A Status Assessment of
Non-timber Resource Modelling

WP-1.5-001

Working Paper

CANADA~BRITISH COLUMBIA PARTNERSHIP AGREEMENT ON FOREST RESOURCE DEVELOPMENT: FRDA II

Canada

BC

A Status Assessment of
Non-timber Resource Modelling

WP-1.5-001

Prepared for

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March 31, 1994

Abstract

Throughout North America, forest managers and research scientists are increasingly challenged by the need for information on non-timber resources. These are broadly defined for this review as forest functions, characteristics, and products other than timber which need to be considered in land management decisions. This review focused on models and decision support tools that predict or assess stand-level non-timber resources using information from growth and yield models and other sources and that are potentially applicable to British Columbia. Non-timber resources that are addressed in this review include over- and understory plant biomass, wildlife habitat, wildlife cover, bio-diversity, views, and forest insects and diseases. Although the prediction and modelling of non-timber resources has only recently received increased attention, there is a wide body of scientific expertise upon which to build future research activities. Many of the examples presented here demonstrate that it is possible to combine ecological, edaphic, and growth and yield information for the successful prediction of non-timber resources. Although there are specific examples of models for many different non-timber resources, these are typically limited to one or a few narrowly defined ecological and geographics regions, mostly outside British Columbia. What is generally missing, are systematic modelling approaches with multiple parameter sets that tie the models to existing ecosystem or forest habitat classifications and thus make them geographically more widely applicable. Many models are in their early life stages or under development and lack (in)validation and verification against field data. If a continued increase in the demand for non-timber resource assessments in forest management decision making in British Columbia is correctly anticipated, then there will be a growing need for better prediction and simulation tools that can support the decision-making process. Although much new work will be required, the development of non-timber resource models can build upon existing simulation tools that predict overstory characteristics and dynamics originally developed for growth and yield forecasting.

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1.0 Introduction

There is an increased need to consider resources other than timber in forest management decision making. "Non-timber" resources include wildlife, water, visual aesthetics, plant biomass, biodiversity, and other forest functions. The increasing economic significance of some non-timber resources in B.C. has recently been reviewed (de Geus 1993). That report also recommends that these resources be further integrated into resource management planning. This will create further need for tools with which to project the dynamics of non-timber resources as affected by forest dynamics and land management decisions.

Because of the traditional emphasis of forest scientists and managers on timber production, a large body of knowledge has been accumulated on the growth dynamics of forest stands as measured in timber basal area, wood volume, and number of trees per hectare. The scientific foundations of this knowledge are innumerable measurements in temporary and permanent sample plots that have been compiled in traditional yield tables and growth and yield models.

One of the primary purposes of this status assessment is to identify how indicators of non-timber resources are derived or simulated using information that has been compiled through growth and yield research. This review explores evolutionary steps towards modelling non-timber resources that build on existing knowledge.

Non-timber resources can be assessed both at the stand and at the landscape level. The emphasis of this review is on stand-level resources. Some of these are simply accumulated to obtain landscape-level information. Others require additional spatial information, such as the juxtaposition and distance between stands (and resources). One of the implications of the broadening objectives of forest land management decision making has been the increased need to recognize larger spatial scales (forests, watersheds, and regions) and longer time horizons (decades to multiple rotations). Both requirements are best addressed through computer simulation models that can manage the large quantities of data associated with the decision-making process.

This status assessment has been conducted with a narrow scope and a very limited time schedule. It must therefore be viewed as preliminary. Questions or comments about this report should be addressed to Dr. Mike Bonnor (Canadian Forest Service, 604-363-0600, Fax 604-363-0775) or Dr. Werner Kurz (ESSA Technologies Ltd., 604-733-2996, Fax 604-733-4657).

2.0 Methods

This project was initiated with a scoping meeting and a review of the objectives of this assessment. The purpose of this review is to provide an overview of the ongoing activities in the modelling of non-timber resources, with primary emphasis on those non-timber resources that can be inferred from stand-level information. Moreover, the review is to identify where non-timber resource models have built upon and made use of existing growth and yield information.

This status assessment is based on three primary sources of information:

1.　a series of interviews with researchers in government, industry, and universities;
2.　published and unpublished reports; and
3.　the professional experience of the authors.

We compiled an initial list of contacts in the modelling community. After establishing a preliminary contact with the scientists and professionals, we faxed information material to those who agreed to further interviews. Only one person who has not been directly involved in non-timber resource model development was unable to participate in the more detailed interview. The information from the interviews was compiled in a standard format (see Appendix 1). Many interviews led to additional suggestions for scientists working in the field of non-timber resource modelling. A complete listing of the agency contacts is included in Appendix 2.

The emphasis of this review was on stand-level non-timber resource models, but the review was not limited to those models. Examples have been included to demonstrate the range of modelling activities that relate to non-timber resource projection for different resources at various spatial and temporal scales. The 20 models selected for more detailed descriptions in this report appeared to be those most relevant to the objectives. We are at present unaware of any other stand-level non-timber resource models that are of relevance to British Columbia.

3.0 Results and Discussion

The non-timber resource modelling community contacted in this assessment is acutely aware of the rapid increase in demand for predictive tools that assist in forest land management decision support and assessment of management options. Throughout North America, the need to project the implications of alternative land management options in terms other than timber yields is driving the development of models and decision support tools.

In this assessment, we selected 20 models from references in the literature and through interviews with members of the modelling community. Table 3.1 provides an alphabetic listing of the model names and the spatial scales at which they operate. Appendix 1 contains detailed descriptions of each of the models listed in Table 3.1.

Spatial scales and additional information requirements for the prediction of selected non-timber resources are summarized in Table 3.2. This table demonstrates the central role of growth and yield (and forest dynamics) information for the assessment of many non-timber resources. The Table also emphasizes additional information requirements for all resources.

Table 3.3 summarizes examples from Appendix 1 and the literature of non-timber resource models that operate at the stand level, use input data that can be generated fully or in part from growth and yield model information, and generate output indicators that are used in non-timber resource assessments.

The state of non-timber resource models reviewed for this assessment is very uneven: wildlife models have been developed for some years now and considerable progress has been made; models for other resources are often in early stages of development. For example, models for the prediction of biodiversity and its change over time as affected by natural forest dynamics and forest management are only now being developed and we did not find any completed models. We found no models for other resources, such as berries, mushrooms, and plant components, which are increasingly utilized for personal and commercial reasons (de Geus 1993).

The state of the NTR models often depends on the complexity of the resource they are trying to project. For example, snags which provide habitat for birds and other animal species can be simulated relatively easily building on growth and yield models that represent tree mortality. Other resources such as animal cover, understory plant species composition and biomass, or stand views that can be derived readily if overstory conditions are known have been modelled in some instances. Animal population dynamics are affected by forest conditions and many other factors (e.g., hunting pressure, migration patterns, habitat changes in other areas, weather, predation) and only a few models have gone beyond the description of habitat suitability.

The prediction and assessment of non-timber resources in forest land management requires an understanding of forest ecosystem structure and function. Non-timber resource models therefore often require detailed information on stand composition and structure. A common approach to NTR models is to build upon existing information of forest conditions and to invoke rules and algorithms with which non-timber resources are inferred from stand-level data as

provided from growth and yield models. The more sophisticated the underlying forest ecosystem dynamics "engine", the more comprehensive the available data from which additional information can be inferred. Non-timber resource models in this review build upon a wide range of forest dynamics models from static assessments of the forest resource which do not attempt to project any change in forest conditions over time to sophisticated models of forest dynamics such as FVS, TASS, or ZELIG.

Table 3.1: An alphabetical listing of the models described in detail in Appendix 1 and the spatial scale at which they operate.

Model	Level of Assessment
Annosus/bark-beetle extension to the forest vegetation simulator (FVS)	Stand
Biodiversity impact assessment (BIAS)	Landscape
BIOPAK	Individual plant/Stand
Coastal temperate rainforest model (CTR)	Landscape
COVER	Stand
DDTSL	Stand
Dwarf mistletoe spread and intensification model	Stand
Ecosystem supply for forest bird populations	Stand/Landscape
ELK COVER	Stand
Foothills forest decision support systems	Stand/Landscape
GRAFFVS	Stand
Habitat assessment and planning tool	Landscape
Moose habitat and population spatial analysis model	Landscape
New Brunswick habitat model	Stand/Landscape
ROTSIM	Stand
SIM FOREST	Landscape
Snag recruitment simulator (SRS)	Stand
Wildlife habitat handbook models	Landscape
ZELIG.BC	Stand/Landscape
ZELIG.MFG	Stand/Landscape

Table 3.2: Spatial scales and information requirements for selected non-timber resources. The table demonstrates the central role of growth and yield (and forest dynamics) information for the assessment of many non-timber resources. Note also the additional information requirements for all resources.

Resource	Assessed at	G&Y Model Input	Other Requirements
Wildlife Cover	Stand level	Yes	Observation points
Wildlife Habitat	Landscape level	Yes	Infer food quality from overstory characteristics, successional stage, spatial arrangement of stands
Wildlife Populations	Landscape level	Potentially Yes	Habitat (see above) and many other factors
Snags	Stand level	Yes	Snag dynamics, fall down rates, decomposition, cause of death (e.g., root disease)
Understory Plants	Stand level	Yes	Overstory characteristics, ecosystem classification, site, predictive rules, successional stage, disturbance history
Berries	Stand level	Yes	Overstory characteristics, ecosystem classification, predictive rules, successional stage, disturbance history
Mushrooms	Stand level	?	Successional stage, disturbance history
Biodiversity	Stand level	Yes	Overstory characteristics, ecosystem classification, predictive rules, successional stage, disturbance history
Biodiversity	Landscape level	Yes	Need to integrate stand-level data on forest dynamics, information on understory species and wildlife habitat, spatial arrangement of stands
View, scenic values	Stand level	Yes	Detailed data on stand structure & species composition (over- & understory), disease status (e.g., mistletoe, root disease)
View, scenic values	Landscape level	Yes	Forest cover, spatial arrangement of stands, digital terrain models, insect & disease status (e.g., mountain pine beetle)
Recreation activities	Landscape level	?	Scenic values, access, terrain

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Table 3.3: Examples of non-timber resource models that operate at the stand-level and build upon growth and yield and other information sources.

Resource	Predicted from	Output Indicators	Examples
Wildlife			
Elk Cover	FVS stand data user input	Percent cover	ELK COVER, USDA FS
Snags	Mortality rates of trees, Growth and Yield output	Snag density and diameter class	DDTSL, B.C. M. of Forests SRS, USDA FS
Goshawk Habitat	Stand data, Reinecke's stand density index	Suitability of stand as goshawk nesting habitat	Lilieholm et al. 1993
Plant Biomass			
Understorey Plants	FVS stand data, edaphic data, habitat type,	Various plant attributes	COVER, Moeur 1985
Plant Biomass	Plant dimensions	Plant biomass and other indicators	BIOPAK, J. Means pers. comm.
View			
Stand appearance, side view	FVS data	Colour graphics display side view of stands	GRAFFVS, USDA FS W. Shepard, pers. comm. 1994
Stand appearance, top view	Stand table data, FVS, trees per acre	Top profile view of stand	FORSEE II, USDA FS
Scenic Beauty	Forest Inventory data	Index of scenic beauty inside stand	Brown and Daniel 1986
Water			
Water yield	Forest cover type, BA, density, harvesting, geographic data, meterological data	Evapotranspiration seasonal net precipitation water yield	WRENSS, Bernier 1990.

The Forest Vegetation Simulator (FVS, formerly called Prognosis, Stage 1973; Wykoff et al. 1982) with its many model extensions provides an example of an incremental approach to the forecasting of timber and non-timber resources. Although its "engine" is a traditional growth and yield model, the extensions that are in use and under development provide a set of tools that greatly enhance the suitability of FVS to land management decision making. Extensions are available that simulate stand establishment (Stage 1973), growth and stand conditions as affected by pest and disease impacts (Stage et al. 1990; McNamee et al. 1991), that infer the understory species composition and biomass from overstory and site conditions (Moeur 1985,1986), that assess wildlife habitat conditions including snag dynamics (see SRS in Appendix 1), and that provide a graphical representation of stand conditions for their visual assessment (see GRAFFVS in Appendix 1). Moreover, with the Parallel Processor Extension (PPE) (Crookston and Stage 1991), many stands can be simulated "concurrently" to represent landscape-level forest dynamics.

This in turn permits the simulation of contagion processes such as the mountain pine beetle (McNamee et al. 1993). The results from each stand-level FVS simulation can then further be used to infer non-timber resources at the landscape level.

Two different approaches are commonly used for the development of stand-level non-timber resource models that are linked to growth and yield models. The NTR-models either become a module or extension of the growth and yield model or they are a post-processor of output generated by the growth and yield model. The former approach is more complex to implement but allows for interaction between the extension and the growth and yield model. The latter approach, however, may be adequate for many NTR models, e.g., snag dynamics, understorey composition, and some wildlife habitat indicators.

The integrated approach chosen by the FVS program of the USDA Forest Service ensures that multiple non-timber resources can be inferred from the same forest vegetation dynamics model. The assessment of various resource values can thus build on the same set of assumptions and scenarios of forest dynamics. This is an additional benefit of the integrated approach, because in the past, resource assessments were sometimes conducted using different scenarios of forest dynamics for resources in one analysis.

Many non-timber resource models require information about stand dynamics and vegetation characteristics from the time of stand establishment through all stages of stand development to disturbance and stand replacement. Most growth and yield models emphasize the stages following stand establishment to maturity, but they often do not address stand establishment with its competitive and often stochastic processes, and they do not address the stand break-up stages. If growth and yield models are to be used as a component of non-timber resource models, their ability to simulate all stages of forest dynamics will have to be examined carefully and, in some cases, may have to be further enhanced.

Moreover, prior to using any growth and yield model, it must be confirmed that the spatial and temporal scales and resolution at which it provides information satisfy the requirements of the NTR models (Stage 1991). For example, growth and yield models that operate at the stand level of organization may not be able to provide information at the individual tree level that may be required by some NTR models.

Technological developments are providing new opportunities for NTR modelling: the arrival of GIS facilities, powerful computers, and the ability to process large amounts of spatially explicit information provide new possibilities for NTR-modelling at the forest and landscape-level. In particular, wildlife models have begun to take advantage of the spatial information contained in harvest scheduling tools. As these provide information on forest cover and forest characteristics in a landscape, tools have been developed that interpret habitat conditions from stand conditions and spatial information (distances between food and cover, fragmentation, etc.).

Although several models for non-timber resource assessment have been developed, their operational use is often rather limited. Some models have been developed mainly for research purposes and their use and interpretation of results requires extensive knowledge and input data. Whenever people other than the developers are intended to become model users, the models must be simple and the results easily understood. For those models, input data must be obtainable and

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user training and technical support must be provided. In the past, this has been frequently a deficiency of model development programs that were based on the assumption that building the models was sufficient to get user acceptance. Without technical support and model maintenance, the use of models will remain limited and their potential to support resource management will not be utilized.

4.0 Conclusions and Recommendations

This review presents examples where non-timber resources have been predicted with tools that build upon traditional stand inventory and growth and yield information. In many cases, standard timber inventory and growth and yield information has been combined with other information sources such as ecological classification, edaphic conditions, and with models (simulation, regression equations, rule bases) that link the available information. It therefore appears possible that, at least some non-timber resources can be predicted with tools that build upon existing data bases rather than requiring an entirely new approach.

Although there are specific examples of models for different non-timber resources, these are typically limited to one or a few narrowly defined geographics regions, mostly outside British Columbia. Some of the existing models can be reparameterized and thus become applicable to some ecological regions of B.C., but there has been no attempt yet to systematically assess the suitability of existing models for B.C. Such an assessment would require a detailed analysis of the input requirements, the forest classification system used (if any), and of the functional relationships incorporated in the models.

The prediction of non-timber resources often requires knowledge of stand conditions and stand dynamics. This is typically only one of several input data requirements, and it must be recognized that the successful prediction of non-timber resources is often limited by other required data. For example, the composition and abundance of understory plant species is often an important indicator of available food sources and biodiversity. There does not appear to be in B.C. a modelling or decision support tool with which to infer understory plant conditions from overstory and ecological information. Much of the required ecological information is being compiled as part of the development of the biogeoclimatic classification system and such a tool could become an important link between growth and yield models and NTR modelling.

Prior to embarking on the development of non-timber resource models in B.C., the anticipated requirements for such models should be determined. There is a need to properly define the types of non-timber resources that are to be predicted, the spatial and temporal scales at which these are to be predicted, and the information sources that are required and available for predictive models. Some of this needs assessment will be challenging as there still is a very limited understanding of the present and future needs for non-timber resource prediction tools.

The development of non-timber resource models in B.C. should be conducted through close cooperation with future users. When planning the development process, the technology transfer to users needs to be considered carefully. For example, how will these non-timber resource models be (in)validated and verified? Where will the users obtain the required input data? What level of technical support and training will be required to transfer the models to the user groups and what can be provided?

The experience of the USDA Forest Service with the Forest Vegetation Simulator program demonstrates the success of an integrated modelling approach centered around one or more models of forest dynamics (growth and yield) for which extensions and interpretive models are

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developed. Its development spans over twenty years (Stage 1973) and was based on a timely vision of an integrated approach to knowledge acquisition and its application to land management (Wellner 1972). The set of modelling tools developed in that program is perhaps the most sophisticated and comprehensive timber and non-timber resource projection system in use anywhere in North America.

If a continued increase in the demand for non-timber resource assessments in forest management decision making in B.C. is correctly anticipated, then there will be a growing need for better prediction and simulation tools that can support the decision-making process. Although much new work will be required, the development of non-timber resource models can make use of the results obtained from existing simulation tools that predict overstory characteristics and dynamics originally developed for growth and yield forecasting.

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Appendix 1: Interviews

1. ANNOSUS/BARK-BEETLE EXTENSION TO THE FOREST VEGETATION SIMULATOR (FVS)

Model Name
The Annosus/Bark-Beetle Extension to the Forest Vegetation Simulator (FVS).
Agency: USDA Forest Service
Contact: Judy Adams, Methods and Applications Group, Ft. Collins, CO.

Purpose of Model
To simulate the effects of Annosus root disease and several bark-beetle types on stand dynamics and tree mortality.

State of Development
In behaviour analysis/testing stage of development.

Input Data
Operates as extension to FVS, can utilize field survey data on initial root disease status. Although all required default data for specific forest regions are provided, user can provide a variety of parameters on root disease and bark beetle dynamics.

Outputs
Growth and Yield and mortality as influenced by annosus and bark beetles. Generates list of dead trees with cause of mortality and root disease status indication which can be used as input for Snag dynamics models (see SRS below). Number of root disease centres and total area involved. Stand conditions inside and outside root disease centres

Spatial Scale
No spatial representation of tree locations, but locations of root disease centres can be spatially explicit. Operates at stand-level.

Temporal Scales
Time steps can be set to annual but are typically set at decades. The temporal horizon is 100 to 200 years.

Actions
Various harvesting regimes (cutting, silviculture) and management strategies, including stump removal and borax application.

Model Type
FVS - is statistical (regression based).

Critical Assumptions
Simulation of spread rates as affected by assumptions of root dimensions and probabilities of disease transfer between trees.

ANNOSUS/BARK-BEETLE EXTENSION TO THE FOREST VEGETATION SIMULATOR (FVS) (continued)

Users
Developed by ESSA Technologies Ltd. for the US Forest Service.
Earlier version of model was tested in USDA Forest Service Region 05 (California) with pathologists, entomologists and silviculturists. After this round of development and testing is completed, model transfer to USDA Forest Service California and Ft. Collins.

Model Behaviour Analyses
Currently undergoing formal behaviour analysis, sensitivity analysis scheduled for April 1994.

Limitations
Limited field testing and validation exercises. Will need additional testing before management implementation.

Appropriateness for B.C.
The model works with several variants of the FVS. Implementation in BC would require parameterization of both the base model and the annosus/bark beetle extension.

Operating Environment
DOS, DOS box under windows, OS/2 on 386 or better, 4MB RAM, 20 MB disk space, written in FORTRAN, graphics package for post-processing of result files desirable.

Availability
Executable: Data General (DG), DOS, OS/2 possible.
Source code: Contact US Forest Service
Cost: Probably free.
Level of training: Revised user-manual scheduled for May 1994, requires training or experience with FVS, support available.

Citations

Frankel et al. 1992.; McNamee et al. 1991.

Comments
Root disease and bark beetles can have significant impacts of stand structure and stand dynamics. The patchiness generated by the mortality of groups of infected trees opens the stand for growth of understorey plant species. Although these are not explicitly modelled by FVS, extensions such as COVER (see below) can be used to infer the impacts of changes in stand structure resulting from root disease and bark beetles. This is one of the few models that handles the impacts of multiple pests (and windthrow).

Source
Werner Kurz, ESSA Technologies Ltd.

2. BIODIVERSITY IMPACT ASSESSMENT (BIAS)

Model Name
Biodiversity Impact Assessment (BIAS)
Contact: Mr. Glenn Dunsworth, Woodland Services Division, MacMillan Bloedel Ltd.

Purpose of Model
To analyze habitat supply determination with respect to harvest schedule impacts on biodiversity

State of Development
Field test stage, there will be a series of watershed level case studies during 1994/95
Completion: uncertain, possibly 1996.

Input Data
Forest age, site index, biogeoclimatic subzone, species, stand level habitat attributes (there are 25), species guild descriptions, species movement cost matrix

Outputs
Maps - colour portrayal of habitat goodness and fragmentation
Screen - maps and tables
Reports - tables and graphs (e.g., #hectares of habitat in categories of interest, #fragments and size...)

Spatial Scale
Watershed
Cannot run for less than one hectare

Temporal Scales
Up to 200 years in increments greater than or equal to one year

Actions
Clearcut harvest schedules

Model Type
Mechanistic
Framework: grid based modelling
Innovative approach: evaluates habitat fragmentation by looking at landscape from standpoint of species movement

Critical Assumptions
1) habitat attribute trajectories
2) species habitat needs
3) species movement cost matrix

BIODIVERSITY IMPACT ASSESSMENT (BIAS) (continued)

Users
Originally developed at UBC (Dave Daust's algorithms are used as a base and modified) and has been moved to an ARCINFO platform and modified.
Has been applied to harvest schedules in Tofino Creek in Clayoquot Sound and the Nahmint watershed near Port Alberni.

Model Behaviour Analyses
Limited work on sensitivity analyses, no uncertainty analyses.

Limitations
Scale: limited to watershed level
Other: doesn't yet look at alternative harvest methods

Appropriateness for B.C.
100%
Transferability: Yes, but would need considerable calibration and validation

Operating Environment
Operating system: Unix
Hardware: SUN workstation
Additional software: Arcinfo, linked to MENO a harvest scheduler
Programming language: Arcinfo and C

Availability
Availability: none
Source code: no
cost: N/A
Level of training: computer interface is user friendly, but the user must have considerable biological expertise.

Citations
None
Other Contacts: Fred Bunnell's group at UBC.

Comments
BIAS is built into an interface which links it to a Harvest Constraint Model (a harvest schedule optimizer) which creates feasible harvest schedules that maximize NPV (net present value) and meet constraints such as visual quality, hydrologic rate of cut, operatability profile, adjacency constraints, recreation, etc. This interface links non-spatial timber supply (TFL timber supply) analyses to determine cut, then allocates cut to watersheds. The watershed information is then sent then back to the interface which sends the harvest information to BIAS which then analyzes with respect to habitat supply over time.

Source
Interview with Glenn Dunsworth, Woodlands Forest Division, MacMillan Bloedel Ltd.

3. BIOPAK

Model Name
BIOPAK: A general purpose plant biomass computation package
Contact: Joseph E. Means, US Forest Service, Pacific Northwest Research Station

Purpose of Model
To link field vegetation data with a library of over 1100 documented equations for predicting plant biomass.
Intended uses: fuels assessment, wildlife browse, cover estimation, ecological studies, general forest management.

State of Development
Completed, user can further edit and modify the library of equations.

Input Data
Plant measurements and field vegetation data in a wide variety of ASCII file formats.

Outputs
Estimates of plant biomass, volume, length, height, or area reported in various formats, including ASCII files, database files, and other formats for graphics and statistical programs.

Spatial Scale
Individual plants.

Temporal Scales
Not applicable.

Actions
Not applicable.

Model Type
Regression equations - empirical.

Critical Assumptions
That regression equations developed in one location are portable to others.

Users
Not applicable.

Model Behaviour Analyses
Not applicable.

ESSA Technologies Ltd.

BIOPAK (continued)

Limitations
Not applicable.

Appropriateness for B.C.
Equations have been derived from Northwestern United States, including Southeast Alaska, northern Rocky Mountains, and Sierra Nevada Mountains. Designed to be customized by user. Geographic areas and equations may be added.

Operating Environment
PC based. DOS 3.3 or later (routines written in FoxPro, Fortran, C). IBM PC or compatible, 386 or above. EGA/VGA, 5 MB Disk Space, 640 KB RAM, 80287/80387 Math Coprocessor.

Availability
Available at no cost from Joseph E. Means, Research Forester, USDA Forest Service, PNW Research Station, Forest Sciences Lab, 3200 Jefferson Way, Corvallis, OR 97331, USA, Tel: 503-750-7351, Fax: 503-750-7329, Internet: means@fsl.orst.edu
Online help, user's manual.

Citations
Not applicable.

Comments
Not applicable.

Source
Schuster et al. 1993 and an interview with Joseph Means

4. COASTAL TEMPERATE RAINFOREST MODEL

Model Name
Coastal Temperate Rainforest Model (CTR)
Contact: Tim Webb or Werner Kurz, ESSA Technologies Ltd., 1765 W 8th Avenue, Vancouver B.C. V6J 5C6

Purpose of Model
To simulate forest dynamics, and the impacts of forest harvesting and road construction on several timber and non-timber indicators, including wildlife habitat supply, sediment production, economic indicators, and fish population dynamics. The model is designed for exploration of alternative what-if scenarios and presents results as maps that change over time and as graphical presentation of various indicators.

State of Development
The model was developed as "proof-of-concept" demonstration in a windows-based graphical environment. Although the demonstration package is working, the model requires additional parameterization and validation of many functional relationships to be used operationally.

Input Data
Spatially referenced (GIS) information on forest age, biogeoclimatic classification (zones), elevation, road location, location of streams, waterbodies, fish spawning grounds, parks, and reserves. Parameters for submodels describing wildlife habitat, sedimentation, fish population dynamics, harvest scheduling, etc.

Outputs
Multiple user-selected maps of spatial indicators and their changes over time, and time-dynamics of several other indicators. The model integrates timber and non-timber indicators with economic indicators, e.g., supply of habitat for cavity nesting birds, volume harvested, cost of road building and harvest, and sediment production.

Spatial Scale
Landscape-level model, operates on fixed-grid cells, size under some user control, plan to develop a polygon-based approach. Best used at the watershed to multiple watershed scale.

Temporal Scales
Resolution: 1 year
Horizon: 50 years

Actions
Natural forest dynamics, harvesting and harvest scheduling, road building, protected areas, etc. Harvest scheduling may be input by the user or calculated based on a dynamic optimization routine in the model.

Model Type
Dynamic simulation model with simulation-time graphical display of user-selected maps and indicators. Simple functional relationships and algorithms that calculate consequences of actions on dynamics of various timber and non-timber resources.

ESSA Technologies Ltd.

COASTAL TEMPERATE RAINFOREST MODEL (continued)

Critical Assumptions

Because this is merely a demonstration prototype, there are numerous functional relationships that need refinement and parameterization. The model has not been field tested.

Users

None, prototype demonstration model

Model Behaviour Analyses

None.

Limitations

The model is a demonstration prototype. It will require extensive calibration and refinement of functional relationships. It does not yet simulate natural disturbances such as wildfire and insects, but these could be added easily. The model uses a grid-based approach - to become operational a polygon-based spatial representation would be desirable and is under development.

Appropriateness for B.C.

Very, the prototype model has been developed for western Vancouver Island.

Operating Environment

Visual basic and C.
Hardware needed: IBM PC or compatible, Windows.

Availability

Not available (yet). Model development funded by Ecotrust and ESSA Technologies Ltd.

Citations

ESSA Environmental and Social Systems Analysts Ltd. 1992.
Model description available from Tim Webb or Werner Kurz, ESSA Technologies Ltd.

Comments

This model simulates forest dynamics, management options, wildlife and fish habitat dynamics, and presents the results of what-if scenarios in graphical and map formats. It combines timber and non-timber resource indicators, and economic indicators in one integrated modelling tool that is designed to allow easy gaming and exploration of alternative futures.

Source

Tim Webb and Werner Kurz, ESSA Technologies Ltd.

5. COVER

Model Name
COVER extension to the Forest Vegetation Simulator (FVS)

Purpose of Model
To predict the understory vegetation composition, abundance and cover in timber stands.

State of Development
Completed, currently the possible expansion of the model for southern Idaho and Utah is being evaluated. This could involve using existing plot data from the development of the habitat classification system (Bob Steel and Cathy Geier-Hayes).
Also planned: 1) more explicit link of the Shrubs component to the regeneration system and small tree development models
2) option of making predictions on individual sample points within a stand (allowing a heterogenous site to be represented in greater resolution)
3) graphical display link, "lollipop diagrams", see GRAFFVS

Input Data
Requires information from FVS - inventory design used to measure the stand, a list of sampled trees for which species, diameter, and plot identification have been recorded. Values for slope, aspect, elevation, habitat type and forest location. If using Shrubs: time since stand disturbance, physiographic position. Understory predictions are improved if field measurements of shrub height and cover are available for calibrating portions of the shrub model. Uses edaphic features, habitat type, time since disturbance, overstory features (from FVS).

Outputs
Structure of tree crowns
Composition of the understory
Summary of overstory and understory cover and biomass

Spatial Scale
Same as FVS, single stands.

Temporal Scales
Resolution same as FVS, default 10 years, shorter time steps possible.
Horizon: rotation

Actions
Natural disturbance and forest management

Model Type
FORTRAN extension to FVS

COVER (continued)

Critical Assumptions
unknown at this time

Users
US Forest Service

Model Behaviour Analyses
Not applicable

Limitations
unknown at this time

Appropriateness for B.C.
It incorporates models that are specific to certain species and conditions prevalent in the northern Rocky mountains, but it is also a general system that can be calibrated to local conditions - crown and shrub data specific to the other area and habitat type are needed). Note: requires extensive data for reparameterization. Moreover, biogeoclimatic classification system uses different approach than the US habitat classification system.

Operating Environment
software needed: DOS 3.0+, FVS version 6.1 Inland Empire Variant
Hardware needed: IBM PC or compatible, Data General AOS/VS, NCC-RC IBM
                 2-4 MB disk space, 550 Kb RAM
 • can be used on any system that supports FORTRAN 77 compilation.

Availability
Available free from Bill Wykoff (PC version), see Schuster et al. 1993.

Citations
See Moeur 1985 and Moeur 1986

Comments
An important criterion in developing COVER was to make it broad enough in design for many applications, but primarily to link vegetation changes with non-timber resources...[it is]...a useful tool for decision making when combined with knowledge of a specific resource ecology and its relations to vegetation management systems (Moeur, 1985).
Potential applications: wildlife habitat
                 hydrologic applications
                 forest insect pest modelling applications
                 succession modelling and planned improvements

Source
Moeur (1985), Moeur (1986), R. Teck, pers. comm. 1994.

6. DDTSL

Model Name
Probable: DDTSL- Dynamics of Dead Trees at the Stand Level

Purpose of Model
To capture mortality information from TASS and TIPSY and translate into standing dead tree information (e.g., how long standing, decay condition?)

State of Development
Pre-prototype stage
An initial prototype should be available by the end of March 1994
This prototype will be for general usage and will only be a shell. Will still need local parameters for general comparison.

Input Data
1) # of dead trees/ha by diameter class
2) time period in which they die (output from TASS and TIPSY)
3) # of dead trees at the start of a rotation
4) user input: #of green trees to be killed in future (intentional snag creation)
5) possible direct inputs: changes in transition parameters (currently an actual input file)

Outputs
# of standing dead trees per hectare in each diameter class, decay class, time period

Spatial Scale
Stand Level
       TASS   - individual tree
       TIPSY - Stand level yield projections
spatial representation:
       not in mortality model
       explicit in TASS
In general, it is not an explicit spatial representation

Temporal Scales
Life of a snag
Yearly increments

Actions
All silvicultural actions of TASS
Adding and changing # of dead trees at start and # of green trees killed

DDTSL (continued)

Model Type
Empirical
Steady state type of model
Framework - Marcot transition matrix - life table

Critical Assumptions
Fall down indication transition rate is appropriate
        - it will change depending on region, climate etc

Users
Currently only Jeff Stone
SRS, UNIT PLAN are in general use in the US Forest Service
Future: TIPSY integration for foresters, Timber supply
No invalidation tests yet

Model Behaviour Analyses
None yet

Limitations
Same as assumptions
Only as good as input transition probability
Not applicable to an individual tree, it is a probabilistic average over a wide range

Appropriateness for B.C.
Very appropriate for B.C.
In the past, data has been limited to Victoria's permanent sample plots, but starting in 1994, all tree information will be captured in other areas of B.C. as well and the model will become even more applicable for B.C. Most of the present data are for Oregon.

Operating Environment
For the general user: PC based, 640 kb RAM, will require linkage to TIPSY
                      For TASS (UNIX based) will be in the UNIX environment
Source Code: C

Availability
Date: End of March 1994
Contact: Jeff Stone
Cost: Free
Level of Training: For first version, not much expertise is required. Traditional executable program with input and output files. Not too user friendly. Have to edit files in a separate editing program for existing snags/green tree kills. To run, type program name followed by the input file.

DDTSL (continued)

Citations
None yet

Comments

Adapts the general algorithms used in SRS (Bruce Marcot) and UNIT PLAN, UNIT PLAN is similar to SRS (it is a spreadsheet model too) but has more input options and is easier to change and is more flexible in size classes, has been used in the Williamette National Forest in OR.

Currently DBH class is used in SRS and UNIT PLAN, and is correlated with the minimum size DBH for a variety of woodpecker species

Thinks this review is a good project and is supportive of it.

Source
Interview with Jeff Stone

7. DWARF MISTLETOE SPREAD AND INTENSIFICATION MODEL

Model Name
The new Dwarf Mistletoe spread and intensification model, an extension integrated into the Forest Vegetation Simulator (FVS)
Agency: U.S. Forest Service
Contact: Judy Adams, Methods and Applications Group, Ft. Collins, CO.

Purpose of Model
To simulate the progression of mistletoe infections in forest stands.

State of Development
Field test stage.
Future: Will be put into management use once tested
No set date of completion.

Input Data
Needs characteristics of sampled trees in a stand.
Minimum: height, DBH, mistletoe infection rating.

Outputs
Growth and Yield and mortality as influenced by mistletoe.
Summary measures of stand infection level.

Spatial Scale
Stand growth is non-spatial, but spatial heterogeneity of infection and tree clustering is statistical. Crown height is explicit.

Temporal Scales
Time steps can be set to annual but are typically set at decades. The temporal horizon is 100 to 200 years.

Actions
Various harvesting regimes (cutting, silviculture) and management strategies.

Model Type
FVS - is statistical (regression based).
Innovative: Mistletoe - Novel combination of spatial statistical and explicit spatial relationships.

Critical Assumptions
1) Tree level: location of infections within crowns.
2) Stand level: knowledge of patchiness of infections.

ESSA Technologies Ltd.

DWARF MISTLETOE SPREAD AND INTENSIFICATION MODEL (continued)

Users
Developed by ESSA Technologies Ltd. for the US Forest Service.
Applied to four sites in western North America (beta tested, B.C. to Mexico)
Validation tests: results are plausible, invalidation is difficult.

Model Behaviour Analyses
Sensitivity analyses: Informal and ongoing.

Limitations
FVS is not spatial, some spatial information cannot be present in management scenarios e.g., partial clear cuts.

Appropriateness for B.C.
Very.
One of the beta test sites is in B.C.
Level of effort: high, little infrastructure to support in B.C.; however, B.C. Silviculture branch is investigating

Operating Environment
DOS, DOS box under windows, 386 or better, 4MB RAM, 50 MB disk space, written in FORTRAN, linked to S (statistical software, needed for graphical output), GRASS (GIS), and Unix MKS toolkit.

Availability
Executable: Data General (DG), DOS, OS/2 possible.
Source code: Contact US Forest Service
Cost: Probably free.
Level of training: Lots, not user friendly, support is available.

Citations
For Mistletoe: see unpublished ESSA reports e.g., "The new mistletoe spread and intensification model", Final workshop report.

Comments
FVS has historically been used for Growth and Yield projections. Non-timber information is derived from inferences drawn from the G&Y data. For example some of the benefits of mistletoe infection in a stand are scenic beauty and habitat. The mistletoe infection produces changes in tree morphology which are found aesthetically pleasing by some, the same morphological changes appear to be preferred habitat of birds and squirrels. There may be future post-processing programming which can interpret the FVS output for indicators of these values, but currently an experienced operator must examine and interpret the G&Y data.

Source
Interview with Don Robinson, ESSA Technologies Ltd.

8. ECOSYSTEM SUPPLY FOR FOREST BIRD POPULATIONS

Model Name
Ecosystem Supply for Forest Bird Populations

Purpose of Model
To predict habitat value for birds based on ecological land classification

State of Development
pre-prototype (its done conceptually)

Input Data
• Spatial FEC (Forest Ecosystem Classification) information for area to be simulated
• Bird-habitat relationships

Outputs
Relative habitat value of landbase and individual FEC units for approx. 20 - 30 bird species

Spatial Scale
• Resolution - FEC unit (approx. same size as a stand)
• Horizon - Forest Landscape (at present model is calibrated for 9 UTM mapsheets)

Temporal Scales
Model is static, no simulation of changes through time

Actions
Removal of FEC units from landbase (via harvesting)

Model Type
• empirical - based on data collected specifically for model calibration;
• non-dynamic

Critical Assumptions
1. value of habitat for birds not related to regional trends, and does not change as population changes through time

Users
at present - researchers, eventually - local forest managers

ECOSYSTEM SUPPLY FOR FOREST BIRD POPULATIONS (continued)

Model Behaviour Analyses
validation of bird-habitat relationships underway using recently collected data

Limitations
1. Data gathering/calibration needs are extensive;
2. Portability of model is limited because of differences in bird-habitat relationships;
3. Model is static - it doesn't predict changes in habitat value over time as knowledge of succession of FEC units is lacking

Appropriateness for B.C.
Concept is valid for B.C., but direct portability of model is unlikely given limitations noted above.

Operating Environment
eventually - IBM- like machines (486), data storage needs may be extensive (1 gigabyte), software needs - IDRIS GIS

Availability
not yet available, can be available from authors when completed

Citations
Not applicable

Comments
Model is unique because 1) it is based on a (provincial) generic land classification system; and 2) calibration data are very rich - considerable field work has gone into collecting information used for calibraion

Source
Interview with Dr. Dan Welsh and Lisa Veneer
Canadian Wildlife Service
49 Camelot Drive
Nepean, Ontario

9. ELK COVER

Model Name
ELK COVER - an extension to the Forest Vegetation Simulator (FVS)

Purpose of Model
To predict the hiding cover for elk provided by stands of Lodgepole or Ponderosa Pine.

State of Development
Completed. Model is available from USFS (see below).

Input Data
The model is a post-processor of FVS output. FVS predicts stand conditions and the user can assess the degree of cover provided for elk by the stand. The user determines the number of observations to be tested, the number of replications to be tested (i.e., new distribution of trees in the stand), the sighting distance to be assessed and the type of tree distribution to be assessed (i.e., random, clumped, or regular). All stand input data are obtained from FVS.

Outputs
Percentage of elk body hidden from viewer. Thermal cover is not included in the analyses.

Spatial Scale
Stand-level analyses.

Temporal Scales
FVS operates in user selected time steps with a default value of 10 years. The post-processor operates on the end state of the simulation

Actions
All stand management actions that are applicable to FVS.

Model Type
Geometric assessment of the coverage of elk body by boles and crowns in overstory and understory (small trees only) of the stand. FORTRAN code.

Critical Assumptions
Based on the work of Frederick Smith and James H. Long (1987).

Users
Used extensively in Region 04, Intermountain Region of the USFS.

ELK COVER (continued)

Model Behaviour Analyses
Not applicable.

Limitations
Not applicable.

Appropriateness for B.C.
Calibration data are for Lodgepole and Ponderosa Pine stands in Utah and Idaho. Reparameterization is easily possible if the data are available.

Operating Environment
Data General, IBM compatible PC, UNIX

Availability
Available from USFS, Rich Teck, Operations Research Analyst, USDA Forest Service, Washington Office, Timber Management Service Center, 3825 East Mulberry, Fort Collins, CO 90524. Tel: (303)-498-1772, Fax: (303)-498-1660. No charge.

Citations
Smith and Long 1987

Comments
Not applicable.

Source
Information from Schuster et al. 1993, and an interview with Richard Teck.

10. FOOTHILLS FOREST DECISION SUPPORT SYSTEMS

Model Name

Foothills Forest Decision Support Systems
Contact: Mr. Rick Bonar, Weldwood of Canada Ltd., 57 Switzer Dr., Hinton Alberta

Purpose of Model

The DSS is not an individual model, but will eventually be a series of linked models on: wildlife habitat (21 individual species models - including pileated woodpecker, caribou, ovenbird, moose, grizzly bear, three-toed woodpecker), timber supply, landscape forecasting, watershed, recreation, risk, and carbon budget. The purpose of the system is "to meet the management need for storage and retrieval of information, prediction of the effects of natural disturbances and management alternatives, and assessment of inventory projections in terms of resource suitability and socio-economic impacts" Bonar (1994).

State of Development

Wildlife models are done, or nearing completion, others are less well developed: Carbon budget model - was developed for national scale and is currently being modified for application to Foothills Forest; Landscape forecasting model is under development; Watershed model design is complete; work on Fire model and Risk models have not yet begun.

Input Data

Individual models obviously require much specific information. All models use/will use spatial forest description at stand and/or ecosystem classification level.

Outputs

Each model has/will have specific outputs. Outputs for wildlife models are spatial habitat suitability indices (HSI's) with some simple extrapolation to population. Output for landscape model will be forest type by spatial unit across the landscape. Output for watershed model will be water yield and impacts on flow. Output for other models not finalized.

Spatial Scale

Different for different models, minimum resolution will likely be forest stand or ecological classification unit. Horizon will be landscape or forest.

Temporal Scales

Different for different models - minimum resolution will be 1 year; horizon will be open ended or 2 rotations.

Actions

Different for different models - generally: harvesting, silvicultural activities; protection.

Model Type

DSS will be a mixture of several model types - some linear programming (LP), some optimization models, some empirical. See figure in Bonar 1994 for more detail.

FOOTHILLS FOREST DECISION SUPPORT SYSTEMS (continued)

Critical Assumptions
Have only been expressed for wildlife models - a publication on these for each of 21 HSI models will be released spring/summer 1994.

Users
Many eventual users are visualized: research, field management, education. Much interest has been expressed by other forest management companies. Other offices of Weldwood in other provinces will eventually use the system.

Model Behaviour Analyses
Underway for wildlife models; report to be released in spring/summer 1994.

Limitations
Specific for specific models. Limitation of wildlife models is that there is little extrapolation to population level.

Appropriateness for B.C.
Highly probable that much of model/s is/will be suitable for B.C. Company long-term plans are to use the system at their operations in B.C. Much re-calibration will be necessary.

Operating Environment
Network of SUN workstations; definitely not implementable on PC's. At present uses ARC/INFO and ARC Forest. Many program languages/protocols used for individual models.

Availability
Not yet available.

Citations
Bonar, R.L. 1994.
Two reports on wildlife models due out spring/summer 1994.

Comments
This seems to be one of, if not the most, comprehensive and well thought-out instances of integrating NTR modelling in Canada. Wildlife modelling began in mid-late 1980's and is very well-developed. Development of other models is following a solid systems-level approach.

Source
R. Bonar, pers. comm. 1994.

11. GRAFFVS

Model Name
GRAFFVS - A PC based graphic projection system for Forest Vegetation Simulator (FVS) output
Agency: U.S Forest Service
Contact: Wayne D. Sheppard, U.S. Forest Service, 240 West Prospect Road, Ft. Collins, CO 80526
Tel: (303) 498-1259

Purpose of Model
To illustrate forest conditions predicted by all variants of the Forest Vegetation Simulator (FVS) forest growth and yield modelling system.

State of Development
Current: available for use on DOS based PC's equipped with VGA monitor
Future: dead trees to be included in the display, move to new Forest Service 615 computer system

Input Data
Default diameter class output file from an FVS run
Height, crown ratio, and stem density for each diameter class and species in all growth projection cycles

Outputs
"wire frame" profile of stand on the computer screen for each growth period projected by the FVS model

Spatial Scale
One acre side view of modelled stand. View into stand extends to 42 feet.

Temporal Scales
Growth projection cycles of the FVS run that produced the data.

Actions
Can illustrate any number of forest conditions or silvicultural activities.

Model Type
Tool to be used in conjunction with FVS

Critical Assumptions
not applicable

Users
U.S. Forest Service

GRAFFVS (continued)

Model Behaviour Analyses
Not applicable

Limitations
Crown width is arbitrarily set as a percentage of the tree height, since the growth model does not provided crown width data.
Not all trees in projected stand will appear in the plot, only first 42 feet looking into the side of an acre are drawn. Because FVS does not explicitly simulate tree locations and new random numbers for x-y coordinates are generated each time a growth cycle is selected, no two plots will be exactly alike.

Appropriateness for B.C.
Depends on applicability of FVS

Operating Environment
Free standing program for DOS based PC's
Executable file capable of running without proprietary graphics software
Source code: gwbasic
VGA colour monitor
Need screen-dump-to-printer or screen capture software to print out stand diagrams.

Availability
Send formatted diskette to Wayne D. Sheppard for copies of program along with test data for current FVS variants

Citations
Not applicable

Comments
Can view effects of management activities in a forest over time.
Growth of new regeneration can be seen as well as the density, hiding cover, species composition and vertical canopy structure of modelled stands.

Source
An unpublished manuscript entitled: Welcome to GRAFFVS: a PC-Based graphic projection system for FVS output. Written by Wayne D. Shepperd and interview with Richard Teck.

12. HABITAT ASSESSMENT AND PLANNING TOOL

Model Name
Habitat Assessment and Planning Tool
Contact: Marvin Eng, B.C. Ministry of Forests

Purpose of Model
To assess the impact of forest harvesting on black tailed deer habitat

State of Development
Prototype, three field tests to date, about half way through development

Input Data
Biogeoclimatic system, site association map- understory plant community map-seral stage, aspect, elevation

Outputs
Habitat quality for black tail deer in summer and severe and mild winters.
Composite management oriented map.

Spatial Scale
Areas of 10-50,000 hectares, landscape scale.
Explicitly considers spatial arrangement of stands rather than only attributes of individual stands (distance from food and cover). This has been missing from other models of this type.

Temporal Scales
five-year time step over a full rotation

Actions
Logging, silvicultural techniques

Model Type
mechanistic (expert based- a biologist described from the ground up, there was a verification procedure)

Critical Assumptions
1) food quality rating for understory plant community
2) snow loading rating for aspect/elevation category

ESSA Technologies Ltd.

HABITAT ASSESSMENT AND PLANNING TOOL (continued)

Users
Ministry of Forests Research Branch
Has been applied to 3 areas on Vancouver Island:
1) Nanaimo River- verification area
2) Caycuse Division TFL 46- validation area, validation in progress
3) Nimpkish Valley

Model Behaviour Analyses
Nothing systematic yet

Limitations
Habitat only. Does not include population dynamics or predator-prey relationships

Appropriateness for B.C.
Strictly for black tailed deer, probably only for coastal B.C.

Operating Environment
GIS based model, PC or UNIX. PAMAP and TERRASOFT- will run on whatever runs these
It is currently a set of instructions for an experienced GIS operator. In the future, it will be available for less experienced operators using FACET, another GIS system. It is currently being coded into FACET (spreadsheet format) this will help with making the required adjustments. There is no known completion date as of yet.
In the meantime, must be operated on a GIS environment. Change area, must enter new maps. New habitat data. Must be tailored for specific users.

Availability
Free, contact Marvin Eng

Citations
Eng et al. 1991

Comments
Not applicable

Source
Interview with Marvin Eng, B.C. Ministry of Forests, Research Branch

13. MOOSE HABITAT AND POPULATION SPATIAL ANALYSIS MODEL

Model Name
Moose Habitat and Population Spatial Analysis Model
Contact: Mr. Peter Higgelke, Dr. Peter Duinker, Lakehead University School of Forestry

Purpose of Model
To predict population effects on moose of forestry-caused habitat changes.

State of Development
Previous version (habitat simulator only) is completed, present work involves modifying spatial scale of habitat model and adding links to a population model.

Input Data
Spatial FRI (Forest Resource Inventory) data; moose life-table information; moose energy requirements; food - energy information (e.g., metabolizable energy required for maintenance per kg moose), population parameters (e.g., parturition rate, twinning rate, sex ratio at birth, etc.)

Outputs
Age-structured moose population and density information.

Spatial Scale
Resolution - Habitat Supply Unit (approx. 100,000 ha)
Horizon - Forest level

Temporal Scales
Resolution - 5 seasons within a year
Horizon - forest rotation age

Actions
forest harvesting and renewal, hunting

Model Type
• Dynamic habitat model (based on wood supply model) linked to life-table based population model via energetics.
• Unique aspect is that this is one of very few models to explicitly link habitat simulation with population simulation.

Critical Assumptions
1. Mostly related to the goodness of certain stand types for moose in terms of utility as shelter and food
2. Energetic requirements of moose, gathered under controlled circumstances are a suitable basis for simulation of "wild" populations;
3. Many assumptions about energetic content of browse

MOOSE HABITAT AND POPULATION SPATIAL ANALYSIS MODEL (continued)

Users
Final version will be suitable for use by field biologists and foresters. Version presently under development is more of an academic tool. Field version may be ready in two years.

Model Behaviour Analyses
Sensitivity analyses planned for the future. Calibration/validation data will be used from two areas in northern Ontario.

Limitations
1. Based on FRI data - which has little information other than tree species and cover.
2. Resolution of Habitat Supply Unit (approx. 100,000 ha) may limit sensitivity of model to forest management actions;

Appropriateness for B.C.
- Possible - recalibration of many variables would be necessary (e.g., life table parameters, energy content of foods, energy needs of moose)
- Moose model does not have any seasonal latitudinal migration which may be important in B.C.

Operating Environment
SUN workstation using ARC/INFO and HSG (Harvest Schedule Generator)

Availability
Not yet completed, when it is completed will be available through Mr. Bob Watt, Ont. Ministry of Natural Resources, Timmins, Ont.

Citations
Duinker et al. 1991, 1993; Higgelke 1994; Koppikar et al. 1990

Comments
Development funded by Northern Ontario Development Agreement, project includes participation of Lakehead University, ESSA Technologies Ltd., Ontario Ministry of Natural Resources, and Lake Abitibi Model Forest.

Source
Interview with Peter Higgelke

14. NEW BRUNSWICK HABITAT MODELS

Model Name
1. Mature Coniferous Forest Habitat Model
2. Deer Winter Cover Model ---> both of these are integrated in to FORMAN +1 wood supply model
Contact: Mike Sullivan, Forest Habitat Program Manager. Dept. of Natural Resources and Energy, P.O.B. 6000,
Fredricton, N.B. E3B 5H1

Purpose of Model
To integrate planning for wildlife habitat into forest management planning process. The Mature Coniferous Forest
Habitat model is intended to accommodate needs of marten and other wildlife species associated with mature forest.
The Deer Winter Cover model is intended to accommodate deer wintering areas/deer yards.

State of Development
• Non-spatial versions are complete and in use in forest management planning process.
• Spatial versions are under development in anticipation of being used for next Forest Management plans. Spatial
versions of models will be completed by Jan 1995.

Input Data
Inputs as required by FORMAN +1 - the wood supply models that habitat models are integrated into (i.e., growth
and yield relationships, forest inventory). Also habitat models require stand structure of interest for habitat, and
spatial definition of habitat.

Outputs
• For non-spatial version - ha. of suitable habitat. - these are then "netted down" outside of FORMAN according to
size, shape, juxtaposition rules and relationships
• For spatial version "netting down" will be done inside the FORMAN GIS model.

Spatial Scale
• For non-spatial version resolution is same as horizon - the forest.
• For spatial version - resolution of forest stand, horizon is the forest.

Temporal Scales
As FORMAN 1+ - predictions of forest state made every 5 years, model runs typically 80 years.

Actions
Harvesting (clearcutting), plantations, thinning, herbicide application.

Model Type
Basically a wood supply model modified to include habitat.

NEW BRUNSWICK HABITAT MODELS (continued)

Critical Assumptions

All the assumptions associated with FORMAN +1 --> forest dynamics assumptions, growth and yield assumptions, harvest transition tables. Biggest assumptions, perhaps not of the model itself but of the modelling program is that managing for wildlife habitat is sufficient to manage for wildlife populations (i.e., link between habitat and population is accounted for).

Users

At present - every forest management company that operates on crown land used the model (with the help of the Forest Management Program staff at Dept. of Natural Resources) in preparation of the last round of Forest Management Plans (which cover the period 1992 - 1997).

Model Behaviour Analyses

Validation of model predictions of habitat have taken place (i.e., ensuring that the habitat the model predicts will exist). Validating that wildlife species are using the habitat is being done, validating whether that habitat that is provided is sufficient for long-term sustenance of the species is a significant research undertaking that is not being tackled at present.

Limitations

As in all models - "results are only as good as data".

Appropriateness for B.C.

Concept is valid for B.C. Models would, of course, need to be specifically calibrated for B.C. species, forests, etc.

Operating Environment

• Non-spatial version: hardware - PC's with Windows; software - FORMAN +1
• Spatial version: hardware - Workstations; software GIS FORMAN, ARC/INFO

Availability

FORMAN is proprietary software. A user/development group exists, mostly in N.B. New users would likely have to buy into group. N.B. DNR will provide habitat relations they use in models free.

Citations

Progress reports have been prepared annually. Next one is due soon - citation will be: New Brunswick Dept. of Natural Resources. 1994. Forest Habitat Project. Report to Wildlife Habitat Canada.

Comments

This modelling program is exemplary because the models are fully integrated with forest management in the province and are in full use in the forest management planning process for all of the over 3 million ha of crown land in the province. The models themselves are relatively simple - this is by design and necessity to facilitate their use in the FMP process.

Source

Interview with Mike Sullivan

15. ROTSIM

Model Name
ROTSIM (A module of TASS)

Purpose of Model
To valuate impact of laminated root rot (*Phellinus weirrii*) on yield and financial estimates.

State of Development
Current stage of development:	Field test
Future development:	Move to other diseases for which same algorithm can be applied. Probably Armillaria, Tomentosa...
Estimated time of completion:	End of fiscal year (1.5 to 2 months)
New version:	Need feedback before progressing on, no further versions in mind at this time

Input Data
Number and location of stumps from original stand and the degree of infection.
Infection passing form one generation to another.

Outputs
Reduction in height growth and mortality. These outputs are input for TASS

Spatial Scale
Individual tree model
Stand/Tree level
Output targeted at stand level decisions

Temporal Scales
Five-year time steps, simulation model

Actions
Can model any silvicultural treatments: established density, stump removal, bridge tree removal, etc.

Model Type
mechanistic, individual tree model, based on very detailed simulation, various depths and spread rates are used unlike straight empirical models. It is a biologically oriented model.

Critical Assumptions
Rate of spread of the disease
Population of disease residual in stumps of the previous stand

ROTSIM (continued)

Users
Canadian Forest Service, validation tests currently under way, Jeff Beale -Silviculture Branch, B.C. Forest Service

Model Behaviour Analyses
Sensitivity analyses in conjunction with Jeff Beale

Limitations
Stand/Tree level, not Forest
Restricted to Coastal Douglas-fir

Appropriateness for B.C.
Yes.
Can transfer to other areas (future development for other diseases)
Level of effort: Not high on the modeller's part, need information from pathologists: spread rates and behaviour - 2 to 5 years

Operating Environment
Workstation IBM RS6000, linked to TASS, written in C

Availability
Executable form: not available
Source code: not available
Cost: not applicable
Level of training: Considerable

Citations

Mitchell and Bloomberg 1986.

Comments
Not applicable.

Source
Interview with Ken Mitchell, B.C. Forest Service, Research Branch.

16. SIM FOREST

Model Name
Sim Forest
UBC Center for Applied Conservation Biology, Dept. of Forestry
Contacts: Dave Daust, Glenn Sutherland

Purpose of Model
- To assess the impact of proposed forest management on biodiversity - especially vertebrate biodiversity
- Current Use: testing and sensitivity analyses

State of Development
- prototype (field testing in Kamloops with Kamloops forest area (?), and on Vancouver Island with Macmillan Bloedel
- final version out in one to two years
- present work, mostly refinements, deciding on the interface to use to make it more user-friendly

Input Data
- Harvest plan, mapped block layouts
- data base describes change in selected forest attributes over time (volume over age curve) uses different structural features (snags, downed wood, large age trees)
- mapped into GIS
- currently research is going on into the parameters of the other inputs which are not readily available

Outputs
- area of suitable habitat for a selected group of species (hectares)
- landscape-level indicators: age class distribution, summary of forest attributes (e.g., total hectares large live conifers, total hectares large snags)

Spatial Scale
- 4 hectare grain size
- 5000 to 50,000 hectares
- so far tested up to 10,000 hectares
- forest cover classes: uses biogeoclimatic subzones and age classes within subzones, uses stratified data, but model changes this data- not really explicit stratification

Temporal Scales
- one year resolution for 250 years
- dynamic simulation
- land base metrics calculated at sampling intervals

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SIM FOREST (continued)

Actions
• logging: location and type of logging (e.g., clearcut vs. selective)
• subsequent silvicultural treatments considered indirectly via impact on the forest attribute database. (e.g., special silvicultural regime, have data say what will happen to forest structure, develop database describing this treatment and insert into model.

Model Type
• empirical (more empirical than semi-empirical)
• innovation: calculates habitat considering spatial distribution of forest attributes

Critical Assumptions
1) habitat can be predicted
2) forest attribute development can be predicted

Users
• UBC
• being tested in Kamloops and on Vancouver Island

Model Behaviour Analyses
Under way at this time

Limitations
• presently limited to vertebrates
• limited spatial and temporal scale
• no economics included in model

Appropriateness for B.C.
• developed for B.C.
• transfer would involve redevelopment of databases
• level of effort depends on local characterization of forest dynamics (this could be variable)

Operating Environment
• DOS, 1MB RAM, 486 DX processor, uses GIS information but there are no explicit linkages to a particular GIS system.
• written in Quick Basic

SIM FOREST (continued)

Availability
- Availability is being decided now by the Ministry of Forests
- Probable low cost
- Must be experienced in forest planning and be computer literate

Citations
- Daust and Bunnell 1992.; Daust et al. 1994

Comments

- Growth and yield modelling is moving away from timber dynamics and into ecosystem dynamics, an area which is currently limited. There is a great demand for help in forest planning, the problem is that getting wrapped up in GIS technology draws you down. Planners need help in getting more user-friendly technology.

Source
Interviews with Dave Daust and Glenn Sutherland

17. SNAG RECRUITMENT SIMULATOR (SRS)

Model Name
Snag Recruitment Simulator (SRS)
Contact: Bruce Marcot, U.S. Forest Service.

Purpose of Model
To simulate in-stand dynamics of dead trees

State of Development
Management use
Richard Teck of the US Forest Service is currently writing it into the Forest Vegetation Simulator (FVS) (formerly Prognosis).

Input Data
Mortality rates of trees.
Model trends of trees based on mortality input from Growth and Yield model. Fall and decay rates will be linked to cause of death at a later stage (i.e., if root disease killed the tree, would expect it to fall faster).

Outputs
Number of snags of various size and decay classes through out a stand growth cycle.
Snag density level as target goal.

Spatial Scale
Stand level - implicit spatial, does not model spatial location and pattern of stand

Temporal Scales
Decades - discrete ten year increments.
The intention is to link to FVS either directly into base code or as a post-processor application. Then the time step will be decided by users of FVS.

Actions
SRS can reflect any sort of stand management input from Growth and Yield models
(e.g., deliberate creation of snags during stand growth cycle [not generally found in G&Y])

Model Type
Compiled spreadsheet model, deterministic, differential equations, based on life table model

SNAG RECRUITMENT SIMULATOR (SRS) (continued)

Critical Assumptions
There are 9 critical assumptions:
1) Snags are created in a stand from three sources:
    i) left on site at age zero (could be after logging)
    ii) self-thinning of stand
    iii) snags created from intentional killing of live trees
        • other tree mortality sources are not explicitly represented (e.g., root disease)
2) Snags will decay (hard to soft) at the same rate for all sources of tree death (not necessarily true - Richard Teck is working on this)
3) Snag decay and falling rates are based on Douglas-fir stands in Oregon coast range and Cascades (should be updated for other areas)
4) Bigger snags stand longer than smaller snags
5) Bigger snags decay more slowly
6) Snags left on site at year zero are on average already half way through decay class for a given DBH - rarely, if ever, do we know the true age of snags out there already.
7) Snags created from intentional killing of green trees begin life as hard snags (the beginning of the snag cycle) contrast with #6
8) The operational feasibility of maintaining or creating snags is not dealt with in the model
9) Safety concerns are not dealt with in the model

Users
Various National Forests in the Pacific Northwest region.
Validation tests are an on going long-term process.

Model Behaviour Analyses
Nothing published - Bruce Marcot has done a series of sensitivity analyses
Dr. Bill McComb and Janet Ohmann have developed their own snag dynamics model and are comparing it to SRS. They use non-linear regression equations to predict fall rates and come up with different predictions for fall and decay rates. The evaluation of the shape of the curve is what is going on with the assessment. Check with Bruce Marcot for details. Intentions are to integrate this model into FVS as well.

Limitations
Single stand focus of model, cannot easily model average conditions across stands of different even age classes.
The real limitation is the lack of good field information of decay rates of snags in different forest types.

Appropriateness for B.C.
Elements have been transferred, see DDTSL description.

Operating Environment
IBM PC: 286 or higher, 512K RAM, not spatially linked to GIS, single disk self unpacking file, .WK1 Lotus 1-2-3 compatible spreadsheets and a stand alone coupled set of Borland Prologue-floating bar front end menu, fill in blanks and run by hitting F9. Documentation with diskette.

SNAG RECRUITMENT SIMULATOR (SRS) (continued)

Availability
From Bruce Marcot
User-friendly
Can input new decay and falling rates without getting inside
In order to input data must be familiar with running Growth and Yield models

Citations
Neitro, W.A. et al. 1985

Comments
Not applicable

Source
Interviews with Bruce Marcot and Richard Teck

18. WILDLIFE HABITAT HANDBOOK MODELS

Model Name
Wildlife Habitat Handbook Models, (Wildlife Habitat Handbook for the Southern Interior Ecoprovince)

Contact: Andrew Harcomb

Purpose of Model
To consider habitat requirements of all wildlife species in forest management.

State of Development
Prototype - no immediate future development plans except to complete planned publications

Input Data
Species of interest, habitats, how habitats will change over time (succession), human disturbances
Habitat matrix

Outputs
Area sub-habitats by species for a point in time. Tried to develop classes of risk (tried to relate to forestry indicators, e.g., % cover)

Spatial Scale
Watershed-level as opposed to site specific. Subregional.

Temporal Scales
Entire range of succession, decades, beyond a rotation
e.g., grass/forb to old growth

Actions
Timber harvesting (clear cut, selective logging), silvicultural activities

Model Type
Semi-empirical
• simple relationship models; species, habitat, season of use; feeding, reproductive, hiding cover; habitat successional stages; try to rank nil-low-medium-high. Expert models - workshops

Critical Assumptions
Ability to relate animal value to habitats (not considering predators, competition, disease, or weather etc.)

WILDLIFE HABITAT HANDBOOK MODELS (continued)

Users
Southern Interior- based on Lewis Creek N.E. of Kamloops
Not really tested

Model Behaviour Analyses
None

Limitations
Geographical
Young GIS technology, could not automatically grow remaining stands, no automated growing model

Appropriateness for B.C.
Developed in B.C. in the Southern Interior region. Could be adapted to other regions (more a methodology than a model).

Operating Environment
PAMAP using DBASE, DOS

Availability
Reports and software are available; not all species are in the data base, must look up and enter; need an experienced GIS operator.

Citations
Main reports (Wildlife Habitat Handbooks, multiple volume set); contact Andrew Harcomb

Comments
Not applicable

Source
Interview with Andrew Harcomb

19. ZELIG.BC

Model Name
ZELIG.BC
Contact: Phil Burton, Faculty of Forestry, UBC

Purpose of Model
To incorporate potential cultivation options and natural regeneration in the projection of stand density for mixed species and uneven aged stands
Currently there are about 1/2 dozen demos that have been distributed for testing

State of Development
Field test stage
There are plans for future development
New release planned for August 1994

Input Data
SILVEX (autecology and natural history of a tree species) driven estimates of species allometries, light response, drought tolerance (see Burns and Honkala 1990).

Local site data: climate normals (mean and variance of monthly temperature and precipitation), and soil properties (developers are presently trying to relate the soil properties to biogeoclimatic standards - field capacity, wilting point, etc.).

It is possible to project for an existing stand, start with a file of individual tree measurements (need replicate plots) and project to the future: species, DBH, height, height to base of crown

Local site index curves are most desirable for any quantitatively reliable estimates. Extensive calibration is required. There are plans to internalize the calibration procedure.

Outputs
Emphasis on relative species abundance.
Greatest reliability at equilibrium stage.
Basal area, density, volume, average DBH, species composition of trees only.
Stand tables and plots over time.

Tracks environmental factors which are most limiting to growth.
Proportional importance of temperature, light, moisture in constraining the growth of each species.

Graphical output - time lines, presently working on adding bar charts.
Tabular output - stand tables.

Spatial Scale
Stand or plot
Plots 100-800m^2
Stochastic, need 20-40 plots to identify central tendency
Transect or grid runs are possible (for more landscape oriented analyses)
Implicit representation of plot juxtaposition, but individual stands do not have spatial position.

ZELIG.BC (continued)

Temporal Scales
Decades to centuries

Actions
Explicitly (using command line): species or size-specific removal of stems, could represent logging or spruce budworm, herbicides (removal of broadleaf trees), climate change (will be working on this in March 1994)

Model Type
Stochastic mechanistic (models competition, demography not physiology; not based on regression curves)

Innovative: Lots of little things, there has been continuous improvement of the model over time: ZELIG.BC is improved over ZELIG Version 1.0 which was an improvement over FORET which was an improvement over JABOWA

Critical Assumptions
Main: • all trees in plot experience the same horizontal environment
  • fixed background mortality
  • accelerated background mortality rate for suppressed trees
  • potential recruitment if environmental conditions acceptable for seedling survival
  • competition primarily for light

Users
Originally developed at the University of Virginia
Has been developed further by others in the Pacific Northwest
ZELIG.BC was developed at UBC
Also being use at the University of Quebec, Montreal

Model Behaviour Analyses
Not on this version, there has been sensitivity analyses on FORSKA (another model developed from FORET) contacts Rick Leemans, also David Price (Canadian Forest Service, NoFC) is currently working with FORSKA for boreal species.

Limitations
1) Detailed calibration is external to model runs, it takes time to derive parameters
2) not yet integrated to deal with multiple growth factors (see ZELIG.MGF), forest floor, snag/log dynamics and other attractions for wildlife - presently working on these bits.
3) No explicit representation of soil layer, forest floor layer, animal disturbance, or fire disturbance.

ZELIG.BC (continued)

Appropriateness for B.C.
Very appropriate, currently including a library for various biogeoclimatic zones in B.C. (working on nailing down the ecosystem classification procedure used by B.C. Forest Service for soil attributes-see OUTPUTS)

Effort required for application to a new area: not much, can pretty well eyeball using published data with very little effort, very portable. But moving from qualitative to quantitative requires more effort.

Operating Environment
For the beta release mode, 286 or higher IBM compatible PC with at least 640Kb RAM. The alpha version runs on a workstation (SGI Indigo)
It is not linked to other models or software, it is a stand alone package
It is written in C

Availability
Executable model: send blank diskette or five dollars
Source code: send blank diskette or five dollars
User's Guide: $10.00 (may be an ASCII version on diskette)
Training: A day or two of interactive work with the developers, arrangements should be made ahead of time.

Citations
ZELIG - General
    Burton and Urban, 1990
    Smith and Urban 1988
    Urban 1990, 1993
    Urban and Shuggart 1992
    Urban et al. 1991, 1993

ZELIG.BC
    Burton and Cumming 1991. User's Guide
    Cumming and Burton 1993.

Comments
Not applicable

Source
Interview with Phil Burton

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20. ZELIG.MFG

Model Name
ZELIG.MFG

Purpose of Model
To detail stand establishment where forest competition with brush or grass prevails over competition amongst trees

State of Development
Prototype
To be integrated with or be an option for ZELIG.BC
Release August 1994

Input Data
same input requirements as for ZELIG.BC

Outputs
Same output as for ZELIG.BC

Option for specific abundance by %cover or biomass

Spatial Scale
Individual plots 5-100m^2
Stochastic- multiple plots must be run
No transect mode currently

Temporal Scales
10-50 year projections, this is where ZELIG.BC is weak

Actions
None currently implemented easily, but are planned when the model is integrated with ZELIG.BC

Model Type
stochastic mechanistic

Critical Assumptions
Same as for ZELIG.BC

Users
No other users

ZELIG.MFG (continued)

Model Behaviour Analyses
No sensitivity analyses

Limitations
Less data available for non-tree species which makes it difficult to calibrate

Appropriateness for B.C.
Good, only one trial calibration for one test site so far
No verification data
Uncertain about ease of transfer

Operating Environment
Currently only on Mainframe/Server in the UBC computing centre, future plans to develop for workstation and microcomputer, written in FORTRAN, but there are plans to translate to C.

Availability
Not currently available

Citations
Burton and Urban 1989, 1990

Comments
under development, not yet reliable, but should have much potential for understanding biodiversity response to different forestry situations

Source
Interview with Phil Burton

Appendix 2: List of Contacts

Interview Contacts

Name	Address	Phone/Fax	Modelling Activity
Andrew Harcomb	Wildlife Branch BC Environment 780 Blanchard St. Victoria, B.C. V8V 1X4	P: (604) 387-9798 F: (604) 356-9145	Wildlife Habitat HandBook Models
Marvin Eng	Research Branch BC Ministry of Forests 1st Floor 31 Bastion Square Victoria, B.C V8W 3E7	P: (604) 387-2710 F:	Habitat Assessment and Planning Tool
Dave Daust	Centre for Applied Conservation Biology University of British Columbia 2357 Main Mall V6T 1Z4	P: (604) 822-6624 F: (604) 822-5410	SIMFOREST
Tom Spies	US Forest Service Corvallis, OR (Presently in Harvard, Mass.)	P: (508) 724-3302 F: (508) 724-3595	Empirical models of stand development, habitat attributes.
Bruce Marcot	US Forest Service Box 3890 Portland, OR 972-08	P: (503) 326-4952 F: (503) 326-2455	Snag Recruitment Simulator (SRS)
Peter Duinker/ Peter Higgelke	Lakehead University Ontario	P: (807) 343-8330 F: (807) 343 8116	Moose Habitat and Population Spatial Analysis Model
Mike Sullivan	Forest Habitat Program Manager Dept. of Natural Resources and Energy Box 6000 Fredericton, NB E3B 5H1	P: (506) 453-2440 F:	Additions to FORMAN +1 timber supply model: 1) Mature Coniferous Forest Habitat Model 2) Deer Winter Cover Model
Rich Bonar	Weldwood of Canada Ltd. 57 Switzer Dr. Hinton, Alberta.	P: (403) 865-2251 F: (403) 865-816	Foothills Decision Support System
Dan Welsh / Lisa Veneer	Canadian Wildlife Service 49 Camelot Dr. Nepean, Ont.	P: (613) 952-2405 F: (613) 952-9027	Ecosystem Supply for Forest Bird Populations
Dr. Rob Remple	Centre for Northern Forest Ecosystem Studies Ontario Ministry of Natural Resources Thunder Bay, Ontario	P: (807) 343-4018 F:	Moose Habitat Effectiveness Monitoring Program

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Name	Address	Phone/Fax	Modelling Activity
Richard Teck	Operations Research Analyst U.S.D.A. Forest Service, Washington Office, Timber Mgmt. Service Center 3825 East Mulberry Fort Collins. CO 90524	P: (303) 498-1772 F: (303) 498-1660	Integrating SRS (Snag Recruitment Simulator) with the FVS (Forest Vegetation Simulator), ELK COVER
Phil Burton	Faculty of Forestry University of British Columbia Room 270 - 2357 Main Mall Vancouver, B.C. V6T 1Z4	P: (604) 822-6020 F: (604) 822-5744	ZELIG.BC, ZELIG.MFG
Glenn Dunsworth	Woodland Services Division MacMillan Bloedel Ltd. 65 Front St. Nanaimo, B.C. V9R 5H9	P: (604) 755-3425 F: (604) 755-3550	Biodiversity Impact Assessment (BIAS)
Jeff Stone	Research Branch Ministry of Forests #506-1175 Douglas St. Victoria, B.C. V8B 3E7	P: (604) 387-6672 F: (604) 387-8197	Dynamics of Dead Trees at the Stand Level (DDTSL)
Ken Mitchell	Research Branch Ministry of Forests First Floor. 31 Bastion Square Victoria, B.C. V8W 3E7	P: (604) 387-6673 F: (604) 387-8197	SIMROT
Don Robinson	ESSA Technologies Ltd. 300-1765 W. 8th Ave Vancouver, B.C. V6J 5C6	P: (604) 733-2996 F: (604) 733-4657	Dwarf Mistletoe Spread and Intensification Model

Non-Interview and Potential Contact

Name	Address	Phone/Fax	Modelling activity	Contact Status
Rick Page	Research Branch BC Ministry of Forests 1st Floor 31 Bastion Square Victoria. B.C. V8W 3E7	P:(604) 387-6710 F:	Multiple species models to link with vegetation simulators	Yes
Alton Harsted	SFU Dr. Harsted was unavailable during this project	P:(604) 291-4809 F:(604) 291-3496		No
Glenn Sutherland	SFU	P:(604) 291-5775 F:(604) 291-4968	Spatial components of SIMFOREST	Yes
Ken Lertzman	School of Resource and Environmental Management Simon Fraser University Burnaby. B.C. V5A 1S6	P:(604) 291-3069 (604) 291-5775 F:(604) 291-4968	Wildlife habitat indicators	Yes
Jiquan Chen (Recommended by Ken Lertzman)	School of Forest and Wood Products Michigan Technological University Houghton. Michigan.	P: F:	Micro climate at edges	No
Andy Hanson (Recommended by Ken Lertzman)	Dept. of Biology Michigan State University Boseman, Michigan.	P: (406) 994-4548 F:	Stand level and landscape level modelling	No
Jerry Badey	US Forest Service Portland, OR	P:(503) 326-2728 F:(503) 326-5569	Forest pathology	Yes
Bob Watt	Ontario Ministry of Natural Resources Timmins. ONT.	P:(705) 360-8216 F:(705) 267-3626	Marten. moose. other wildlife models	No

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Name	Address	Phone/Fax	Modelling activity	Contact Status
Ken Abraham	Ontario Ministry of Natural Resources Sault Ste. Marie	P:(807) 343-4018 F:	moose, forest values	Yes
Laurie Gravelines	Ontario Ministry of Natural Resources Sault Ste. Marie	P:(705) 945-5833 F:	Currently developing travel cost models independently and with Kim Rawlins of Dept. Agr. & Rural Econ. @ U. of Guelph.	No
Vic Adamowicz	Dept. of Rural Economy U. Alberta	P: (403) 492-4225 F:	economic valuation of NTRs	No
Jim Fox	Alaska	P: F:	STELLA model hydrology and cumulative effects	No
Lowell H. Suring	USDA Forest Service Alaska region Juneau, Alaska	P: F:	Wildlife habitat models	No
Richard Holthausen (Recommended by Bruce Marcot)	USDA Forest Service Oregon State University	P: (503) 737-1979 F:	Wildlife Habitat Relationships Program USDA Forest Service Manager for U.S.	No
Norm Cimon (Recommended by Bruce Marcot)	U.S. Forest Service Grand Oregon, Forest Science lab	P: (503) 963-7122 F:	Has worked with different models, good for leads.	No

Name	Address	Phone/Fax	Modelling activity	Contact Status
Dr. Reg Barret (Recommended by Bruce Marcot)	University of California. Berkley	P: (501) 642-7261 (501) 642-3765 msg F:	Wildlife Habitat Relationship Models	No
Dr. Bill McComb (Recommended by Bruce Marcot) On sabbatical	The Dept. of Forest Science Oregon State University Corvalis. OR. 97331 E Mail: MCCOMBB@PERTH.DIALIX.OZ.AU	P: (503) 737-2244 F:	Snag dynamic projection model (SDPM)	No
Charlie Bruce (Recommended by Bruce Marcot)	Oregon State Dept. of Fish and Wildlife	P: (503) 757-4816 F:	Elk modelling that state agency is doing and other models	No
Tommy Gregg (Recommended by Jerry Badey)	U.S. Forest Service	P: (503) 326-6696 F:	Biometrician	No
Patrice Janiga (Recommended by Jerry Badey)	Methods Application Group U.S. Forest Service 3825 E. Mulberry Fort Collins. COL 80524	P: (303) 498-1777 F: (303) 498-1660	Decision support systems-models and GIS within the decision support system	No
Ross Piwell	U.S. Forest Service	P: F:		No
John Nelson (Recommended by Dave Daust)	UBC Forest Management	P: F:	spatial simulation modelling- economic aspects of different harvest plans	No
Jack McDonald (Recommended by Dave Daust)	FERIC (Forest Engineering Research Institute of Canada) UBC	P: (604) 228-1555 F:	involved in lots of modelling	No
Carl Walters (Recommended by Dave Daust)	UBC	P: F:		No
Nelly De Geus (Recommended by Rick Page)	Integrated Resource Section Policy and Planning Div. Ministry of Forests 1450 Government St. Victoria. B.C. V8W 3E7	P: (604) 387-6656 F: (604) 387-6751	wrote a report on Agroforestry resources for CORE and will send ESSA a copy (Received!)	Yes

Name	Address	Phone/Fax	Modelling activity	Contact Status
Warren Kilby (Recommended by Rick Page)	Energy, Mines, and Resources	P: (?) 952-0422 F:	mineral potential mapping	No
Keith Reynolds (Recommended by Bruce Marcot)	U.S. Forest Service	P: (907) 271-2572 F: (907) 271-2898	Decision Support Systems	Yes
Dr. Gordon Hartman		P: F:	Studied Carnation Creek System Fisheries vs. Forestry	No
Natasha Kottiar	Wildlife biologist Fort Collins Research Center	P: F:	working with habitat evaluation models	No
Dr. Peter Bisson	Weyerhaueser in Washington may be contacted through Cooperative for Forest Systems, Engineering . U. of Washington	P: F:	studied cumulative hydrologic effects, has worked with both Oregon and Washington assessing affects of forestry	No
Catherin Enns (Recommended by Phil Burton)	Larkspur Consultants	P: 479-6216	A report for the wildlife branch of the forest ministry, a problem analysis on the state of integrated modelling in natural resource management	No
Evilyn Hamilton (Recommended by Phil Burton)		P: 387-3650 F:	Knows what's happening in the NTR area	No
Susan Stevenson (Recommended by Jeff Stone)	Silvifauna 101 Burden St. Prince George. B.C. V2M 2G8	P: F:	Arborial Lichens	No
Steve Cumming (Recommended by Phil Burton)		P: 822-6013	Currently developing a landscape model which deals with stand development (distribution, harvesting, habitat indices)	No
Darrell Erico (Recommended by Tom Niemann)	Timber Supply Section Ministry of Forests	P: (604) 387-5111 F:	Modelling at Forest Level	No

Name	Address	Phone/Fax	Modelling activity	Contact Status
Gerard Olivotto (Recommended by Tom Niemann)	Timber Supply Section Ministry of Forests	P: F:	Modelling at the Forest Level Currently writing a timber supply review	No
Tom Niemann	Research Branch Ministry of Forests #506-1175 Douglas St. Victoria, B.C. V8B 3E7	P: (604) 387-6642 F: (604) 387-8169	Research	Yes

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Appendix 3: Additional References

These references may be of related interest to this project

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