from government of increasingly reduced resources over the next three years.

Perceived near-term barriers are presented in the section below regarding issues related to inventory information, habitat–species relationship knowledge, spatial functionality, capacity, consolidation of information and experience, identification of focal species and ecosystem components (indicators), documentation, extension, and the transferability of models.

#### Biophysical Inventory Availability and Succession Knowledge

Many respondents identified the lack of data suitable for modeling habitat supply to be a key area of failure. Increased availability of Terrestrial Ecosystem Mapping (TEM) and Predictive Ecosystem Mapping (PEM) was seen as a substantive improvement of the biophysical base data. However, many people also noted that other limitations remain, particularly regarding successional knowledge and the inability to model these units through time. The inability to obtain recent updates of forest cover and related data from industry was also seen as a barrier. Moreover, the lack of mapped information for parks and non-Crown land, especially where private land constitutes a large percentage of the land base, represents an additional information block for effective HSM.

#### Habitat–Species Relationships

The identification of the relationships between habitat, ecosystems, and species was noted as a key area of failure. For some, developing the ability to adequately calibrate existing models with this relationship information was suggested to be more important than actual model development. Interviewees noted that the lack of development in this area is not surprising, given the inherent complexity involved in modeling habitat supply in contrast to modeling timber supply.

#### Consolidation of Information, Focal Species and Ecosystem Components

Many respondents identified a tendency to think very little is known about many species and ecosystems, when in fact there is a large volume of information available from reports and projects. The problem is that much of it has not been consolidated into a useable form to support HSM. There are a number of "species summaries" for the province; however, the level of detail required for HSM is much finer than is generally available. Identifying focal indicators and compiling useable summaries would be helpful. Regional data-sharing networks may also provide an opportunity to address these needs in the context of higher-level planning, operational planning, and adaptive management monitoring and reporting.

Identifying key species or coarse-filter indicators and developing modeling methods with appropriate thresholds was suggested as an important strategy. First, it would reduce the challenge of seemingly having to "divide the pie into many small pieces." Second, it would help to reduce the size of the task of gathering all the appropriate information (for example, species-specific) and designing the associated tools and models.

Interestingly, it was noted that timber supply analyses often use inventory and growth and yield information that is untested, has variable reliability, and known false assumptions. These realities nonetheless do not seem to halt its application. In fact, the Timber Supply Review seems to provide many with a level of comfort that the protocol is sufficient and that there will be opportunities for future reviews using updated information.

### Spatial Functionality

A number of respondents identified problems associated with using HSM approaches that are based on "pseudo-spatial" output from the most commonly used disturbance scheduling and recovery forecasting models. Although strides have been taken recently to improve the "spatiality" of timber supply models, even the most advanced may be inadequate to realistically model spatial and temporal location of habitat for many species. Progress is being made in an attempt to solve some of these computational issues (for example, through Timber Supply Branch projects and elsewhere in the private sector).

### Technical Capacity to Develop, Calibrate and Interpret Models

While some habitat supply analysis tools exist, several people expressed frustration that there is only a handful of people who have the knowledge to use them effectively. The lack of available expertise to recalibrate, let alone develop new habitat supply models, is a key barrier to the broader application of models. In addition, there is a lack of capacity to understand or interpret habitat supply information within various public groups involved in land-use planning processes.

### Poor Documentation, Little Coordinated Development, Poor Transferability

Many different groups of professionals in the province are working on similar types of habitat supply decision needs with people trying to solve common technical problems. However, it was clear from the interviews that relatively little communication occurs between these various groups. District staff, typically with large workloads, tend to not have the time to document progress (or failure) in written form so it can be shared. Problem solving experience is therefore not able to be shared effectively. In fact, it would seem that a lot of the work to date has failed to properly document the methods and assumptions used with these analyses. This reduces the opportunity to share experience and results in poor credibility. In the same vein, the lack of a standard approach even for key species such as grizzly bear leads to continual redevelopment of methods already developed elsewhere.

It was also noted that the available habitat supply models are not easily transferred between different regions of the province. Designing models with well-developed user interfaces that allow the user to change key parameters without having to re-code the model would improve potential transferability.

To address some of these barriers, a forum for information sharing was suggested. It could consist of a webpage designed to increase awareness of the potential of habitat supply models, and provide real-world examples of their use and standard templates for complete documentation of the model features and related assumptions and limitations.

### Extension

Most people identified the need for increased extension and continuing education opportunities in order to bring together HSM practitioners and resource managers. Such opportunities help improve communications, transfer knowledge, and promote understanding about HSM and its interpretation to support decision-making. Some positive examples were noted of where this has occurred, such as the Habitat Supply Decision Support Workshop held in Richmond (February-March 2001; see also Section 5.3) and activities around the MOF's "Strategic Silviculture Planning Initiatives in British Columbia" which acknowledge habitat supply as a key component.

## 4.4 Current Decision-Making — "Expert Opinion" Prevails

The overwhelming response to the question "How is habitat supply information currently incorporated into decision-making?" was that information is largely unavailable in an appropriate format, and is therefore poorly incorporated into decision-making. Furthermore, where habitat supply information was available, staff (usually MWLAP) were often unsatisfied with the way it was incorporated into decision-making.

In lieu of formalized habitat supply information processes, use of expert opinion is the predominant method by which habitat supply perspectives are currently incorporated into decision-making. It was noted by decision-makers that expert statements are often presented in a form similar to the following:

> **We think there are negative impacts for species *y* associated with action *x***
>
> or
>
> **All of this area is habitat of species *z***

This format raised a number of concerns for SDMs. First, information presented in this way is difficult to incorporate into decision-making because it is not quantified. Second, it does not present the decision-maker with options or scenarios from which to choose. Finally, there are also clear gulfs in understanding or perspective between biologists and decision-makers regarding, for example, the likelihood that certain populations require all remaining habitat to have a reasonable probability of being maintained. Some SDMs believe that advising biologists tend to request the optimum scenario for the species–habitat of concern. Contrary to this view is the comment from biologists who feel environmental values are already compromised prior to starting the negotiation. Some biologists feel, therefore, that they are virtually always advancing their case by starting with less than optimal habitat conditions.

The major concern with the use of expert opinion was the predominance of contradictory expert opinions presented by government, industry, and consulting biologists. Many SDMs commented that these contradictory situations typically result in the least qualified person, the SDM, making the decision. The use of a formalized modeling processes, where assumptions and relationships are explicitly identified, was seen clearly as the preferred approach to addressing this problem.

## 4.5 Barriers to Incorporating Modeling into Decision-Making

The following were identified as barriers to incorporating HSM integrally into decision-making processes.

### *4.5.1 Information Adequacy vs. "Best Available"*

There was universal agreement that the assessment of habitat supply for current and future scenarios is inadequate. However, SDMs noted that if information is the "best available," then it is used for the decision. This is, of course, different from "this is as good as it can be."

### 4.5.2 Lack of an Enabling Legislative Framework, Recognized Protocol & Corporate Vision

Currently, there is no standard or formal methodology for accounting and reporting on the state and quality of habitat supply throughout the province. Several people noted that there is no legislative mandate to report on the state of habitat or impacts to habitat under the current Timber Supply Review (TSR) process enabled through the Forest Act. There is nothing in legislation that mandates government or industry to report on sustainability of habitat. Establishing a legal mandate to undertake regular periodic analysis and reviews of habitat would go a long way to addressing this shortfall. Examples might include the requirement to produce *State of Habitat Supply Reports* throughout the province or a revision of the current Timber Supply Review process to provide a systematic way of accounting for environmental values.

Many people mentioned the need to have a legislated protocol for habitat supply assessment equivalent to that used for timber supply review. At present, decisions related to habitat supply are highly fragmented, with no opportunity for a consolidated assessment of the cumulative impact of all the individual habitat-related decisions. The Timber Supply Review provides a step-wise protocol that provides a recognized level of rigour and certainty that is applied consistently across the province. Building a similar framework and protocol was seen as a key solution for achieving consistency in the use of and confidence in HSM to support decision-making. A number of issues would be dealt with in so doing; for example, increased transparency of the review process and more confident decision-making, particularly in knowing that there is opportunity for further review and that new information will be incorporated effectively in the process.

Currently, the roles and responsibilities for habitat supply analysis are not clearly defined, and it is unclear who has the mandate and responsibility in government or industry to undertake habitat supply analysis. Concerns were expressed that in some cases, wildlife habitat needs did not receive balanced consideration in relation to other values, such as timber, within provincial strategic land-use planning processes. The current approach to incorporating wildlife habitat modeling interpretations within these strategic processes is considered ad hoc.

Some respondents felt that MWLAP's lack of legal decision-making power based on a mandate to protect the environment automatically resulted in habitat information being incorporated with less rigour. Many felt that without a legal mandate to protect environmental values, the provision of improved habitat supply information would not necessarily produce the desired outcomes. This lack of confidence appears to relate to differences in the interpretation of FPC Section 41 (1)(b) by the ministries, and perhaps to educational and cultural differences between the forester and biologist professions.

A number of instances were raised where HSM was presented to inform a decision, but its validity was questioned by the SDM because it was not developed using a ministry-sanctioned accredited model or process. In order to bring HSM information legitimately into the decision-making process, the three responsible ministries need to develop and sanction a cohesive and consistent protocol. Exacerbating this issue further is the fact that key staff are now dispersed across three ministries. For example, it is not uncommon to have the decision-maker in one ministry, the person responsible for the value in another ministry and the GIS capabilities in yet another ministry. Each of these individuals may also receive different and not necessarily compatible instructions. Similarly, it was noted that having research capacity under MOF when the work is equally relevant to MWLAP and MSRM, is also not the most effective research solution.

### 4.5.3 Forester vs. Biologist Culture

Some respondents suggested that ecologists and biologists tend to be schooled in a culture that promotes caution over risk, favoring protection of species and populations and their habitats. Yet, scientific training tends to prevent these individuals from voicing concerns about potential population trends before scientific proof is concrete. Alternatively, foresters tend to be schooled in a culture that encourages anthropocentric changes to forest landscapes; therefore, they are more accepting of risks associated with the design and implementation of resource management strategies. It was commented that in order to engage fully in the process biologists need to be given some certainty that their information will be treated fairly. Many individuals providing habitat recommendations commented that their opinions were requested as part of the process, but then were often discounted or ignored.

It was noted on a number of occasions that the model chosen for habitat supply analysis often appeared to be determined on the basis of "which model seller arrived first", rather than being the result of asking "is this the most appropriate model for the task?" There is a need to provide potential users with a way to assess the appropriateness of different modeling approaches to inform specific decision requirements and processes.

### 4.5.4 Standardization and Devoted Resources

During the interviews, people were asked whether and how standardization should be achieved in HSM. The majority of respondents felt that some form of standardization would provide stability to model development and use, would put different areas of the province on an equal footing, and would help to co-ordinate different development teams. Overall, this would result in increased efficiency and robustness to the efforts.

Most people, however, did not necessarily advocate that there be a single model or group of models. This was due to proprietary concerns and the need for maintaining flexibility across the province. Many felt it would be helpful to develop a working set of standards or a framework that outlined a base (minimum) approach; for example, typical types of inputs, outputs, and interpretations.

Decision-making based on analytical habitat modeling will require long-term funding to support the continued need for specialized technical expertise and appropriate inventory information. Establishing a focused resource group within government to act in the same manner as the Timber Supply Branch was seen to be advantageous by the vast majority of interview participants. Similarly, the concept of having a *Chief Biologist*, whose task would be equivalent to Chief Forester, was raised by a number of respondents as a possible part of solution. Regardless of where such a resource group might reside, there was agreement that the current lack of dedicated staff and focused effort is a barrier.

### 4.5.5 Ecological Benchmarks and Risk

Almost all respondents supported formulating output from modeling processes in terms of absolute or relative risk. SDMs, in particular, embrace the risk approach because it feeds directly into making trade-off decisions. Using "relative risk" categories associated with multiple scenarios was seen by SDMs as the most effective and useful information to provide. Agency staff making recommendations largely supported using a risk approach, but were a little more hesitant, raising the inherent difficulties of identifying meaningful risk classes and thresholds for environmental values. Concerns were raised that "higher" risk can be interpreted as higher risk only when using a relative risk scenario, and that absolute "high risk" scenarios may be downplayed.

There was clearly a lack of common understanding between respondents about the appropriate use of ecologically relevant benchmarks and the process necessary for identifying thresholds or absolute risk. Identifying some standard ways of interpretation may help decision-makers[8]. The complexity of doing this should not be understated, however.

### *4.5.6 Model Capability: Non-Expert User, Scenarios, Link to Timber Supply*

A large majority of respondents mentioned the need to move to models, with two important requirements. First was the need for models that can be used by agency staff and industry and not only specialists. Second, there is a need for models that are designed to run and compare scenarios and provide priorities rather than "single" answers per se. Furthermore, where appropriate, linking to timber supply forecasting was identified as an approach that provides the most useful output to SDMs tasked with making tradeoffs.

### *4.5.7 Interpretation and Presentation of Habitat Material*

Almost all respondents thought development and interpretation of models required a joint effort across the ministries and that increased cooperation could increase the level of trust in habitat-related interpretations and recommendations. As noted earlier, SDMs automatically discredited information in cases where there was obvious conflict between professionals providing the information. Where habitat supply information had been supplied to support decisions, a number of people commented on the ineffective or inefficient presentation of material. In particular, the use of visual aids was identified as important, as was the development of a more consistent professional template.

## 4.6 Summary[9]

The effective use of habitat modeling in decision-making is dependent not only on high-quality models and reliable results, but also on a decision-making process that is receptive to incorporation of HSM information and sensitive to the implications of the modeling results. Ensuring the accountability of those presenting modeling information and those making decisions based on those results would improve the utility of the process. Figure 4.1, developed by the study team, also provides an overview some of the steps necessary for incorporation of habitat modeling results in a decision-making process and highlights some key barriers that inhibit this process.

There is a significant and on-going effort currently directed at HSM in BC. However, agency professionals are often involved only peripherally and are therefore unable to assess the real efficacy of the process and/or they do not feel in general that current modeling efforts are meeting their needs. The need for a strategic, more coordinated and cooperative approach among the three natural resource ministries was seen to be fundamental. Rather than these ministries continuing to

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[8] As a part of the strategy development process, a separate discussion paper on this topic was prepared and is on file with MWLAP. The paper by Rachel Holt and Greg Utzig (March 2002) is entitled: *Indicators, Thresholds and Risks — Links to a Habitat Supply Modeling Strategy and Environmental Risk Analysis in BC.*

[9] Additional summary comments provided by the participants of a Habitat Supply Modeling Strategy Workshop held in Victoria, February 12–13, 2002 have been incorporated into this section.

be in conflict over habitat issues, there is a need to jointly develop constructive solutions. For example, development of a multi-agency framework that encourages all three ministries to be receptive to the challenges raised by new resource management approaches (for example, environmental effectiveness monitoring) is required for these initiatives to effectively incorporate habitat supply information. Simultaneously, development of a process that allows the best available data to be used in decision-making, and yet forces periodic review and update of information (equivalent to timber supply review) would increase the comfort and efficient use of the use of habitat supply information. The current process of change within ministries perhaps provides opportunities for these important changes.

**Key barriers to developing improved models** that were based on our analysis (in approximate order of importance) are

1. Lack of knowledge about habitat–species relationships, including thresholds and baseline information;
2. Insufficient detailed biophysical inventory and successional information;
3. Inadequate HSM training and extension for decision-makers and advisors; and
4. Poor consolidation of existing habitat-related information suitable for practical application (for example, empirical data and existing species-habitat relationship information).

**Key organisational and cultural barriers** to effective incorporation of habitat supply information that were identified in the interviews included (in relative order of importance):

1. Unclear mandates regarding the conservation and protection of habitats;
2. Poor communication between biologists and decision-makers, resulting in confusion over the value and use of habitat information;
3. Lack of a ministries-wide corporate vision and cohesive approach to developing, supporting, and using habitat supply models;
4. Need for consistent and sanctioned standards and protocols for fully incorporating HSM procedures and interpretive reports into resource analysis and management processes;
5. Need for greater professional accountability to ensure that the most appropriate individuals have the opportunity to present the most appropriate information; and
6. Need to develop HSM presentation formats that are easily understood and used by decision-makers.

# 5 State of Modeling: Modeling Approaches

In this section, we provide a summary of the state of HSM in BC. First, Sections 5.1 to 5.3 provide a historical overview of habitat modeling developments over the past (approximately) 40 years. This overview has been included to provide a general historical and developmental context for the strategy, and is not intended to serve as an exhaustive analysis or literature review. Sections 5.2 and 5.3 follow, with a summary of the main highlights of a scan of current modeling approaches and projects in BC. A detailed listing of the 34 modeling approaches surveyed is provided in Appendix C.

## 5.1 History

In various forms, habitat modeling has been taking place in BC for about 40 years. The early work generally focussed on species–habitat requirements for game species (for example, ungulate winter range). This early modeling typically did not include forecasting habitat supply over time. More sophisticated models for ungulates were developed as part of the Integrated Wildlife-Intensive Forestry Research program on Vancouver Island and other research programs, both academic and government. Some early models developed at the University of British Columbia (UBC) as part of the International Biological Program linked species to habitat and modeled population responses over time.

Early habitat suitability index (HSI) models were developed in response to the work pioneered by Jack Ward Thomas in his Blue Mountains handbook (Thomas et al. 1979). This work has continued for various species and specific life requisites (for example, elk winter range HSI in the West Kootenays). HSI projects often serve as the sources of the basic species–habitat relationships for more recent modeling.

In the late 1960s and 1970s, the habitat capability mapping approach was introduced as part of the Canada Land Inventory program. This approach was further refined under the BC Land Inventory program and by the Resource Analysis Branch in the late 1970s and early 1980s, incorporating the concept of habitat suitability. The Ministry of Environment, Lands, and Parks (MELP) and the RIC Standards process further developed and standardized this approach throughout the 1990s. With the advent of geographic information systems, increased computing capabilities, and Terrestrial Ecosystem Mapping (TEM) or Predictive Ecosystem Mapping (PEM), this approach has gained widespread usage throughout BC. However, this approach has not generally been used to forecast habitat quality and quantity until recently.

Species–habitat relations for high profile species have been investigated in various research projects, and some of these projects resulted in descriptions of species-habitat relationships that could be considered simple models. These descriptions were then employed for developing management strategies and handbooks, or for assessing the potential impact of forestry activities on habitat over time.

As FPC biodiversity management embraced the coarse-filter approach to landscape level habitat management, the use of seral stage distribution became a common indicator of ecosystem integrity, often focussing on the seral stages most at risk – mature and old forest and their associated stand structure. Predictions of environmental conditions/coarse-filter habitat supply have been used to evaluate options in regional land use planning and timber supply reviews (for example, environmental impacts of the Kootenay Boundary Land Use Plan – Implementation Strategy, 1997; environmental implications of the Robson TSA Timber Supply Review base case, 2001; and assessment of sustainable forest management scenarios for the McGregor Model Forest, 1998).

During the 1980s, theoretical work on modeling proceeded on university campuses (for example, Forcyte at the Faculty of Forestry, UBC) and in government (MOF, MELP) research programs. In the early- to mid-1990s, as computer hardware capabilities increased, model development for environmental application continued, both at universities and in consulting companies (for example, UBC's Centre for Applied Conservation Biology and the SIMFOR model; ESSA and the Prognosis Environmental Indicators model).

The technology and microprocessor explosion of the 1990s, both in hardware and enabling software — GIS, statistical packages, spatial disturbance scheduling, data management — has facilitated significant advances in HSM capacity. With the increased availability of spatial timber supply models, habitat suitability ratings have been applied to predictions of seral or structural stage conditions of forest stand output by the timber supply models, allowing forecasting of habitat supply. Multiple accounts analysis associated with Regional Land Use Planning, scenario planning for Enhanced Forest Management Pilot Projects (EFMPP) and IFPAs, and other planning initiatives have provided numerous opportunities for model development and application. The dwindling populations of some species have also spurred the development of single-species models for high-profile species at risk in the last few years (for example, caribou, marbled murrelets, grizzly bears, and spotted owls).

To date, habitat modeling in the province has not been well co-ordinated, with the dominant focus being on individual projects designed to answer specific habitat management questions. In a few cases, attempts have been made to take individual projects and further develop them into modeling tools with wider applications (for example, SIMFOR). In some cases, there has actually been competition between models and model developers, particularly when consulting firms are attempting to protect their investments in proprietary software.

## 5.2 Biodiversity Working Group, Forest Productivity Council

In the winter of 1999, the Biodiversity Working Group (BWG)[10], was formed and charged with co-ordinating the development of techniques and tools that accurately predict, at the stand and landscape level, the habitat and biodiversity consequences of any management regime applied in the forests of BC. The BWG includes professionals from both government and the private sector. This vision supports the strategic direction of the Forest Productivity Council in development and implementation of provincial forest growth and productivity programs. In 1999, the BWG conducted a survey of approximately 60 individuals to determine the following:

- What was currently being done to address habitat and biological diversity in forest productivity assessments and projection of future conditions in forest planning;
- The adequacy of currently available data and modeling tools for addressing habitat and biodiversity; and

[10] The BWG is one of four working groups operating under the direction of the Forest Productivity Council. The Forest Productivity Council reports to the Chief Forester, MOF.

- Gaps in data and modeling tools, and priorities for addressing additional needs.

Some of the key findings, gaps, or needs from the survey pertinent to this strategy include the following[11]:

- Existing inventory programs provide data on most of the key habitat – biodiversity attributes.
- Definition of habitat requirements for province's featured species (at least).
- Linkage of habitat requirements to forest inventories and structural attributes which can be measured (quantitatively) and modeled over time.
- Spatially explicit habitat supply models for use at strategic level – to direct forest development plans and assess impacts of alternative scenarios.
- Linkages to explicit models like SIMFOR need to be evaluated and incorporated into GY procedures
- Responses suggested low awareness and use of existing models; limited sense of their value.
- Data gaps fall into several categories including basic research, inventories of species/habitats, modelling/predictive tools, reliability assessments of existing procedures, linking existing inventory data to habitat.

The BWG Strategy identifies four objectives:

1. Determine information and knowledge needs of clients,
2. Acquire information and knowledge on species and disturbance relationships to habitat,
3. Develop and implement habitat modeling tools, and
4. Assess consequences of current management practices on sustainability of habitat supply.

In the fall of 2001, the BWG developed a strategy implementation plan for fiscal years 2002-03 through 2004-05. The work identified is intended to put in place some important foundation components and processes in a manner similar to what was done for timber supply analysis information, knowledge, and processes only a few years ago. It concentrates largely on bringing together a number of currently disparate sets of information, knowledge, tools, and procedures. The estimated level of funding required to implement the BWG implementation plan over the next three years is $1.5 million.

## 5.3 Habitat Modeling Steering Committee

In a further effort to improve the coordination of habitat supply modeling efforts across the province an inter-ministry Habitat Modeling Steering Committee (HMSC) was struck in 2000. The HMSC includes representatives from MWLAP, MOF, and MSRM. Three of the members of the HMSC are also members of the BWG. Under the general guidance of the Committee, a number of projects have been sponsored and/or have been brought together under a single web access point in government[12]. This website provides an overview of habitat supply modeling,

[11] The full results of the survey are available on the Internet at: http://www.forestproductivity.gov.bc.ca/working/bio/biodiversity.htm
[12] http://www.for.gov.bc.ca/hfp/silstrat/habitat/habitat-home.htm

including a set of downloadable documents, a list of contacts, and other web links related to habitat supply.

Of the documents available on the habitat supply web site, two are surveys. The first was prepared by Diana Demarchi (2000) and is entitled *Habitat Supply Modeling Survey*. Demarchi compiled a database of wildlife and habitat modeling projects that have been undertaken in BC (71), Alberta (3), and northwestern US (5). For each of the 584 projects, the database lists the species focus; interpretive features considered (for example, food and cover, winter range); scale of interpretive map (for example, 1: 50,000); type of analytical model used; study location and geographic applicability; management application for model; and contact name. Appendix A of Demarchi's document provides a description of some of the main habitat supply models identified in the survey.

The second survey was prepared by Rick Page (2001), entitled *Assessing the Effects of Forest Management on Wildlife: The Models*. The report reviews the characteristics of computer models used or potentially useful for predicting wildlife values in BC's forests (as of March 2000). The survey examined both stand (4) and landscape models (11). The study concluded that overall, the level of modeling expertise in BC is high. Some of the model limitations noted included the following:

- A strong focus on strategic models with limited application operationally;
- Poor linkage of outputs back to GIS;
- Little consideration of ecological functions of forests or the wildlife that inhabits forests; therefore, models do not consider the abundance of predators or the importance of stand structure as refuges; and
- Little model output testing or sensitivity analysis.

In March–April 2001, a two-day Habitat Supply Decision Support Workshop was held in Richmond, BC. The objectives on the workshop were to extend state-of-the-art information on:

- Decision support tools available;
- Recent applications that have been made in BC; and
- Management questions that have been addressed.

Attended by over 150 people and with 25 speakers[13], the workshop provided a useful overview of the current applications, and the extent of investment in habitat supply and biodiversity modeling in BC. In concluding the workshop, Jane Perry noted some bad news, some unfortunate news, and some good news, summarized as follows:

> *Bad News:* In some circumstances, habitat is significantly under-rated and under-regarded despite its importance. At worst, habitat values are still considered by some as a constraint to "getting the wood out."
>
> *Unfortunate News:* Public expectations and certification are often used as the reasons for being more inclusive in defining and addressing a variety of resource management values, including habitat. What I would like is for the resource management professionals to be

[13] The presentations can be obtained from http://www.for.gov.bc.ca/hfp/silstrat/habitat/hsworkshop/hs-workshop-summary.htm.

acknowledging their relevant Code of Ethics, their training—and what I really think they truly believe—and putting non-timber values more in the forefront.

*Good News:* Public expectations and certification will help us achieve what we want regarding habitat values and habitat supply. As well, I believe that professional accountability by all resource management professionals (foresters, biologists, engineers, geoscientists, and agrologists) will play a key role.

Particularly pertinent to this strategy was Jane Perry's statement: **"We need some consolidation of the habitat supply decision support tools we've learned about at this workshop, for more widespread, easily-understood use."**

Up until the Richmond workshop, there had been few opportunities for co-operative learning between the various modeling groups in BC. Neither had there been the ability for managers and other users to view the scope of habitat modeling activities occurring in BC in order to practically compare the various approaches. The next section is focused largely on approaches to addressing this need.

## 5.4 Scan of Current Modeling Approaches and Projects

Our interviews were focused on some of the key modeling "nodes" of activity in BC and elsewhere. In total, 34 modeling approaches, typically in the form of projects, were reviewed. Of the modeling approaches reviewed, the following are highlights of some of the key functional capabilities discussed.

Appendix B provides a list of the interview questions, while Appendix C provides full details on the individual modeling approaches. The information in Appendix C has been reviewed and verified for interpretive accuracy by each modeler. The reader is also referred to the previous HSM surveys undertaken by Page and Demarchi, described in Section 5.1.

Table 5.1 shows a summary of modeling approaches and projects in BC and elsewhere, in relation to the Decision Type classification described earlier in Section 3 and Table 3.1. It is important to note that the allocation of each modeling approach to the Decision Types was confirmed with each modeling team. Table 5.1 indicates that of the 32 modeling approaches (projects) examined,

- 31 are able to address landscape-level habitat questions (Decision Type A);
- 13 are able to address ecosystem-level habitat questions (Decision Type B);
- 12 are able to address stand-level habitat questions (Decision Type C);
- 22 are able to address single species–guild, specific life requisite questions (Decision Type D);
- 8 are able to address single species–large area home range, all/most life requisite questions (Decision Type E); and
- 9 are able to address single species–small area home range, all/most life requisite questions (Decision Type F).

### 5.4.1 Spatiality

***Of the models reviewed, how many of the models incorporate spatiality?***

Almost all of the modeling approaches address both static atemporal analysis and spatial–temporal analysis, either internally or externally through post-processing models. Companion software is often used with habitat supply models to provide spatial analysis functionality. While the importance of spatiality is widely acknowledged, it is also appreciated that not all HSM questions need to be addressed using spatial analysis.

One of the most significant barriers to HSM continues to be the time and costs associated with cleaning topological data coverages for input into the models. Future surveys (for example, if creating a model registry) should attempt to characterize the exact nature of the spatial and temporal functions in the modeling approaches.

### 5.4.2 Resolution of Ecosystem Classification Input

***How many models can incorporate and interpret ecological site series information?***

Virtually all of the modeling approaches can directly or indirectly utilize ecological site series information at any resolution. The more limiting factor is the amount of computer memory available to run the model against these often large data sets.

### 5.4.3 Ability to Evaluate Multiple Scale Life Requisite/Habitats and their Nested Spatial Relations

***Can your model concurrently analyze spatially nested habitat areas (for example, Goshawk – nesting, post fledging and foraging)?***

All modeling approaches can analyze spatially nested habitat areas, provided that the user can define the necessary rules and relationships for input into the model. In other words, for the most part the rules and relationships are not pre-built, but rather rely on analytical information, research, and expert opinion. In several cases this kind of analysis is accomplished through the application of pre- or post-processing analysis using GIS.

### 5.4.4 Ability to Incorporate User-Defined Species-Habitat Relationships

***Are the species–habitat relationships transparent and explicit in the model structure? If yes, how are they represented? Are they fixed or user definable? How does the model allow the user to enter or load these relationships? Is there a user interface?***

The models in the survey reflected a range of ways to incorporate species–habitat relationships: however, the vast majority of models allow users to define species–habitat relationships. For example, with TELSA, the user defines what states are used; how they are defined; what is meant by cover type; how long it takes to move from one state to another; what disturbances are present; and what management activities are applied. In several of the models the species–habitat relationships are fixed through empirical equations. For most of the models, a user interface is used to enter the species–habitat relationships. Some models import the species–habitat relationships by means of existing or derived GIS coverages.

### 5.4.5 Ability to Interpret Proximity Information

***Do models have the capability to analyze proximity to features/polygons relative to one another?***

A few of the models are capable of addressing proximity issues. Most of the models identify GIS post-processing as the means by which this type of topological relationship analysis is addressed. Several modelers noted that they have developments underway to implement proximity type rules within their models. Development of new algorithms to address proximity issues should be encouraged.

### 5.4.6 Population Response Prediction

***Does the model have an integral population analysis component — i.e., predict population size?***

Most of the models do not have an integral population analysis component. However, most can address population through post-processing methodologies. The majority of models having an integral population analysis component use density assumptions that are derived through regression analyses in a deterministic manner. The most limiting factor identified by modelers is the availability of localized species population–habitat data on which to base population predictions.

### 5.4.7 Forecasting Future Conditions

***Can the model generate projections of future conditions?***

The majority of models in the survey can produce predictions of future states. Those models that lack the capability to generate future projections can output the necessary information to a post-processing model with forecasting capability.

### 5.4.8 Model Building Process

***What process is used to build the model?***

A number of different processes are being used to build the models, summarized as follows:

1. Independent (more or less) statistical analyses.
2. Inclusive, collaborative, and participatory approach used to build the model, involving stakeholders (local knowledge), specialists (expert opinion) and researchers (analytical research results, literature-based knowledge).
3. Formation and use of a core scientific team (workshops, meetings, email exchanges).
4. Workshop(s) with experts to identify rules, relationships, and expected outcomes.

The relative strengths and weaknesses of these model-building approaches were not evaluated in this survey. Further assessment of these techniques may help modelers select the most appropriate process for building their particular models.

### 5.4.9 Indicators

***What types of indicators of habitat supply and condition are used in the various modeling approaches reflected in the survey?***

A broad range of HSM indicators were identified The predominant use of indicators was based on forest inventory attributes and stand structure. Empirical models and modelers reported indicators based on probability of use. Several modelers mentioned that for indicators to be useful, they must be quantitative and forecastable. However, there is a wide range of opinion as to what constitutes a good indicator. Efforts should be made to provide better linkages between resource objectives, management strategies, and indicators that can be forecasted in relation to some hypothesis of expected or desired future condition.

The relationship between most spatial statistics and the ecology of individual species or ecosystems is not clear. For example, Schumaker (1996) found that most spatial indicators were only weakly correlated with the results of a simulation model of animal dispersal. There has been little field testing of the correlation between spatial statistics and ecological processes in complex and dynamic forest environments (Klenner et al. 2000).

Consideration should be given to establishment of sets of habitat supply indicators and accompanying protocols (including benchmark maps and tables) for use in presentation of habitat supply analysis results. This will encourage greater acceptance of these methods by decision-makers.

## 5.5 General Observations from Modeler Interviews

The following general observations have been made on the basis of feedback from interviews with modelers. A number of these modeler comments reinforce similar messages heard from decision-makers and resource managers (see Section 4).

1. **Structure and successional information:** HSM in BC could be significantly improved if the forest/vegetation resource inventory information included additional attribute information on forest structure and succession.
2. **Structural feature protocols:** Generally accepted protocols for calculating structural features such as patch size, connectivity, wildlife tree patches, and old growth habitat and management areas, would provide better consistency in modeling approaches.
3. **Integration of timber and habitat supply models:** Realistic spatial and temporal projections of both timber and habitat supply are needed to better inform decision-makers. To accomplish this, habitat and timber supply analyses would benefit from being integrated for purposes of evaluating alternative strategic and operational land use scenarios.
4. **Formal training:** Formal of habitat supply analysis training sessions similar to those developed for timber supply analysis, as well as associated skills training, would help habitat supply analysts.
5. **Habitat Baseline Information:** Development of habitat supply baselines of historical ranges of variation is needed to evaluate the potential impacts on habitat supply under alternative management scenarios.

6. **Decision analysis and inference techniques:** Decision-makers and planning tables would benefit from training in decision analysis and inference techniques (for example, Bayesian methods and fuzzy logic) for comparing alternative resource scenarios and their potential impacts.
7. **Model Registry and evaluation criteria:** Creation of a web-based habitat supply model and modeling approach via a Model Registry and project catalogue is generally supported. It was recommended that consideration be given to developing criteria to evaluate the various models and modeling approaches. This would help to focus the Registry framework and encourage the appropriate posting and validation of the information contained therein.
8. **Strategy workshop:** A province-wide habitat supply workshop to discuss the HSM strategy would encourage continued and broader discussion on how best to realize improvements in the modeling approaches, and in the use of results for more informed and effective decision-making.
9. **Standard habitat feature definition:** Defining a standard set of habitat feature requirements (that is, base level features for HSM) would help to broaden the acceptance of the interpreted results based on habitat supply analysis models.
10. **Benchmark outputs with documentation:** HSM is broader than timber supply modeling and therefore requires more flexibility. However, there could be some standard benchmark outputs and documentation that would serve as a reference for decision-makers.
11. **Trends in modeling:**
    - ***Greater information resolution***: As people become more familiar with spatial habitat supply analysis, they will want to handle more and more information at finer and finer resolutions.
    - ***More integrated approaches ahead:*** Timber and HSM developments will produce integrated approaches that enable forecasting of stand development (succession) complete with management interactions, natural disturbance events, and species population responses.
    - ***Modeling will support expert opinion.*** Habitat and environmental risk assessment will result in a shift from expert opinion to the use of habitat models, based on research that provides empirical results supported by expert opinion

**Table 5.1. Summary of the modeling approaches (and projects) in BC and elsewhere in relation to the six Decision Types.**

| Habitat Supply Modeling Survey – Modeling Approaches<br>*Modeler Interviewed, Appendix No., Project No. and page no. in Appendices (Strategy Report: Volume II)* | DECISION TYPES | | | | | |
|---|---|---|---|---|---|---|
| | COARSE–FILTER | | | FINE–FILTER | | |
| | A<br>Landscape Level Habitat | B<br>Ecosystem Level Habitat | C<br>Stand Level Habitat | D<br>Single Species – Guild Specific Life Requisite | E*<br>Single Species – *Large* Area Home Range– All/Most Life Requisites | F*<br>Single Species – *Small* Area Home Range – All/Most Life Requisites |
| 1. Omineca Northern Caribou Habitat Supply Modeling – NETICA, SELES<br>*Fall* – Appendix 1.2: Project #6, p.14*<br>*McNay – Appendix 1.16: Project #1, p,101* | ☑* | | | ☑* | ☑ | ☑* |
| 2. Robson Valley TSA Assessment of natural disturbance impacts on timber supply – SELES<br>*Fall – Appendix 1.2: Project #1, p.14* | ☑ | | | | | |
| 3. Parks Canada Caribou Habitat Assessment - SELES<br>*Fall – Appendix 1.2: Project #2, p.14* | ☑ | | | ☑ | | |
| 4. Prince Rupert Forest Region – Hydrological Flow Modeling to Identify Key Habitat Features – SELES<br>*Fall – Appendix 1.2: Project #3, p.15* | ☑ | | | | | |
| 5. Boreal Forest – Individual-based bird dispersal model for assessing landscape connectivity – SELES<br>*Fall – Appendix 1.2: Project #4, p.15* | | | | ☑ | | ☑ |
| 6. NCE Quebec – Development of Management Plans that Integrate Habitat Requirements for variety of boreal species – SELES<br>*Fall – Appendix 1.2: Project #5, p.15* | ☑ | | | ☑ | | |
| 7. BC Interior – Landscape level Mountain Pine Beetle Modeling – SELES<br>*Fall – Appendix 1.2: Project #7, p.16* | ☑ | | | | | |
| 8. Columbia Mountains Assessment of Caribou Habitat – SELES<br>*Fall – Appendix 1.2: Project #8, p.16* | ☑ | | | ☑ | | |

| Habitat Supply Modeling Survey – Modeling Approaches<br><br>*Modeler Interviewed, Appendix No., Project No. and page no. in Appendices (Strategy Report: Volume II)* | DECISION TYPES | | | | | |
|---|---|---|---|---|---|---|
| | COARSE–FILTER | | | FINE–FILTER | | |
| | **A** Landscape Level Habitat | **B** Ecosystem Level Habitat | **C** Stand Level Habitat | **D** Single Species – Guild Specific Life Requisite | **E*** Single Species – *Large* Area Home Range– All/Most Life Requisites | **F*** Single Species – *Small* Area Home Range – All/Most Life Requisites |
| 9. West Arm Demonstration Forest Case Study - Prognosis EI<br>*Robinson – Appendix 1.6: Project #1, p.41* | ☑ | ☑ | ☑ | ☑ | ☑ | ☑ |
| 10. North Coast LRMP Marbled Murrelet – NETICA<br>*Steventon – Appendix 1.7: Project #1, p.48* | ☑ | ☑ | | ☑ | | |
| 11. BC and Alberta Habitat Assessment of Songbirds - SIMFOR<br>*Wells – Appendix 1.13: Project #1, p.81* | ☑ | ☑ | ☑ | | | ☑ |
| 12. BC - Grizzly Bear Habitat Assessment – SIMFOR<br>*Wells – Appendix 1.13: Project #2, p.81* | ☑ | ☑ | ☑ | | ☑ | |
| 13. BC – Various Habitat Assessment Marbled Murrelets and Black-tailed Deer – SIMFOR<br>*Wells – Appendix 1.13: Project #3, p.81* | ☑ | ☑ | ☑ | ☑ | | |
| 14. ALPAC – Habitat Assessment of shrub nesters and cavity users – SIMFOR<br>*Wells – Appendix 1.13: Project #4, p.81* | ☑ | ☑ | ☑ | ☑ | | |
| 15. Invermere – Habitat Analysis of Two FSSIM Harvest Scenarios in the Rocky Mountain Trench – SIMFOR<br>*Valdal – Appendix 1.8: Project #1, p.53* | ☑ | ☑ | | | | |
| 16. Invermere EFMPP – Analyzed individual and groups of species for habitat and structural issues<br>*Valdal – Appendix 1.8: Project #2, p.53* | | | | ☑ | | ☑ |
| 17. Invermere TSR II – Evaluation of Base Case Timber Supply Forecast in relation to Habitat Requirements for Northern Goshawk and songbirds.<br>*Valdal – Appendix 1.8: Project #3, p.54* | ☑ | | | | | |

| Habitat Supply Modeling Survey – Modeling Approaches<br><br>*Modeler Interviewed, Appendix No., Project No. and page no. in Appendices (Strategy Report: Volume II)* | **DECISION TYPES** | | | | | |
|---|---|---|---|---|---|---|
| | **COARSE–FILTER** | | | **FINE–FILTER** | | |
| | **A**<br>Landscape Level Habitat | **B**<br>Ecosystem Level Habitat | **C**<br>Stand Level Habitat | **D**<br>Single Species – Guild Specific Life Requisite | **E***<br>Single Species – *Large* Area Home Range– All/Most Life Requisites | **F***<br>Single Species – *Small* Area Home Range – All/Most Life Requisites |
| 18. Landscape Analysis of Caribou Habitat - FSSIM and SELES<br>*Morgan – Appendix 1.4: Project #1, p.28* | ☑ | | | ☑ | | |
| 19. North Coast LRMP Grizzly Bear Analysis – SELES<br>*Morgan – Appendix 1.4: Project #2, p.29* | ☑ | | | | | |
| 20. North Coast Goshawk Model – SELES<br>*Morgan – Appendix 1.4: Project #3, p.29* | | | | ☑ | | ☑ |
| 21. Manitoba Forest Plan: Towards Ecosystem Management - Options<br>*Reimer – Appendix 1.5: Project #1, p.34* | ☑ | | | ☑ | | |
| 22. The Potential Impacts of Enhanced Forestry on B.C. Forest Productivity and Yield. – Options<br>*Reimer – Appendix 1.5: Project #2, p.34* | ☑ | | | | | |
| 23. Plum Creek Habitat Conservation Plan – Options<br>*Reimer – Appendix 1.5: Project #3, p.35* | ☑ | | ☑ | ☑ | ☑ | ☑ |
| 24. State of Washington Trust Lands: Sustainable Harvest Analysis – Options<br>*Reimer – Appendix 1.5: Project #4, p.35* | ☑ | | ☑ | | | |
| 25. Testing a Landscape Evaluation Model Developed for Grizzly Bears - Logistic Regression<br>*Hovey – Appendix 1.9: Project #1, p.60* | | | | ☑ | | |
| 26. Assessment of Environmental Impacts of Various Options for the Kootenay Boundary Land Use Plan Implementation Strategy – FSSIM<br>*Utzig – Appendix 1.10: Project #1, p.66* | ☑ | | | | | |

| Habitat Supply Modeling Survey – Modeling Approaches<br><br>*Modeler Interviewed, Appendix No., Project No. and page no. in Appendices (Strategy Report: Volume II)* | **DECISION TYPES** | | | | | |
|---|---|---|---|---|---|---|
| | **COARSE–FILTER** | | | **FINE–FILTER** | | |
| | **A**<br>Landscape Level Habitat | **B**<br>Ecosystem Level Habitat | **C**<br>Stand Level Habitat | **D**<br>Single Species – Guild Specific Life Requisite | **E***<br>Single Species – *Large* Area Home Range– All/Most Life Requisites | **F***<br>Single Species – *Small* Area Home Range – All/Most Life Requisites |
| **27. Assessment of Environmental Trends of various Implementation Strategies of the Kootenay Boundary Higher Level Plan - CASH, ATLAS**<br>***Utzig – Appendix 1.10: Project #2, p.66*** | ☑ | ☑ | ☑ | | ☑ | |
| **28. Environmental Indicators in Timber Supply Review. – FSSIM Environmental Indicator Database**<br>***Eng – Appendix 1.11: Project #1, p.71***<br>***Buell – Appendix 1.12: Project #1, p.76*** | ☑ | ☑ | | | | |
| **29. TFL 14 Type 3 Analysis – TUMS, CASH**<br>***Wilson – Appendix 1.18: Project #1, p.115*** | | | ☑ | ☑ | ☑ | ☑ |
| **30. Morice and Lakes TSAs Innovative Forest Practices Agreement – MSM, HIS**<br>***Voros – Appendix 1.7: Project #1, p.106***<br>***Turney supplementary interview re– HSI**** | ☑ | ☑* | ☑* | ☑* | | |
| **31. TFL 30 Scenario Planning Project Wildlife and Biodiversity Emphasis – MSM**<br>***Voros – Appendix 1.17: Project #3, p.106*** | ☑ | | | | | |
| **32. Robson Valley Enhanced Forest Management Pilot: Scenario Planning Project – MSM, SELES**<br>***Voros – Appendix 1.17: Project #2, p.107*** | ☑ | ☑ | ☑ | ☑ | | |
| **33. Mackenzie LRMP Impact Assessment Biodiversity Emphasis – MSM**<br>***Voros – Appendix 1.17: Project #4, p.108*** | ☑ | | | | | |
| **34. Kidprice Landscape Unit Analysis – MSM**<br>***Voros – Appendix 1.17: Project #5, p.108*** | ☑ | ☑ | | | | |

| Habitat Supply Modeling Survey – Modeling Approaches<br>*Modeler Interviewed, Appendix No., Project No. and page no. in Appendices (Strategy Report: Volume II)* | DECISION TYPES | | | | | |
|---|---|---|---|---|---|---|
| | COARSE–FILTER | | | FINE–FILTER | | |
| | **A** Landscape Level Habitat | **B** Ecosystem Level Habitat | **C** Stand Level Habitat | **D** Single Species – Guild Specific Life Requisite | **E*** Single Species – *Large* Area Home Range– All/Most Life Requisites | **F*** Single Species – *Small* Area Home Range – All/Most Life Requisites |
| **35. Weldwood Hinton1999 Forest Management Plan – HSI, Woodstock**<br>***Bonar – Appendix 1.14: Project #1, p.88*** | ☑ | | ☑ | ☑ | ☑ | ☑ |
| **36. Vanderhoof: Adaptive Management of Forestry Practices in Pine-Lichen Winter Range for Northern Caribou in North-Central British Columbia – NETICA**<br>***Sulyma – Appendix 1.1: Project #1, p.9*** | | | | ☑ | | |
| **37. Parsnip Grizzly Bear Project and Central Rockies Caribou Project – Logistic Regression**<br>***Siep – Appendix 1.3: Project #1, p.22*** | | | | ☑ | | |
| **38. BC north coast, BC southern interior, Alberta boreal forest, Idaho range-lands, US National parks – TELSA**<br>***Beukema – Appendix 1.15: Project #1, p.22*** | ☑ | ☑ | | ☑ | ☑ | |
| | | | | | | |
| **Total-Management Issues and Decision Types Addressed by the model–modeling approahes** | **31** | **13** | **12** | **22** | **8** | **9** |

*** Denotes which modeler allocated a particular project to a decision type in cases where more than one modeler was involved.**

# 6 Future Context

Beginning in July 2001, the nine months over which the strategy was developed represents a period of unprecedented change and uncertainty within the provincial government and, more broadly, in the forestry and natural resources sector. Within government, these changes are having a dramatic impact on mandates, organizational structure, roles and responsibilities, budgets, resources, and priorities. Further program delivery changes and resource reductions are planned over the next couple of years. These changes will continue to have strong influence on responses to this strategy. More business changes will also occur with the implementation of the new Results-Based Forest Practices Code and new planning approaches being developed by MSRM. Many of these factors would suggest that HSM will become increasingly more important in the future as a cost-effective and broadly applicable tool to inform and defend complex resource management decisions.

There is great deal of uncertainty and confusion regarding the kind of future in which this strategy will come into action. It is important, therefore, to consider the premises upon which the strategy are built are explicit. The following key assumptions are the basis for developing the strategic vision, objectives and implementation plan. Since so many changes are occurring, only those that were thought to be of direct interest to the habitat modeling strategy are listed here**. If these assumptions prove to be inaccurate, then it will be important to revisit the implementation plan for the strategy and make adjustments accordingly.**

In the form of assumptions, the following are the **short-term predicted future conditions** over the next three to five years, the time-frame within which the strategy is designed to operate[14].

## 6.1 Organizational – Funding

1. Budgets and overall resources of government agencies will be reduced. The key agencies are MWLAP, MSRM and MOF.
2. Forest Renewal BC will be eliminated and a Forest Investment Account (FIA) established from consolidated revenues (rather than through superstumpage). However, the funding available through the FIA will be less than that available through Forest Renewal BC. As well it may decrease over time, and will be more focused on meeting forest industry needs, in contrast to the multi-stakeholder and more provincially-coordinated approach taken by Forest Renewal BC.
3. Forest industry profitability in BC is currently low due to a number of factors (see Pearce 2001); consequently, industry is not likely to be a source of significant private-sector funds for HSM.

[14] For easy referencing, these assumptions have been listed using a continuous numbering system.

## 6.2 Organizational – Human Resources

4. Staffing of government agencies will be reduced. Regional and district centres will be merged or eliminated, and consequently a number of government staff who are currently key players in HSM may be impacted.
5. Reduced staffing levels will be achieved through early retirement packages, meaning there will be the potential for more experienced staff and some key players in HSM to leave the government work force. Hence there may be a capacity and core competency shortfall within government to conduct HSM.
6. Offsetting the above-mentioned government capacity shortfall will be an increase in the number of experienced people offering their services outside of government – therefore the capacity shortfall may be lessened through private sector sources and not-for-profit non-governmental organizations.

## 6.3 Organizational – Roles and Responsibilities

7. The MOF is responsible for protecting and managing BC's forest resources, with a focus on productivity and health, including the diversity of ecosystems that support a full range of forest products, businesses, and other opportunities. Key responsibility areas are protecting and managing the province's forest and range resources; providing the basis for a globally competitive forest industry with high environmental standards; and maximizing net revenues to the Crown.
8. MWLAP's role is to protect human health and safety by ensuring clean and safe water, land and air; to maintain and restore the natural diversity of ecosystems, and fish and wildlife species and their habitat; and to provide park and wildlife recreation services in BC.
9. MSRM is the primary provincial agency responsible for land-use planning and co-ordination of the land and water policies for the development of natural resources. It is mandated to provide a balance between economic development and environmental integrity, as well as providing key information about our natural resources.
10. Government will remain committed to research that is well focused and prioritized; however, staffing and budgets allocated to research within the largest research group (the Research Program of the MOF) will be reduced significantly.
11. Government will probably focus on standards (inventory, information, criteria and indicators, state of forest/environment reporting), definitions, best practices frameworks, information system coordination and planning, and performance audits. Government may use HSM to aid in defining criteria and indicators and in designing monitoring and auditing programs.
12. The day-to-day management of forest values will probably be largely the responsibility of industry. There will be a transfer of responsibility for habitat management to the forest industry, with industry becoming a key user of HSM. Forest companies will probably mainly use consultants to develop and run habitat supply models, rather than develop this specialized expertise in-house.
13. Professional accountability will probably become increasingly important in forest planning. Consequently, professional foresters, who must sign plans, may rely on habitat supply models as evidence that habitat resource values were adequately considered in

resource decision-making. This will require clear standards for acceptable models and their applications, to allow for auditing by government and other independent bodies.

14. It is possible that industry will react to the predicted sharp increase in responsibility and accountability. Industry may take on this accountability and then attempt to push it back onto government; however, this will probably occur beyond the two- to three-year horizon of this analysis.

## 6.4 Technical – Resource Management

15. Lengthy planning process like LRMPs and LUPs will be "short circuited" and streamlined. LRMPs are planned to be completed on the coast by the end of 2003, and in the interior by March 2004. This may cause a backlash from environmental groups and from communities. This will probably increase the short-term demand for HSM results, and may make ENGOs key users of HSM information.
16. There will be a move toward greater land zonation and the defining of a "working forest." HSM will probably be used to inform the mapping of areas to be designated as part of the working forest, and to define the allowable types and levels of development in various zones.
17. "Species at risk" will become a high priority management issue. HSM may be used as a key tool in informing decisions regarding key habitat maintenance for species at risk.
18. The incremental silvicultural strategy will probably continue to be implemented and HSM will probably continue to be used to effectively plan silviculture investments.

## 6.5 Technical – Information Management

19. Data management issues will be a significant issue and a possible source of conflict between government and industry; however, information will be essential in the development of both an evidentiary basis, on the part of industry, and monitoring systems, on the part of government. HSM could provide guidance regarding which information should be used in both these activities.
20. Current ecological classification and mapping systems will be key input data sources for HSM and will probably continue to be valuable in this application. As HSM advances, it is likely there will be requests that additional aspects of the ecological information base be researched, collected, and mapped for use in models.
21. As the forest industry takes on increasing responsibility for forest resource management, access to inventory data for independent application of habitat models by government and non-governmental groups may become an issue. This may affect the ability of the various parties to apply habitat models.

## 6.6 Market / International

22. As the forest industry continues to consolidate, individual corporate philosophies and commitments will strongly influence the industry's stewardship approach. This may lead to some companies taking a keen interest in HSM as a useful tool, and others not being particularly interested in supporting or using this approach to any great extent.

23. The increasing role of the forest industry in forest management and the reduced direct oversight role by government will probably result in increased scrutiny by environmental organizations, and possibly in increased action in the form of market campaigns and targeted boycotts. ENGOs will probably continue to use HSM as a means of providing evidence of management practices that do not adequately conserve biodiversity.
24. Certification of forest practices and products will become increasingly important, and external audits will increase. This may lead to the increased reliance on HSM as a basis for rationalizing alternative resource planning and management decisions, and for identifying targets for monitoring and auditing performance.
25. Timber pricing systems will change and access to US markets will be re-established; however, lack of equivalent environmental protection to US standards may become a "subsidy" issue. This issue, combined with significantly greater experience and expertise in HSM in the US, may result in increased demand for habitat modeling in BC.
26. Tourism in BC will probably increase relative in value to the overall economy; consequently, wildlife and wildlife habitat will increase in importance as social and economic values. HSM could have an increasingly more important role in this area in the future.

## 6.7 First Nations

27. Treaty-making with First Nations will probably slow significantly; however, First Nations issues may still become increasingly important if these groups begin to more aggressively assert their rights and/or successfully use the courts to confirm further rights. HSM may be used by some First Nations to define specific areas and management regimes necessary to maintain and/or restore wildlife populations for their use.

Given these assumptions, the HSM strategy is designed to focus primarily on **<u>what</u>** is required to develop a useful set of tools to inform resource management and the basics of **<u>how</u>** this could be done, rather than the specifics of **<u>who</u>** could or should do it.

# 7 Strategy

Drawing from the material presented in the preceding sections, we present a proposed vision and five Strategic Objectives for HSM in British Columbia.

## 7.1 Vision

The vision for habitat supply modeling is that —

> **Decision-makers and practitioners in British Columbia will use habitat supply modeling effectively as a part of a suite of tools to evaluate options for the sustainable management or restoration of habitats, and to predict the potential implications of development alternatives on habitat supply.**

## 7.2 Strategic Objectives

Five Strategic Objectives have been identified to address the range of issues and opportunities described in the preceding sections. The Strategic Objectives have both a technical and a "people" focus. Strategic Objectives 1 through 3 are intended to enable more coordinated model development and increase model building capacity in the province. Strategic Objectives 4 and 5 address the establishment of HSM standards and protocols and increasing the understanding and use of models.

Figure 7.1 shows how the Strategic Objectives of this HSM Strategy relate to the Biodiversity Working Group's Strategic Objectives noted earlier in Section 5.1.

### *7.2.1 Strategic Objective 1: To ensure the development, full documentation and availability of at least one fully complete modeling approach for each of the six Decision Types.*

### *7.2.2 Strategic Objective 2: To accelerate model development and increase modeling capacity by assembling a high caliber, multi-disciplinary, development team.*

While there is a considerable amount of high quality HSM effort going on throughout the province, it is fragmented, not well coordinated, and lacking in leadership. Model building is often done by people who have several other responsibilities; it can only be accomplished as time permits. The lack of dedicated time for model development and application was clearly evident from the interview discussions. There is also a shortage of expertise in knowledge engineering — i.e., the expertise in choosing and applying alternative modeling techniques. A significant enhancement in modeling techniques would arise from establishing a dedicated team that can assemble the full range of specialized expertise required.

To maximize synergies, the development team should ideally work from a single location. It is appreciated, however, that this may not be practical. In this case, significant time and effort will need to be committed to face-to-face development sessions, and for regular team communications between these sessions, using the full suite of information and communications technology tools available.

The team should comprise a core group of model builders (knowledge engineers) who have working relationships with a critical mass of multi-disciplinary expertise (for example, field and theoretical ecologists and biologists, software design engineers, database and GIS expertise, documenters, and project managers). This team will need to have the technical competence to incorporate conflicting data and professional opinions into the modeling approaches. It will also need to have access to channels for independent evaluation. The group should be committed to strong principles in software design, development, testing, and documentation. Because the focus of this group is on development (i.e., the "D" of R&D) and packaging, gaps of a research nature should be directed to appropriate research groups for investigation (see also strategic objective 3).

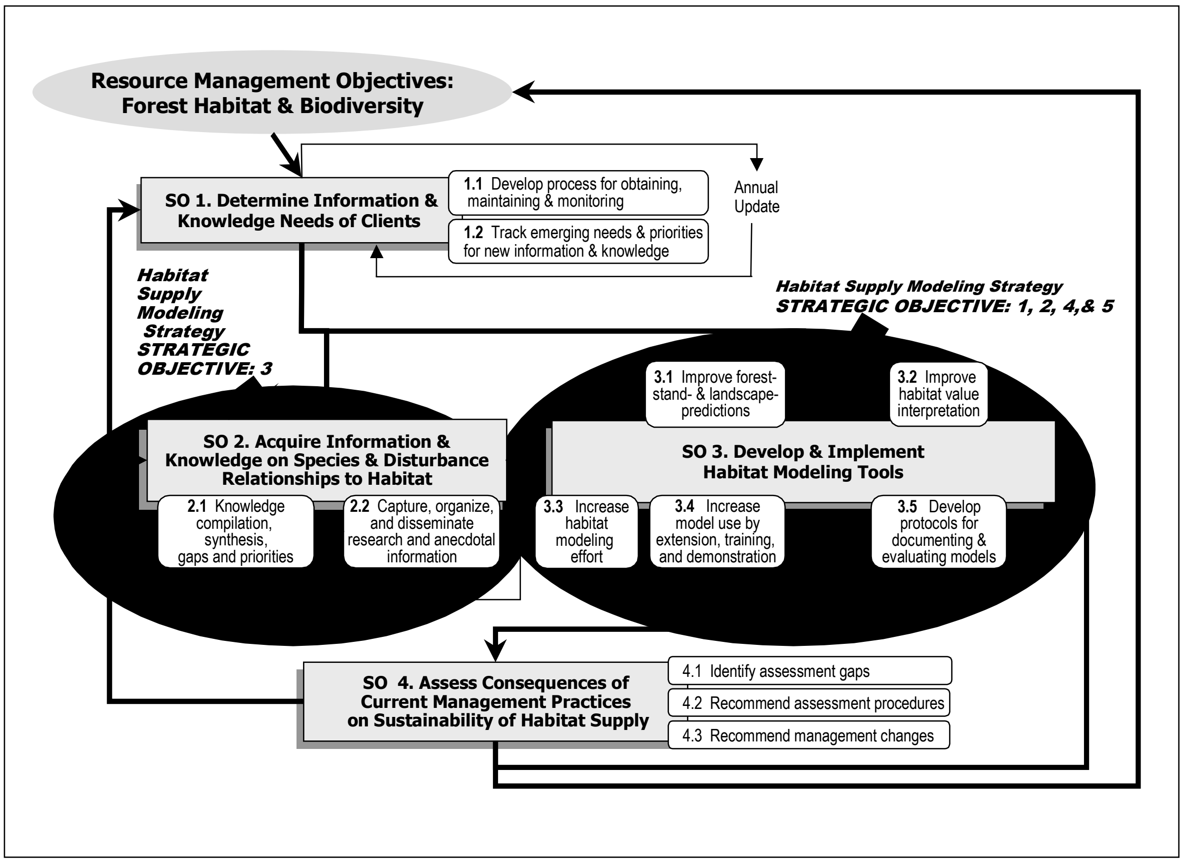


**Figure 7.1 The Strategic Objectives of the Habitat Supply Modeling Strategy support Strategic Objectives 2 and 3 of the Biodiversity Working Group, Forest Productivity Council.**

Following an assessment of the current state of existing modeling approaches, the development team should focus on designing, developing, testing, and delivering at least one fully completed modeling approach for each of the six Decision Types. By "fully completed" we mean in the broadest "modeling system" and "product" sense. This would include a well-designed and engineered modeling "engine" and input/output components; flexible interfaces for inputs, outputs, and model run parameterization; system documentation; user documentation; and interpretive reporting options and tools. For some Decision Types, as evident in Table 5.1, there are already some immediately available modeling approaches that may not require a lot of further development or documentation. The development and piloting of these model sets should be tied directly to an ongoing management planning need such as an LRMP, or may require targeted pilot projects.

This strategic objective is closely aligned with the ***Biodiversity Working Group's Strategic Objective 3: Develop and implement habitat modeling tools****, and* particularly with their sub-objective 3.3: *to increase the habitat modeling effort*.

### 7.2.3 Strategic Objective 3: To identify critical knowledge gaps regarding habitat–ecosystem thresholds and linking habitats to population response.

While considerable research in this area has been accomplished, continued efforts are needed as new gaps are identified with the model development activities (strategic objective 2). Researchers working to address this objective will probably need to focus on two key areas. First is the acquisition and synthesis of existing information on habitat–species relationships and habitat–ecosystem thresholds.

Second is the theoretical and practical basis for linking habitat to populations and consequently translating habitat information into interpretations regarding population response to management. This is particularly important for the application of models addressing Decision Types D, E and F.

This strategic objective is directly supportive of the ***Biodiversity Working Group's Strategic Objective 2 — Acquire Information and knowledge on species and disturbance relationships to habitat****,* sub-objectives 2.1: ***Knowledge compilation, synthesis, gaps and priorities*** and 2.2: ***Capture, organize and disseminate research and anecdotal information*****.**

### 7.2.4 Strategic Objective 4: To organize and maintain the modeling "toolbox," including the development of modeling protocols and standards to ensure consistency, quality, and broad access.

This strategic objective aims to put in place an important organizational and quality control infrastructure to support all HSM activities across the province. Some of the elements of such an infrastructure include:

**Development, implementation, and maintenance of a Habitat Supply Model Registry.** Using a standard format, the Registry would list all available modeling approaches that have been used to address various Decision Types. Table 3.2 provides an example of the kinds of model functional capabilities, system features, and performance capabilities that could be used to structure the Registry, and Appendix C provides a first approximation of a completed Registry for 18 modeling approaches. The Registry could be made available through the Internet so that modelers could enter and update the information. A Registry custodian would be required for maintenance and quality control.

**Development, implementation, and maintenance of a Model Evaluation Protocol.** This function would also include a mechanism whereby the Registry custodian could obtain an independent peer review of different modeling approaches entered in the Registry.

**Development, implementation, and maintenance of a Model Documentation Protocol.** While the Registry would focus on a summary of key descriptive attributes and features, this protocol would set minimum documentation standards for modeling approaches. Documentation is a critical and often neglected activity in model development. It becomes especially important with complex modeling approaches, as the number of people involved in model development increases and as the number of users and support requirements increases. There are several model components that should be fully documented: the concepts and processes being modeled; the overall design layout and relationships; system architecture; the standards employed; the input and output data model; implementation and installation procedures; hardware and software configuration; system optimization considerations; system and database administration; version control; and so on.

**Development, implementation, and maintenance of protocol and standard reporting format for the field testing and validation of model forecasts (indicators).** These procedures should be used to direct the ongoing improvement of modeling approaches. They should also be used to structure adaptive management processes that test resource management policies and regulations.

**Development, implementation, and maintenance of protocols for organizing species–habitat relationship information and natural or managed ecosystem succession information.** These procedures should be used as a way to bring together the array of existing and future information, perhaps in a manner similar to what has been done for the states of Washington and Oregon (Johnson and O'Neil 2001).

**Development, implementation, and maintenance of a protocol for the interpretation, presentation, and application of model analysis results.** This protocol will need to focus on the design of standard processes and reporting and visual formats and scripts that provide information in a meaningful manner to decision-makers. These procedures might also include a "user guide" and a checklist for decision-makers when using the results of HSMs. This item is particularly important for models that address Decision Types A, B, and C, since a key impediment to the immediate use of these models is currently poor and ineffective presentation of the interpreted

This strategic objective supports the ***Biodiversity Working Group's Strategic Objective 3 — Develop and implement habitat modeling tools****,* sub-objective 3.5**:** ***Develop protocols for documenting and evaluating models.***

### *7.2.5 Strategic Objective 5: To increase user and decision-maker capacity through the development and delivery of general and specialized training and demonstration packages.*

In response to the issues noted by the resource professionals (Section 4), it is clear that there is a critical need for increased effort focused on training and the demonstration of HSM using real-world examples. At least two "extension packages" need to be developed: one specifically targeted at a decision-maker audience, and another of a more general nature.

The decision-makers' package should be designed jointly by habitat and habitat modeling specialists, extension-training professionals, and a decision-maker who has benefited from the use of habitat supply models. This extension package should not be focused on the technical aspects of HSM. Rather, it should be focused on helping decision-makers and resource managers with understanding, interpreting, and applying model outputs to the planning process and the decisions they make. This decision-makers' package should emphasize those steps of the decision-making process that elucidate and structure the decision requirements, and that portray the decision trade-offs and risks through the use of modeling results.

Elements of the decision-makers' extension package would form a part of the general extension package; however, the general package would aim to have a broader appeal and would include the public as part of its target audience.

Both extension packages could be organized to reflect the structure of the Decision Type classification described in Section 3. Case studies from completed projects could be used to illustrate the analysis and interpretive process from "end-to-end." The existing modeling approaches listed in Appendix C provide an initial list of candidates across the range of Decision Types.

This strategic objective is directly aligned with the ***Biodiversity Working Group's Strategic Objective 3 — Develop and implement habitat modeling tools****,* sub-objective 3.4**:** ***Increase model use by extension, training and demonstration.***

# 8 Implementation Plan

The implementation plan is focused on turning the vision and strategic objectives described in Section 7 into an initial set of coordinated actions. In light of the inordinate level of change caused by new government directions, this plan is focused on a two- to three-year time horizon. This time frame is in line with the government's current budgetary time frame of 2002/03 – 2004/05. Since roles, responsibilities and delivery models within government and the private sector are in flux, the plan focuses on identifying the actions (what should be done) rather than on the responsibilities (who should do it) for actions.

Reinforcing the current Biodiversity Working Group Strategy, the steps outlined below are intended to put in place some critical foundation components and processes to support HSM in a manner similar to what was done for timber supply analysis a few years ago. The plan concentrates largely on bringing together a number of currently disparate sets of expertise, knowledge, tools, and procedures.

The implementation plan provides two options. Option 1, developed by the HMSC has a near-term focus (6 months to 1 year) and employs an incremental approach.

Option 2, developed by the consulting team, takes a longer-term view (2-3 years) and advances a bolder agenda for addressing the strategic objectives. The two plans are referred to as options, but could be viewed as being somewhat sequential.

## 8.1 Prerequisite Considerations

With the completion of this strategy, an important transitional step will be for senior executive in MWLAP, MSRM, and MOF to endorse the directions advanced in the strategy and to take "ownership" and responsibility for championing its implementation. Commitment at this level is essential if the full value from the investment in the strategy is to be realized and the momentum continued. Assuming the strategy is endorsed generally, senior executives will need to consider the implementation options and steps outlined below in the context of the following: the current situation in government; new program and delivery model directions; and relationships with its partners.

Given the significant changes within government over the past year, roles and responsibilities for many functions in MWLAP, MOF, and MSRM need to be clarified among the respective Service Plans, including those related to HSM. To address this, the government needs to establish some form of "**Inter-Agency Steering Committee**" (hereafter referred to as the *Steering Committee*) at least at the director level[15]. This kind of governance group will be essential for sorting out the different mandates, roles, and responsibilities regarding habitat supply-related needs and services within government. It is presumed that this Steering Committee would, in

[15] For example, MSRM has recently established an Integrated Steering Committee (ISC) to deal with related inter-agency issues. The ISC includes external representation from WLAP, MOF, and other ministries for selected meetings. An inter-ministry governance structure at the Assistant Deputy Minister level would also be helpful. At the Deputy Minister Level there is a Deputy Minister's Committee on Natural Resources and the Economy.

turn, report to some form of higher-level inter-agency governance body[16]. It is important to note that the government is currently reviewing options for establishing effective governance models for serving the needs internal to government, as well as between government and other private and public sector organizations.

Finally, an important consideration in the spring through fall of 2002 will be to assess the impact of the new Results-Based FPC on the strategy implementation, again in terms of changing requirements, roles (functions), and responsibilities between government, industry, and the private sector[17].

## 8.2 Option 1: Near-Term

Option 1 is focused initially on obtaining a more coordinated HSM effort across the natural resources ministries within government. Progress in this area would in turn set the stage to expand these coordination efforts beyond government involving industry, academia, NGOs, and other parties.

The primary steps identified for Option 1 are outlined below.

### *8.2.1 Step 1: Establish an Inter-Agency Habitat Supply Modeling Technical Committee*

The **Inter-Agency Habitat Supply Modeling Technical Committee** (hereafter referred to as the *HSM Technical Committee*) would receive its mandate from and report to the Steering Committee. In effect, the HSM Technical Committee would provide a similar role to what has been provided in the past by the former HMSC. The main purpose of the HSM Technical Committee would be to coordinate HSM activities of a technical nature within the provincial government. These activities would include model development, applications, standards and protocols, interpretation, presentation, training, demonstration, and so on. The HSM Technical Committee would respond to issues and action items identified by the Steering Committee regarding HSM, particularly those identified in this strategy (i.e., the strategic objectives, implementation plan, and recommendations), and possibly those identified in the BWG Strategy and Implementation Plan regarding HSM.

### *8.2.2 Step 2: Recruit Habitat Supply Modeling Manager*

In order to provide dedicated resources to respond to the needs identified by the HSM Technical Committee, a **Habitat Supply Modeling Manager** (hereafter referred to as the *HSM Manager*) will need to be recruited. The HSM Manager should have a broad understanding of the HSM business area and be experienced in championing and delivering inter-ministry initiatives. Logically, the HSM Manager would serve as chair for the Technical Committee. The HSM Manager will provide an essential role in formulating and sustaining a cooperative environment, driving a progressive collaborative HSM agenda, and providing an overall leadership and coordination function.

[16] For example, a group of Assistant Deputy Ministers similar to the Joint Steering Committee involving MSRM, MOF, and MWLAP. Note that at the Deputy Minister level there is presently a Deputy Minister's Committee on Natural Resources and the Economy.
[17] For more information, see website: http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpc.htm.

### 8.2.3 Step 3: Establish Habitat Supply Modeling Advisory Council

While it will be important initially for the provincial government to improve the coordination of HSM efforts internally among the natural resource agencies, these efforts will soon need to expand to include partners outside the provincial government. This will be especially important as the government aims to create more public-private partnerships involving industry, NGOs, academia, First Nations, and so on. To facilitate this broader cooperation, it is proposed that a **Habitat Supply Modeling Advisory Council** (*HSM Advisory Council*)[18] be established. The HSM Advisory Council would have representatives from across the range of HSM clients and stakeholders. The role of the HSM Advisory Council would be to provide both strategic and high-level technical advice to HSM initiatives throughout the province. The HSM Advisory Council should comprise a mix of HSM-related experience, including strong representation from both HSM users and decision-makers.

In time, the HSM Advisory Council would probably subsume the role of the HSM Committee. The HSM Manager would serve a similar role for the HSM Advisory Council as she/he did for the HSM Committee (secretariat and "staff" function). However, the chair of the HSM Council should probably be someone other than the HSM Manager. To be most effective, the HSM Advisory Council should have a mandate from, and report to, a senior executive governance body representing key HSM stakeholders in the public and private sector[19].

### 8.2.4 Step 4: Formulate a Work Plan

Following the establishment of the HSM Technical Committee and/or Advisory Council, a work plan will need to be developed by the HSM Manager under the guidance of the Committee/Council. The work plan should lay out a detailed action plan based on this strategy, implementation plan, and recommendations. It should first consider the implications of any recent changes that will have occurred since the preparation of this strategy. It should then identify a set of projects, task series, dependencies, milestones and deliverables; performance measures; resource requirements; a budget; and a schedule to March 2005. The initial work plan should be detailed for the first year (i.e., an annual work plan), and more general for subsequent years. It will need to be updated annually and should include performance assessment and reporting to the Steering Committee and/or broader governance body as noted in Step 3.

## 8.3 Option 2: Longer-Term

This second option advances a bolder and longer-term agenda for addressing the HSM issues identified in this strategy. The time frame for Option 2 is approximately two to three years. It begins with the formation the HSM Advisory Council and an HSM "Institute" focused on coalescing much of the current HSM effort, and on focusing future work towards critical modeling and supporting infrastructure gaps. Past this time period, effort can shift to more of a maintenance and continuous improvement mode. This is not to suggest that all aspects of HSM will have been addressed fully by this date. However, by that time we expect a number of the critical elements of the strategy will be well underway, with some positive outcomes and benefits starting to be realized.

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[18] The term "council" is used to mean a multi-stakeholder group involving representatives from both within and outside the provincial government. The term "committee", in contrast, is used being used to mean an internal provincial government group.

[19] One possibility might be a group like the Forest Investment (Account) Council.

### 8.3.1 HSM "Institute"

A central element of Option 2 is the proposed formation of an *HSM "Institute."* It is important to note that this is not meant to be an institute in terms of "bricks and mortar." Rather, this goal aims to establish an "organization or society for some special purpose;" in this case, to address the HSM issues and needs identified in this strategy. While institutes vary in terms of their structures and functions, this institute will create a venue where multiple parties with a stake in HSM can participate, contribute resources and expertise, and advance the overall state of HSM across the province.

As an example, one of the consulting team members used to work as a federal government employee under the umbrella of the Ontario Institute of Pedology (OIP). The OIP was focused on soil survey, soil research and soil extension, and comprised approximately equal numbers of federal, provincial, and university staff[20] who worked together on many different projects. Funding from federal, provincial, and university sources together with significant leveraged funds from other sources (administered through the University of Guelph) provided a platform for a well-coordinated and well-resourced soil survey program for Ontario. The OIP operating model created a leveraged and synergistic partnership environment, something that no single agency could have achieved on its own.

For HSM, an institute with similar objectives could be formed for BC, and could assemble and coordinate a critical mass of HSM expertise. It would also enable a focused and dedicated effort to address the priority needs identified in this strategy, as well as the modeling components of the Biodiversity Working Group Strategy.

### 8.3.2 Implementation Steps

Based on the Strategic Objectives described in Section 7, the implementation steps below are proposed for Option 2. Some of the initial steps are formative, while subsequent steps focus on developing the models and modeling tool-kit. The initial activities are staged (inter-dependent), while other supporting efforts will probably be concurrent. The general scheduling considerations and relationships are shown in Figure 8.1 in Gantt format.

#### Step 1: Establish a Habitat Supply Modeling Advisory Council

This is relatively comparable with Step 3 in Option 1. In Option 2 the HSM Advisory Council would have the principal function of guiding the implementation of the HSM Strategy. In so doing, the Council would provide an essential governance and advisory role for the HSM Institute. The HSM Advisory Council's membership would include a representative set of key client-stakeholders — for example, provincial and federal governments, industry, the university research community, First Nations and NGOs. The Council would need to meet frequently in the first year to properly launch the HSM Institute. It would report regularly on its progress to either some form of inter-ministry executive committee or to a multi-stakeholder executive council represented by government, the private sector, First Nations, and NGOs (see also the discussion in Section 8.1).

The HSM Advisory Council's terms of reference and performance would be tied directly to the accomplishment of the HSM strategic objectives. In support of the director for the HSM Institute, the Council would provide ongoing strategic direction across the range of Institute

[20] In the case, all working mainly out of the same location.

activities. Through its collective access to various resources and partnerships, the Council would help the director secure the necessary resources to ensure an effective and efficient delivery of the Institute's annual work plan.

### *Step 2: Recruitment of Director for the Habitat Supply Modeling Institute*

The recruitment of an effective director will be critical to the Institute's success. Leadership, dedication, drive, perseverance, and a positive style will be essential attributes for the director. He or she will need to create an innovative, productive, and accountable environment for the participants and partners. Other critical skills for the director will be team building, coordination, creating and maintaining collaborative relationships, program/project management, and administration. The director's activities will be focused on implementing the strategy and in particular, the design, development and packaging of practical HSM "products."

The director would serve as secretary to the HSM Advisory Council. He or she will play an important role in driving and coordinating the Council's agenda. At the operational level, the director will be the most senior project management authority. He or she will be responsible first for assembling the multi-disciplinary development team described in Section 7.2.2 and for the recruitment of the knowledge engineers (i.e., step 4 below)

### *Step 3: Selection of Demonstration Project Applications*

Given the strategic objective (1) of having a demonstration project for each Decision Type, a key consideration will be the selection of appropriate projects. A practical approach will probably be to build upon existing HSM projects, especially those that are linked to addressing the immediate-term priority application areas outlined in Table 8.1. Candidate projects are summarized in Appendix C.

### *Step 4: Recruitment of Knowledge Engineers*

Under the leadership of the director, this step involves the recruitment of a high-calibre team of knowledge engineers to develop, complete, or enhance the HSMs across the range of Decision Types. The HSM Institute may hire some individuals, while others may come via one- to two-year secondments. It is envisioned that in total there will be a need for between three and six knowledge engineers who will serve as project leaders and modeling system designers. For example, one knowledge engineer might handle development models to address Decision Types A and B (Coarse Filter: Landscape–Ecosystem), another might handle Decision Type C (Fine Filter: Stand-level), and a third might handle Decision Types D, E, and F (Fine Filter: Guild–Single Species).

### *Step 5: Assembly of Pilot Project Teams*

With the advice and guidance of the knowledge engineer project leaders, the director will assemble a multi-disciplinary team for each pilot project. The multi-disciplinary team members will be drawn from staff within government and other partner organizations.

### *Step 6: Building of Habitat Supply Models*

Under the direction of the knowledge engineers, the different working groups will focus their attention and resources on the assessment, design, building, and documentation of functional habitat supply models. The design phase of the process will be exceptionally important.

Invariably, sound efforts expended at the design stage will yield large returns when it comes to the generation of the final products. Well-proven system engineering principles should be followed. It will be important not to design single “one-off” solutions. Wherever possible, problems should be abstracted and modularized so that common classes of problems can be handled. This may mean that some existing models should be viewed more as prototypes that will need to be restructured into more modular and parameterizable modeling systems. Typically these kinds of model designs can be applied to a wider range of ecological settings and output requirements.

### *Other Concurrent Activities*

Concurrent with the above tasks, the actions listed below need to be undertaken to address other aspects of the strategy. (Please note that this list is not exhaustive.)

A. Develop and implement protocols listed under Strategic Objective 4. A first approximation of many of these should be completed as quickly as possible with subsequent revisions based on their initial piloting. To support and maintain these protocols, an appropriate custodian will need to be identified and resourced.

B. Design and develop basic HSM training packages for general practitioners and for decision-makers that is linked to and uses the application priorities outlined in Table 8.1. (Strategic Objective 5).

C. Deliver the basic training program, perhaps via the Forestry Continuing Studies Network (FCSN) and the Forest Research Extension Partnership (FORREX) (Strategic Objective 5).

D. Design and develop a “Using Model Results” operational training package targeted at decision-makers and their resource analysis and planning support staff. (Strategic Objective 5).

E. Deliver the “Using Model Results” operational training package perhaps via FCSN and FORREX. (Strategic Objective 5).

F. Identify knowledge gaps to address critical modeling needs. (Strategic Objective 3).

G. Monitor all HSM Institute program areas including progress on the operational implementation and use of modeling results.

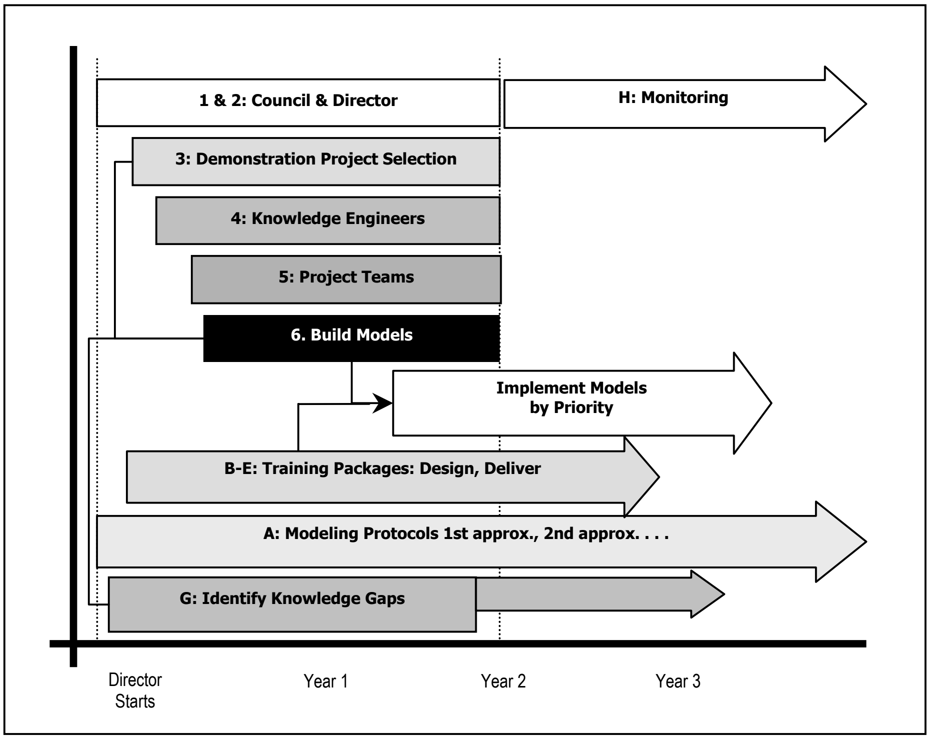


**Figure 8.1 General sequencing of implementation activities over the next two- to three-year period under Option 2.**

## 8.4 Target Clients/Beneficiaries

Table 8.1 provides a consideration of which current client–program areas are likely to most benefit, and should therefore be a priority for HSM development.

**Table 8.1. Anticipated natural resource program area priorities for HSM support over the next five years.**

| Sector | Program Area or Entities | Priority over next 2 years (immediate-term) | Priority after initial 2 years (mid-term 2-5 years) |
|---|---|---|---|
| **GOVERNMENT** | **Resource Planning** (e.g., Resource Planning Div., MSRM)<br>❑ LRMPs: allocation, zones, targets, etc. (Decision Types: A, B, E, (D)) | High | Low (plans completed) |
| | ❑ Landscape Unit Planning (Decision Types: A, B, E, (D)) | Medium | Low (plans completed) |

| Sector | Program Area or Entities | Priority over next 2 years (immediate-term) | Priority after initial 2 years (mid-term 2-5 years) |
|---|---|---|---|
| | ❑ Working Forest Definition | High | Low |
| | ❑ Timber Supply Review (Chief Forester) | High | High |
| | **Environmental Stewardship** (e.g., Environmental Stewardship Div., MWLAP)<br>❑ Wildlife (Identified) – setting of standards (Decision Types D, E & F)<br>❑ Ecosystems, including monitoring | High – Medium<br>High – Medium | High<br>High |
| **INDUSTRY** | **Management Unit Level Plans** (TFLs, TSAs) models will become a part of their evidentiary basis for to address Results-Based Code<br>**Timber Supply Review** | Low<br>High | High<br>High |
| **NON-GOVERNMENT Organizations** | **Independent application of models.** | Medium | High |

# 9 Recommendations

The following nine recommendations draw from the key issues identified during the strategy development process, particularly those noted in Section 4. These recommendations are also advanced to support the strategic objectives and implementation plan options (with an emphasis on Option 1) provided in Sections 7 and 8 respectively. The recommendations are grouped into six general topic areas.

## Habitat Supply Modeling Strategy Workshop

**Recommendation 1: The provincial government (MWLAP, MSRM, and MOF) and the forest industry should sponsor a Habitat Supply Modeling Strategy Workshop soon in order to communicate and obtain feedback on the proposed strategy directions, the implementation options, and recommendations.** A province-wide habitat supply workshop to discuss the HSM strategy would encourage continued and broader discussion on how best to realize improvements in HSM approaches, particularly with reference to new responsibilities and delivery models in government and industry. The workshop could follow the general structure of the strategy report, and could also include breakouts on key topics such as the Decision Type classification, barriers to the use of HSM, the proposed Model Registry, and alternative governance/advisory structures for HSM. Such a workshop would also fill the need for follow-up identified by participants at the February 2001 session Richmond.

## Decision-Making

**Recommendation 2: Habitat supply modeling should be a standardized analytical procedure that is used to assess habitat supply and habitat values in a manner parallel and at least equivalent to the approaches being used for timber supply analyses.** This will provide a mechanism for dealing with habitat supply issues that is equivalent in credibility and rigour to methods used for timber supply analysis. This process should include a similar range of elements, such as necessary data sources, reliability requirements, and required habitat and population analyses. The process would also have a specified period for public review prior to release of the final decision and rationale. Use of habitat supply modeling results in timber supply analyses will also provide greater public credibility for the timber supply review process

**Recommendation 3: Habitat supply modeling approaches should incorporate the use of ecological benchmarks and environmental thresholds when reporting on analysis results.** Effective interpretation and presentation of habitat supply assessment results are as important as the assessment results themselves, risk analysis and interpretation being an essential component. Key aspects of risk assessment are the identification of appropriate benchmarks against which to assess risk, and the development of environmental risk thresholds. Model outputs, therefore, need to show absolute or relative risk, which can, in turn, contribute to trade-off analyses and decisions. While these features are preferable, it is acknowledged that the identification of benchmarks and thresholds requires careful analysis and consideration.

## Inter-Agency Cooperation and Coordination

**Recommendation 4: A cooperative agreement needs to be established between the natural resources agencies (MWLAP, MOF, MSRM and possibly others) regarding the coordination of HSM-related activities within government.** The agreement should aim to promote collaborative opportunities, describe roles and responsibilities, and increase the efficiency and effectiveness of all aspects of modeling, including development, testing, registration, application, interpretation of results, demonstration, and training. The cooperative agreement should be prepared by an *Inter-Agency Habitat Supply Modeling Technical Committee* (see recommendation 6) for consideration and approval of some form of *Inter-Agency Steering Committee* at the director level or higher.

**Recommendation 5: The provincial government should form an *Inter-Agency Habitat Supply Modeling Technical Committee* with representatives across the provincial natural resources agencies.** The Committee would provide a coordinating, advisory and advocacy function for HSM within the provincial government and beyond. The Committee, as their first order of business, would prepare a cooperative agreement between the provincial natural resources agencies (see recommendation 5). The Committee would take on the previous role of the ad-hoc Habitat Modeling Steering Committee (HMSC) and, if appropriate, be responsible for guiding the implementation of the habitat modeling component of the Biodiversity Working Group Strategy (under the Forest Productivity Council). The Committee should operate under the authority of, and report regularly to, some form of Inter-Ministry Steering Committee (see recommendation 5). With the provincial government providing the initial lead, other participants in the modeling community should be subsequently included as a basis for establishing broader partnerships and expanding coordination across the HSM community in the province. The Inter-Agency Habitat Supply Modeling Technical Committee may evolve to become a *Habitat Supply Modeling Advisory Council* which would include representation from the public sector, private sector, First Nations and NGOs.

**Recommendation 6: The provincial government should establish a high-calibre technical habitat supply modeling team, led by a dedicated manager and champion, that can focus on priority model development needs, offer expert advice and provide technical leadership.** The function and form of the group might be similar to what was established for timber supply analysis in MOF a few years ago. The work program of the team could be guided by the Inter-Agency Habitat Supply Modeling Technical Committee (or the Habitat Supply Modeling Advisory Council, depending on which group is providing the oversight function). The modeling group champion should also serve as the chair for the Inter-Agency Habitat Supply Modeling Technical Committee.

## Standards and Protocols of and Demonstration of HSM

**Recommendation 7: The provincial government should establish a set of habitat supply modeling protocols and standards to ensure consistency, quality, and broad access to existing models.** The protocols and standards should address the following:

- Model evaluation;
- Model documentation;
- Field testing and validation of model forecasts;
- Organization of species-habitat relationship information and natural or managed ecosystem succession information;
- Interpretation, presentation, and application of model analysis results; and
- Baseline information

## Model Registry

**Recommendation 8: The provincial government should establish a habitat supply model registry that includes a standard and required set of features to be used for characterizing existing and new models.** To allow broad and easy access, the registry should be web-based. Since most models are developed as a result of specific project needs, an associated project registry would allow further elaboration of the model and modeling approaches. In addition to the standard characterization framework, which will allow for model comparisons, a practical model evaluation tool should also be a part of the registry system.

## Training and Demonstration

**Recommendation 9: Under the direction of the Inter-Agency Habitat Supply Modeling Technical Committee, the provincial government should develop and deliver general and specialized training and demonstration packages for habitat supply modeling.** The specialized training package should be targeted at a decision-maker audience. The general training package should deal with habitat supply modeling in a broad manner and be suitable for general public audiences.

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