Design Document for a Wildlife Modelling System

prepared for

Western Newfoundland Model Forest

by

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Original Report
For/By Western NF
Model Forest

Table of Contents

1.0 System Overview

This document describes the preliminary structure of a computer modelling system intended to help resource managers consider wildlife related objectives when planning and conducting forest management operations. This document has several purposes:

- to provide an initial description of the system and the manner in which it may function and be operated;
- to provide a preliminary basis upon which to refine system design;
- to provide a guide for the initial development of the system; and
- to crystallize the vision of the system so that subsequent development can proceed in a clear and organized manner.

The system described here is based on the results of a workshop organized by the Western Newfoundland Model Forest and held in Cornerbrook Newfoundland, March 1 - 3, 1994.

1.1 Terminology

A few key terms are defined below to clarify how they have been used in the document.

System	In the context of this document, the system refers to the entire wildlife modelling system that is the subject of this report.
Model	A model is any simplified representation of an object, process, or series of processes. Although there are many types of models, including conceptual models, physical models, and mathematical models, in this document the term is used to refer to computer programs whose intent is to simulate the dynamics of natural processes related to forestry and/or wildlife management. The wildlife modelling system will include a number of models.
Interface	The interface of computer software, as referred to in this document, is that part of the software that allows users to control the execution of the system - it's what the users see when they use a piece of software. The interface of the wildlife modelling system will allow users to run models, examine output, design scenarios, etc.
Scenario	A scenario, as the term is used in this document, is any single execution of a model or models with a unique set of conditions. For example, one scenario may simulate the effects of a timber harvesting pattern on a wildlife species, another

scenario may simulate the effects of a different harvesting pattern, and a third scenario may simulate the effects of the original harvesting system, but may simulate the effects on the wildlife species differently.

1.2 General Description

The system will be comprised of a linked series of models controlled by the user through an interface. The emphasis in this document will be on describing the system's interface, rather than the design and specifics of the models. Two general types of models will be components of the system: vegetation models that simulate changes in forest vegetation over time as a function of forest management actions (e.g. levels of silviculture), and wildlife models that use the output from the vegetation models to simulate to the subsequent effects on wildlife habitat and populations. A simple representation of the system is presented in Figure 1.1.

The system will have two distinct uses:

- as a planning tool, the system will be used by forest and wildlife managers to design forest management strategies and plans to meet wildlife and forestry objectives; and
- as a scientific tool, wildlife researchers and managers will use the system to investigate hypotheses and relationships about the manner in which forest management and vegetation change affect wildlife habitat and populations.

As noted above, this document is intended only to provide a preliminary description of the wildlife modelling system. We expect and hope that it will be modified and refined in the future as knowledge of wildlife-forestry relationships improve, user needs change, data availability increases and modelling and software design techniques and features improve. At present, the general state of knowledge about the manner in which forest management actions affect wildlife is very imperfect. In Newfoundland, as elsewhere, much data remains to be collected and even simple relationships are not well understood. One school of thought suggests that models should only be used to make predictions once significant amounts of data have been collected, and relationships are well understood. In this capacity, models serve basically as integrators of data and relationships. This project, however, is based on an alternate approach, known as Adaptive Environmental Assessment and Management (AEAM) (Holling 1978; Walters 1986), that has the following premises:

- models should be used as a basis to improve our understanding of ecological systems and test hypotheses about the manner in which systems function - this implies that having "all the data" is not a necessary precursor to developing and using models;

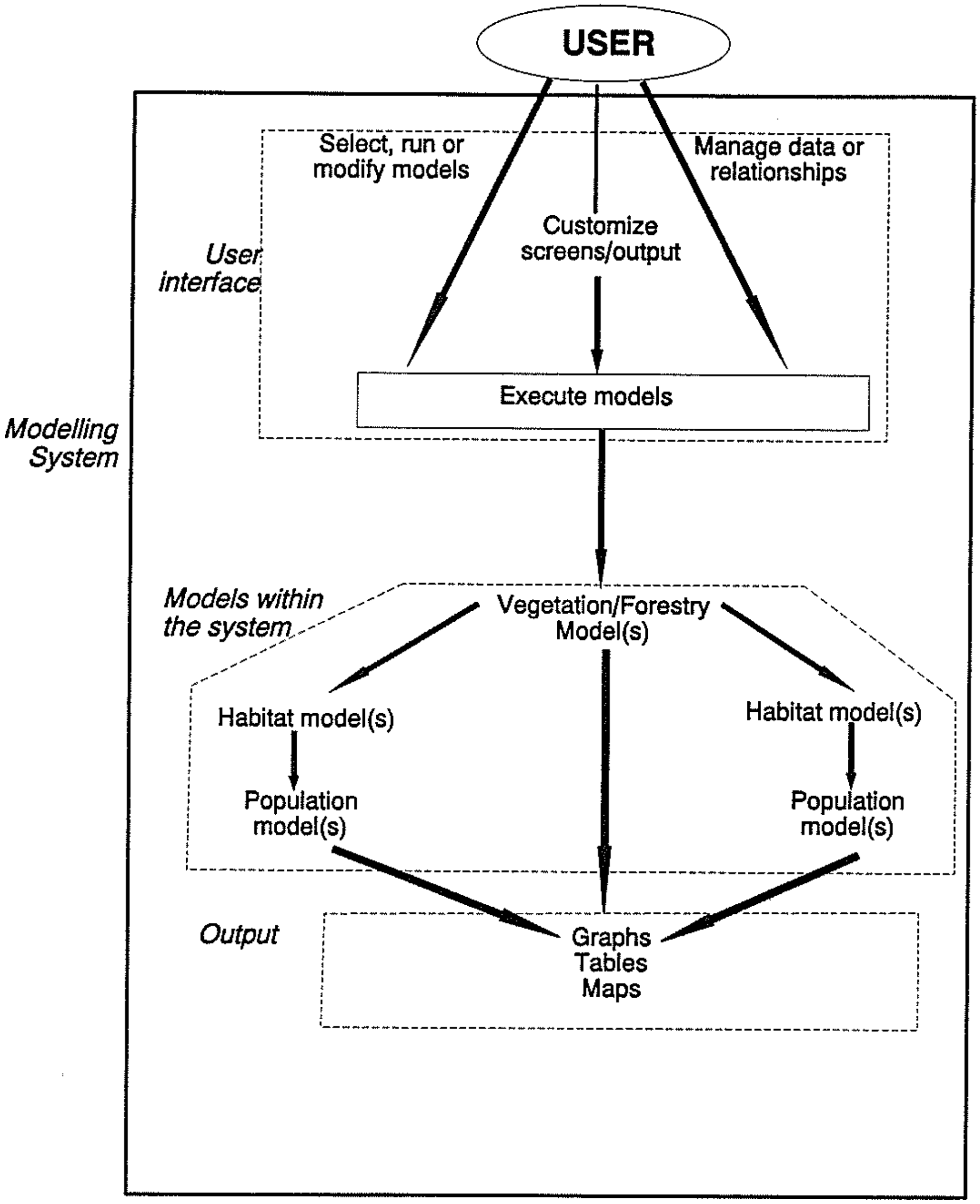


Figure 1.1 Simple representation of the wildlife modelling system

- models developed with imperfect or missing data can make valuable contributions to planning, as they predict quantitative results - quantitative predictions provide a solid basis upon which to improve, while qualitative estimates provide a much poorer basis.

Following up on these points, it will be important for users to remember that model predictions will be imprecise and often incorrect. Natural dynamics are far too complex and poorly understood to be accurately mimicked by computer models of the sort that will comprise the preliminary version of the wildlife modelling system. Model results should be interpreted as forecasts, rather than reality. The system is intended to support decisions made by human resource managers, and definitely not to replace managers' abilities to make decisions based on their professional judgement.

2.0 Bounding the System

The most important choices in any modelling exercise include deciding upon the basic level of concern and selecting the components to be explicitly considered in addressing this level of concern. With the AEAM approach, these choices are initiated in what is known as a "bounding exercise". The bounding exercise forces workshop participants to define a finite and realistic set of model inputs and outputs, and to place them in an appropriate spatial and temporal framework.

The following sections outline the decisions made by participants during the workshop's model bounding exercise. For the purposes of this exercise, the system to be bounded included only the vegetation and wildlife models of the overall decision support system (as shown in Figure 1.1). Components of the decision support system that involved tasks such as database management, Geographic Information Systems (GIS) and user interface were considered external to the bounding exercise.

2.1 Spatial Extent and Resolution

Any model of a physical system is necessarily confined within some spatial extent. Workshop participants agreed that the system should be developed for use over the entire Western Newfoundland Model Forest (approximately 900,000 ha). The system should be designed so that it can be used to make predictions either over the entire Model Forest, or alternatively for only certain portions of the Model Forest. For example, users may wish to use the system for analysis within a particular management unit, watershed, or collection of stands. While the initial focus will be to develop a system that can be used in the Model Forest, where possible the system should be designed so that it can easily be adapted for use in other parts of the province.

The spatial resolution of the system is defined as the smallest spatial unit over which the decision support system will make explicit spatial predictions for the user. For this system, participants agreed that this should be a stand (of which there are approximately 40,000 represented in the Model Forest).

2.2 Temporal Extent and Resolution

The temporal extent of the system is the time period over which the system should be capable of making predictions. For the system to predict the full range of impacts that might occur as a result of a management action, it should be capable of making predictions for at least one complete overstory rotation. Participants felt that a temporal extent of approximately 100-200 years would be appropriate.

The temporal resolution of the model is defined as the smallest unit of time over which the decision support system will be required to make predictions for the user. Participants felt that changes in overstory vegetation, which in turn will drive much of the system's dynamics, can at best be predicted every 5 years. As a result, a 5-year step was selected as an appropriate temporal resolution for the system.

2.3 Actions

Using AEAM terminology, "actions" are simply those activities that managers can consider in their attempts to manipulate a system to meet goals and objectives. From the standpoint of simulation models, they are quantities (e.g. silvicultural treatment) which have some influence on the model, but which are not predicted by the model. Instead their levels are specified outside of the model, usually as a part of an overall policy or management strategy. Although management strategies are usually implemented as a suite of actions, it is important that the system be capable of varying and responding to actions individually, to gain a sense of the system's sensitivity to particular decisions.

The following actions were identified by workshop participants to be included in the preliminary version of the decision support system:

1. *Target level of harvesting*. Expressed as the volume of wood harvested (in m^3) for the entire Model Forest, for each 5-year time step.

2. *Target harvesting pattern*. Set the minimum and maximum block size for harvesting, for each 5-year time step.

3. *Area damaged by fire and insects*. Identify stands damaged for each 5-year time step.

4. *Silvicultural treatment* (thinning, planting and herbicides). Identify treatment type for each stand, for each 5-year time step.

5. *Width of riparian zone*. Set the width around streams in which harvesting will not occur (by stream type), for each 5-year time step.

A number of additional actions were identified by participants for future versions of the decision support system.

6. *Levels of hunting, snaring and angling*. Expressed as the number of animals harvested in the Model Forest (or possibly by management unit), for each 5-year time step.

7. *Target forest age class distribution*. User should be able to set a target age class distribution for the forest at any time in the future.

8. *Level of human intervention* (e.g. number of visitor days).
9. *Level of habitat enhancement.*
10. *Changes in climate.*

2.4 Indicators

Indicators are those quantities which allow the user to observe and evaluate the performance of the system in response to changes in management actions. As different users will rely upon different measures to evaluate system performance, it is important to include a diverse and comprehensive set of indicators that truly represent the interests of all participants and agencies.

The list of indicators is divided into those that are the responsibility of the vegetation component of the decision support system, and those that are the responsibility of the wildlife component. Note that many of the vegetation indicators are also required as inputs to the wildlife models. Participants agreed, however, that for the first version of the system, the effects of wildlife on vegetation (e.g. through browsing) would not be included. These effects could be accounted for, however, in future versions of the system.

Vegetation Indicators

Participants agreed that the following indicators of vegetation should be predicted by the decision support system for each time step (i.e. 5-year period) and spatial unit (i.e. stand) of a model run:

1. *Volume of harvest.* Expressed as the volume of wood harvested (in m^3).
2. *Volume of overstory growing stock.* Expressed as the volume of wood standing (in m^3) for the stand.
3. *Overstory crown density.* Expressed as the average crown density of the stand.
4. *Overstory age.* Expressed as the 5-year age class of the stand.
5. *Overstory height.* Expressed as average height of the stand (in metres).
6. *Overstory species composition.* Expressed as the species working group of the stand (e.g. balsam fir, black spruce, hardwood/softwood).
7. *Understory species composition.*

8. *Understory percent ground cover.*

9. *Volume of coarse woody debris.*

An additional vegetation indicator was identified by participants for future versions of the decision support system:

10. *Density of snags.* The number of snags per hectare.

Wildlife Indicators

The following indicators were identified for the wildlife module. These would be predicted for each time step (i.e. 5-year period) and spatial unit (i.e. stand) of a model run:

11. *Habitat suitability indices* . Calculated for different species, including the following: marten, moose, raptors, caribou, bears, fish, furbearers, hares, grouse, waterfowl, songbirds, cavity nesters, and bats.

Additional wildlife indicators identified by participants for future versions of the decision support system include:

12. *Population densities.* Densities (in number per hectare), by age class, for different species.

13. *Measure of biodiversity.*

14. *Measures of water quantity and quality.*

3.0 Vegetation Models

Having bounded the overall decision support system, participants at the workshop then focussed upon defining the specific models and information required to predict the vegetation indicators (as outlined in section 2.4). In order to predict the vegetation indicators associated with the preliminary decision support system, it was agreed that two separate models would be required:

- a spatial wood supply model for predicting the growth of the overstory; and
- a succession model, based upon Dammen's FEC system, for predicting the dynamics of the understory.

Table 3.1: Vegetation indicators of the preliminary decision support system. Whether or not it is currently possible to predict each indicator for the Model Forest is also shown.

Vegetation Model	Indicator	Currently Possible?
Overstory	Volume of harvest	Yes
	Volume of overstory growing stock	Yes
	Overstory age	Yes
	Overstory species composition	Yes
	Overstory crown density	No
	Overstory height	No
Understory	Understory species composition	No
	Understory percent ground cover	No
	Volume of coarse woody debris	No

3.1 Overstory Model

A number of the vegetation indicators are associated with the overstory of the forest (see Table 3.1); foresters currently use wood supply models to predict many of these indicators. A wood supply model is simply a bookkeeping device that tracks changes in the overstory over time in response to user specified harvesting and silvicultural activities. Such models generally require three basic inputs:

- the current state of the forest (i.e. a forest inventory);
- rules for how the forest inventory will change over time (i.e. yield curves);
- a management strategy - a prediction of the nature, timing and extent of management actions, such as harvesting and silviculture, that will be implemented over time.

Participants agreed that a spatial wood supply model, in which the fate of each stand is predicted over time, would serve as the cornerstone for the vegetation modelling in the preliminary decision support system. A spatial wood supply model (as opposed to non-spatial) was chosen for the following reasons:

- the spatial arrangement of vegetation is a key determinant of the value of habitat to many wildlife species;
- the technology exists to make spatial predictions of changes in vegetation (e.g. GIS-FORMAN and HSG); and
- the forestry branch is moving to spatial modelling and it makes sense to be as integrated with their approaches and practices as possible.

A number of spatial wood supply models have already been developed and are currently being used in various locations across Canada and North America. A decision support system working group is currently evaluating a number of these models, and is planning to recommend a single model for use in all Model Forests. The choice of model has been narrowed down to either GIS-FORMAN or HSG. It is anticipated that whichever of these two models is recommended by the working group will be adopted for use in this decision support system.

Without any significant modifications, current wood supply models will predict some, but not all, of the overstory indicators (see Table 3.1). Those indicators which can currently be predicted for the Model Forest, using a model such as GIS-FORMAN and existing data, include the following:

- volume of harvest;
- volume of overstory growing stock;
- overstory age; and
- overstory species composition.

The remaining two overstory indicators, height and crown density, will require some additional analysis before predictions can be made within the decision support system:

- ***Overstory height.*** As a wood supply model is currently capable of predicting the age of a stand over time, participants suggested that the height of a stand could also be predicted if a relationship between the overstory age and height were developed. Such a relationship would likely be developed for every volume yield curve in the wood supply model. Participants suggested that the same data that was used to generate the current volume yield curves for the Model Forest could in turn be used to develop these age-height relationships.

- ***Overstory crown density.*** Changes in crown density over time could also be predicted in similar way to overstory height. Participants suggested that crown density could be predicted if a relationship between crown density and age were developed for every volume yield curve in the wood supply model. It was further suggested, however, that the data required to develop this relationship may not be as readily available as the height data for the Model Forest.

3.2 Understory Model

While there are several existing models capable of predicting changes in the overstory over time, there are no models currently capable of predicting the dynamics of the understory for the Model Forest. Participants agreed that, in order to predict the understory indicators outlined in Table 3.1, it would be necessary to develop some form of forest successional model.

The basis for such a successional model would likely be Dammen's FEC system for Newfoundland. The successional model would track and predict the state of the FEC for each stand over time as function of natural succession and disturbance (such as harvesting). Using the predicted FEC for a stand in the future, and simple relationships between FEC and each of the understory indicators, the model would then predict the various understory indicators.

At present there are a number tasks that will need to be undertaken in order to develop a version of such a successional model suitable for use within the Model Forest.

- ***Develop temporal rules for succession.*** While general rules exist for predicting changes in FEC after various forms of disturbance, there are no rules for predicting the timing of these successional changes. A group at Memorial University, under the direction of Dr. Simms, is currently working to develop these temporal rules of succession; a preliminary version of the rules is scheduled for completion in the summer of 1994.

- ***Develop computer model.*** Once the temporal rules for FEC succession have been developed, along with the relationships between each of the understory indicators and the site type, the next step will be to develop a computer model that uses these rules to track and predict the FEC state for each stand over time. This computer model will need to be designed so that it runs in parallel with the decision support system's wood supply model; this will allow the two models to respond to the same management strategies over time.

- *Dammen FEC inventory.* As a starting point for its predictions, the successional model will require an inventory of the present Dammen FEC for each stand in the Model Forest. An initiative is currently underway, under the direction of George Kitchen, to derive such an inventory for the Model Forest from the Canada Land Inventory (CLI) forestry maps; a preliminary version of this inventory is scheduled for completion in the summer of 1994.

- *Understory indicator relationships.* In order to predict each of the understory indicators listed in Table 3.1, relationships between the Dammen FEC and the understory indicators will need to be developed. While the relationship between the FEC and both the understory species composition and the percent ground cover should not be too difficult to infer, predicting the volume of coarse woody debris as a function of FEC will be much more challenging.

4.0 Wildlife Models

The preliminary version of the system will be designed to simulate effects of various management actions on individual species of wildlife. While recent definitions of wildlife have been broadened to include all living organisms, workshop participants agreed that the preliminary version of the system would focus upon terrestrial vertebrates. This assumption reflects the bias of those involved in the design of the preliminary version, and is a practical starting point in the development of a more complete system.

For the purposes of the Western Newfoundland Model Forest, the most significant drawback of limiting the scope of the system to terrestrial vertebrates is that effects on fish and aquatic habitat are explicitly excluded from the preliminary version of the system. Although fish are a critical aspect of the ecology of the Model Forest, workshop participants agreed not to include the effects on fish and aquatic habitat in order to simplify the initial system development. The explicit assumption here is that aquatic modelling work will continue in parallel to the development of this system, with an eye towards eventually merging the modelling efforts if and when it is appropriate.

4.1 Habitat Suitability Indices

For most terrestrial vertebrates, the principle effect of forest management operations is due to changes in habitat. For this reason, a decision was made to focus the design of the preliminary version of the system on predicting changes in wildlife habitat. A Habitat Suitability Index (HSI) is a relatively simple means of measuring changes in habitat of a wildlife species. An HSI mathematically combines estimates of the availability of certain critical habitat features to produce a numerical index (generally between 0 and 1) of the quality of the habitat in a stand or group of stands for a wildlife species. HSI's have been developed for many species across North America, and the technique, although simple, has proven to be a robust and useful approach for estimating the quality of wildlife habitat.

A simple and preliminary HSI has been developed for boreal owls for Newfoundland (Brazil and Knox 1994). In this HSI, stand measures of proximity to bogs (PB), age (AGE), height class (HGT), species composition (SPC), and crown density (CD) are assigned numerical ratings from 0 - 3 based upon their suitability for use by owls.

The first step in the calculation of this HSI is combining the values for HGT and CD to generate a composite habitat quality measure (HC) as follows:

$$HC = \frac{HGT + CD}{2}$$

This implies that, for boreal owls, height class and crown density contribute equally to a composite quality of habitat that is, in turn, of equal value to the other attributes. Independently, however, HGT and CD are of lesser value than the other attributes.

The suggested HSI formula is:

$$HSI = \frac{(PB * AGE * SPC * HC)^{0.25}}{3}$$

The calculated value is applied only to similar stands 12 ha in size and with a minimum diameter of 200 m. Smaller stands, or groups of stands, are not considered to be useful habitat.

HSI's for other species will obviously combine different stand/habitat variables in different mathematical formulae. Few HSI's have been developed for species in Newfoundland, but because of the robustness and utility of the approach, workshop participants felt that it will likely be a key technique in managing habitat and estimating potential effects of timber management on habitat in the Model Forest.

From this discussion and the example above, they key point that is relevant for the design of the wildlife modelling system is that users will need to have a great deal of flexibility in i) selecting which stand/habitat attributes to combine in an HSI; and ii) in specifying the mathematical equations with which to combine the attributes.

4.2 Population Modelling

Generic Population Model

Wildlife managers are concerned about managing habitat and effects on habitat only because habitat quality influences wildlife populations. In some instances the ultimate determinant of a wildlife population is not habitat, but some other influence (e.g. hunting). Therefore, knowing the quality of habitat is necessary, but not sufficient information upon which to base wildlife management decisions.

For this reason population models should be included in a comprehensive wildlife modelling system. It would likely be possible to design generic population models that would i) estimate a habitat-based carrying capacity based upon an HSI; and ii) estimate a "true" population by simulating non-habitat related effects on the habitat-based carrying capacity. These effects would include hunting, trapping, predation, disease, etc. Each of these effects may occur by density-dependent or density-independent means. Such a model would be considerably more complex than the HSI model described above. Depending upon the immediate needs/interests of the Model Forest biologists, it may or may not be appropriate to include such a model in the preliminary version of the wildlife modelling system.

Considerable effort would need to be devoted to designing such a model. Obviously the model design would need to be complete before an interface could be designed. For this reason, the interface for such a model is not included in this document. Should the decision be made to include such a model in the preliminary version, the model design would need to be completed before the interface could be developed and included in a document such as this.

Detailed Population Models

Many wildlife computer models are highly-refined and species specific. Although none exist at present that are applicable to the Model Forest, development efforts are underway (e.g. marten persistence model). These models usually have species-specific algorithms, functions, logic, and utility. Although models such as these are less flexible than those described above, their detail and depth can make them powerful management and research tools. In future versions of a wildlife modelling system, it may be appropriate and useful to integrate such detailed models into the system.

5.0 Preliminary System Design

The following section provides a preliminary design for the wildlife modelling system. The design presented here is intended only as a starting point for future users to comment on before it is built, and to serve as a guide for future software development.

The system could be developed to run in either a Microsoft Windows or a Unix workstation environment (e.g. as an ARC/INFO AML application); the final decision on the hardware and software to be used will depend upon the availability of software development tools at the time the actual programming for the system is initiated. Regardless of which environment is selected, running the wildlife modelling system will require access to a Unix workstation in order to process and store all of the information associated with the vegetation model runs. Software currently exists that allows a PC-based computer, running Microsoft Windows, to be linked to a Unix workstation through a local or wide area network (e.g. across the entire province). While they will not necessarily require a workstation of their own, users of the wildlife modelling system will at least require *access* to a workstation.

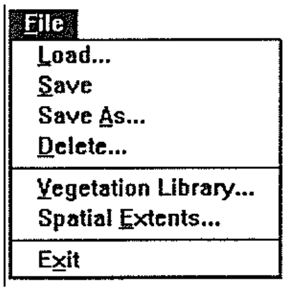
User Interface

Users would access all of the functions of the wildlife modelling system through the main menu. Each of the menus is described in detail below.

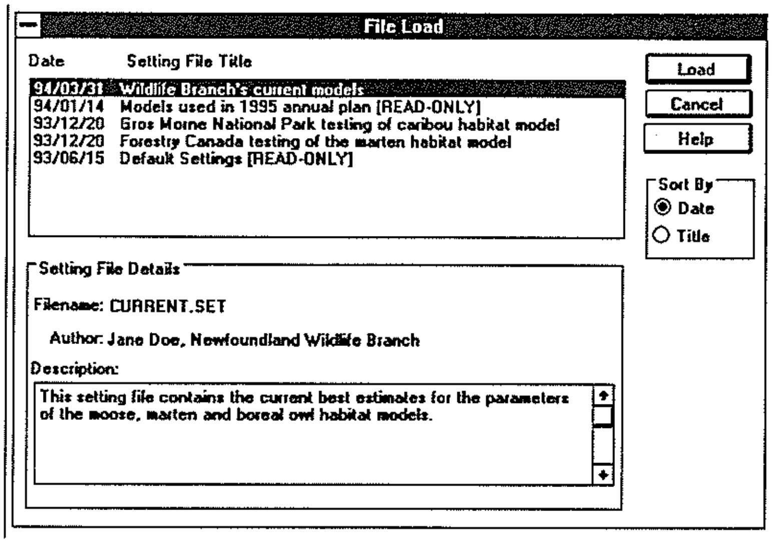
The **File** menu is used for file management. The options under the **Model** menu let users set habitat indicators, modify the population model, or select a particular species model. The **Run** menu allows user to specify a scenario and run the model. The results of the run can be viewed, saved, and printed by using the options found under the **Display** window. Users can compare two or more different displays using the options found under the **Window** menu. Finally, a help system is accessible by selecting the options in the **Help** menu.

File Menu

The **File** menu houses all of the file management options.



Load Selecting *Load* under the **File** menu allows users to load pre-created setting files. Each file contains a complete record of the settings for every other menu choice in the system, and is created whenever the user selects *Save* or *Save As* from the **File** menu.



Date	Setting File Title
94/03/31	Wildlife Branch's current models
94/01/14	Models used in 1995 annual plan [READ-ONLY]
93/12/20	Gros Morne National Park testing of caribou habitat model
93/12/20	Forestry Canada testing of the marten habitat model
93/06/15	Default Settings [READ-ONLY]

Setting File Details

Filename: CURRENT.SET

Author: Jane Doe, Newfoundland Wildlife Branch

Description:

This setting file contains the current best estimates for the parameters of the moose, marten and boreal owl habitat models.

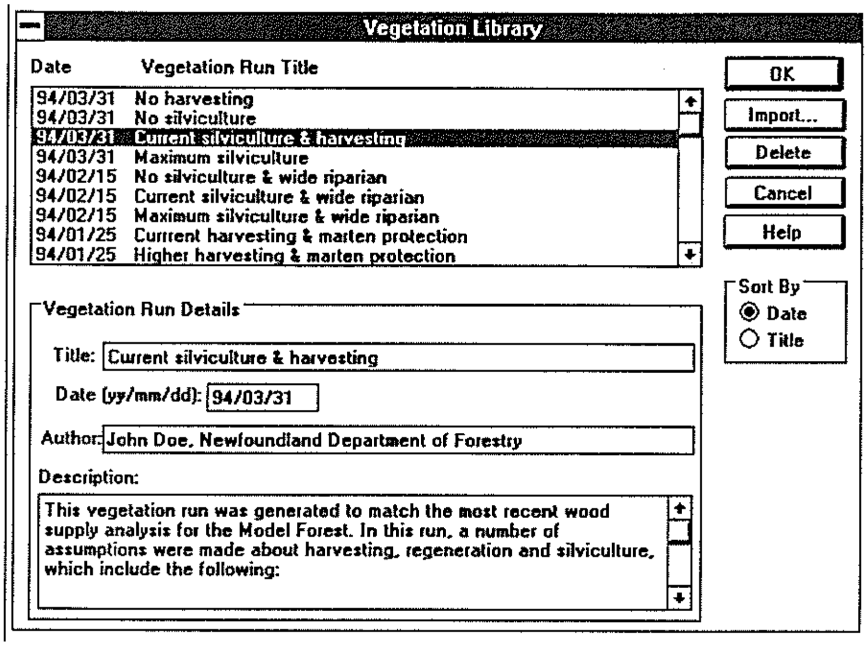
When a user selects a file to load, all of the system's settings that are associated with that file will be retrieved. This includes all of the habitat models and their parameter values. Information about the file name, author(s) of the file, and a detailed description of the file are provided in the bottom half of the screen to provide useful supplementary knowledge about particular files. For example, a setting file might well contain all of the HSI models for a particular planning exercise several months earlier. By loading this setting file in the future, any user could see all of the models (and parameter values) used earlier, and can be sure of reproducing the same predictions as any other user using this same setting file.

Save, Save As, Delete

These menu choices under the **File** menu allow users to perform standard file management practices with setting files. Pressing *Save* will save the current values for the settings of all menu choices (including all models and parameters). Files that are particularly significant, such as the default settings or the settings used to create annual plans, can be saved in "read-only" format to prevent users from altering or modifying them. *Save As* allows users to make a copy of a file under a new name. Unwanted setting files can be removed by using the *Delete* function.

Vegetation Library

This choice under the **File** menu acts as a library or database of the results from running the vegetation model. The vegetation model will simulate changes in the forest vegetation over time as a result of forest management activities, and will not be run directly from within the wildlife modelling system. Instead, a library of output for various runs of the vegetation model will be accessible from this option, where each run will consist of output from a spatial wood supply model such as HSG or GIS-FORMAN.



Date	Vegetation Run Title
94/03/31	No harvesting
94/03/31	No silviculture
94/03/31	Current silviculture & harvesting
94/03/31	Maximum silviculture
94/02/15	No silviculture & wide riparian
94/02/15	Current silviculture & wide riparian
94/02/15	Maximum silviculture & wide riparian
94/01/25	Current harvesting & marten protection
94/01/25	Higher harvesting & marten protection

Sort By
● Date
○ Title

Vegetation Run Details

Title: Current silviculture & harvesting

Date (yy/mm/dd): 94/03/31

Author: John Doe, Newfoundland Department of Forestry

Description:

This vegetation run was generated to match the most recent wood supply analysis for the Model Forest. In this run, a number of assumptions were made about harvesting, regeneration and silviculture, which include the following:

Users can import results from the wood supply model by selecting ***Import***. Once the results have been imported, users can provide details about the run (such as title, data, author(s), and a description) to help distinguish between different vegetation model outputs. In the screen above, for example, the run *Current silviculture & harvesting* has been selected. Details about this run are provided in the bottom half of the screen.

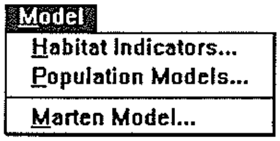
Users have the ability to edit the detailed descriptions of the vegetation run by simply typing the new information into the appropriate text boxes. Any unwanted runs can be deleted by pressing ***Delete***.

Spatial Extents

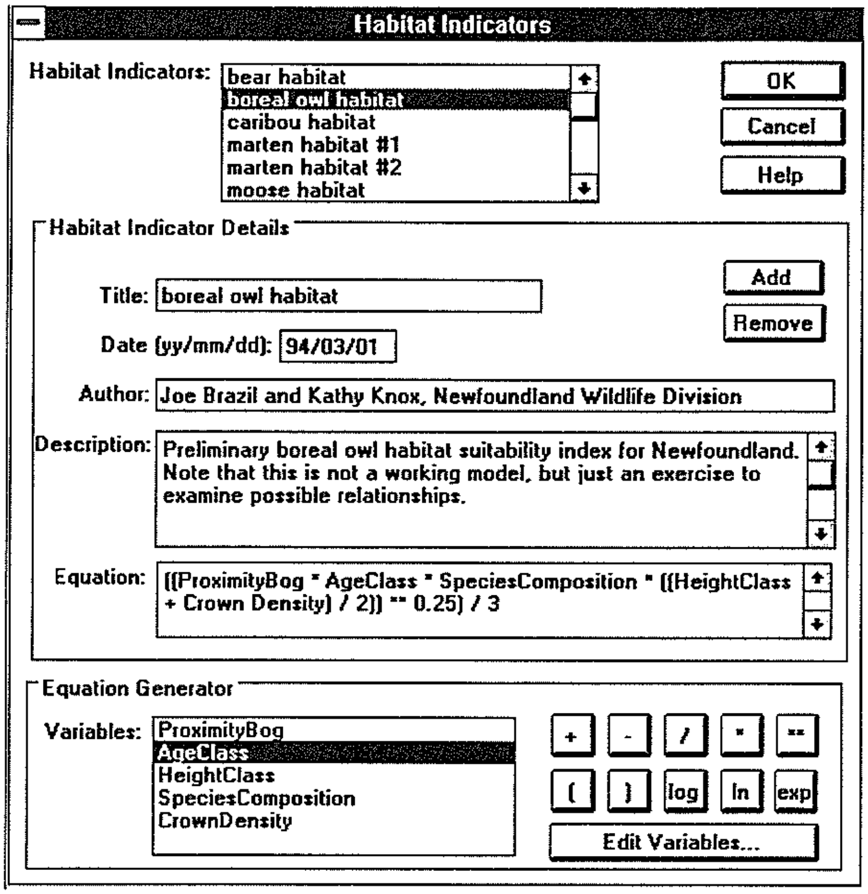
This choice under the **File** menu will allow users to define a series of spatial extents for use by the model. Users might be presented with a map of the entire Model Forest, from which they can use a mouse to define a particular area, ranging from a collection of stands to the entire Model Forest. This area will then be named and saved as a new spatial extent.

Model Menu

The wildlife models are manipulated through the options available under the **Model** menu.



Habitat Indicators By selecting *Habitat Indicators* under the **Model** menu, users are able to define models for various habitat indicators.



Habitat Indicators:
- bear habitat
- boreal owl habitat
- caribou habitat
- marten habitat #1
- marten habitat #2
- moose habitat

Title: boreal owl habitat

Date (yy/mm/dd): 94/03/01

Author: Joe Brazil and Kathy Knox, Newfoundland Wildlife Division

Description: Preliminary boreal owl habitat suitability index for Newfoundland. Note that this is not a working model, but just an exercise to examine possible relationships.

Equation: [(ProximityBog * AgeClass * SpeciesComposition * ((HeightClass + Crown Density) / 2)) ** 0.25] / 3

Variables:
- ProximityBog
- AgeClass
- HeightClass
- SpeciesComposition
- CrownDensity

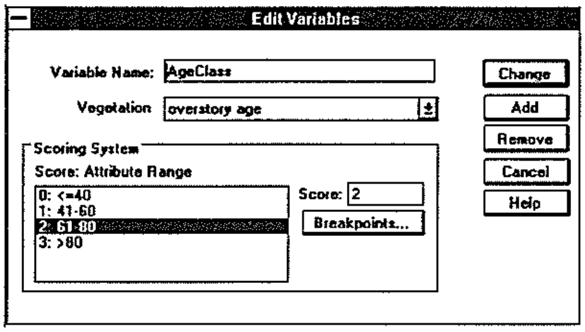
Users begin by selecting a particular habitat indicator. In the example above, boreal owl habitat has been selected.

The central portion of this screen contains details about the selected habitat indicator. Information is provided on the date the indicator was created, its author(s), a description of the indicator, and an equation that can be used to predict a Habitat Suitability Index (HSI) for a particular species. Users can edit and modify the detailed information on a particular habitat indicator by typing the new information into the appropriate text boxes. New habitat indicators are easily added to the system by naming a new indicator and selecting *Add*. Habitat indicators that are no longer required can be removed by selecting *Remove*.

One of the most significant pieces of information about the habitat indicator is the equation used to define the HSI. This equation uses vegetation attributes, as predicted by the vegetation model (and stored in the *Vegetation Library)*, to produce a numerical index of the habitat quality of an area for a particular species. By manipulating the equation generator, users have extensive flexibility and power to create HSI equations. Equations are created by clicking on operators and double-clicking on variables listed on the bottom portion of the *Habitat Indicators* screen.

Edit Variables

To add, delete, or edit the available variables for a given habitat, press the ***Edit Variables*** button at the bottom of the *Habitat Indicators* screen. The screen below will appear.

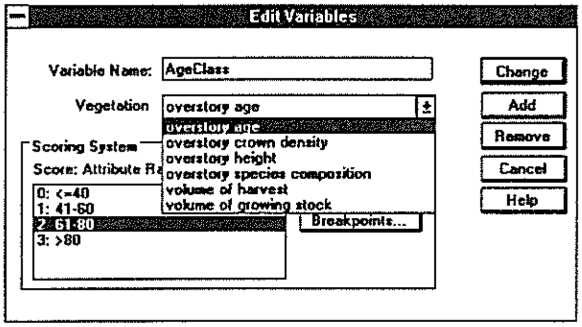


Variable Name: AgeClass
Vegetation: overstory age

Scoring System
Score: Attribute Range
0: <=40
1: 41-60
2: 61-80
3: >80

Score: 2

Each variable is linked to a single vegetation indicator. In the example above, the variable *AgeClass* is associated with the vegetation attribute *overstory age*. Users may wish to link a variable to a new attribute, or create a new variable. By clicking on the scroll arrow to the right of the text box, a drop-down list box of vegetation attributes appears, as is shown below, from which users can select a vegetation attribute of their choice.



Variable Name: AgeClass
Vegetation: overstory age

- overstory age
- overstory crown density
- overstory height
- overstory species composition
- volume of harvest
- volume of growing stock

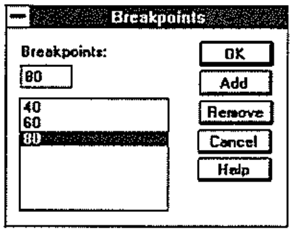
Scoring System
Score: Attribute Ra
0: <=40
1: 41-60
2: 61-80
3: >80

Once users have selected the variable and its attribute, they will need to set scores for the ranges of a specific attribute. In the example above, the scores for various ranges in *overstory age* are displayed. Stands with ages less than 40 years receive a score of 0 for the variable *AgeClass*, stands with ages between 41 and 60 years receive a score of 1, stands between 61 and 80 years receive a score of 2, and stands with ages greater than 80 years receive a score of 3. Older stands receive higher scores than younger stands because boreal owls nest in tree cavities, requiring that trees be of a certain diameter and age. Immature stands (i.e. those younger than 40 years) provide minimal nesting opportunities for boreal owls.

Any time a new vegetation attribute is selected, the scoring system will automatically change to reflect appropriate ranges and scores for that attribute. For example, if *overstory height* was selected as an attribute, the scoring system will assign points to various ranges of tree heights.

Breakpoints

Users may want to edit the scoring or rating system for a particular attribute. This is done by pressing the ***Breakpoints*** button at the bottom of the *Edit Variables* screen. For example, the following screen would appear for the variable *AgeClass* that was described above:



Breakpoints:
80
40
60
80

A breakpoint divides a range of data. To set a new breakpoint, simply type in the new value and select ***Add***. The system will automatically adjust the scoring system. Existing breakpoints can also be removed by selecting the breakpoint and clicking on the *Remove* button.

Population Models

Although habitat greatly determines wildlife populations, other influences such as hunting or disease are also important. The *Population Models* choice under the **Model** menu will allow users to estimate the effect of non-habitat related indicators on wildlife populations. Note that, for the preliminary version of the system, population models would not be included.

Marten Model

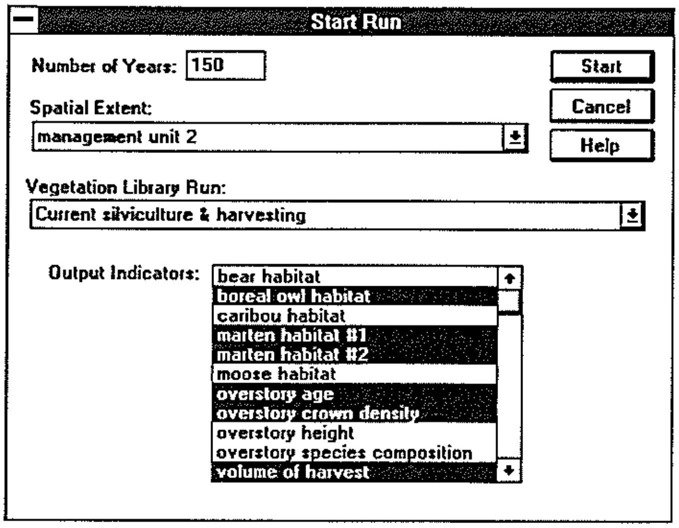
Detailed population models, such as a marten model, may be integrated into the system as further menu choices in the future.

Run Menu

The options under the **Run** menu allow users to run the model.

Start Run

Users define a scenario and run the model by choosing the *Start Run* choice under the **Run** menu.



Number of Years: 150

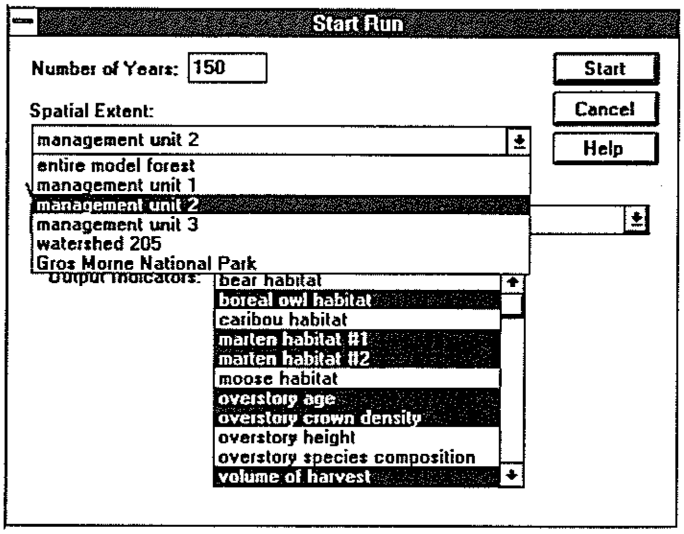
Spatial Extent: management unit 2

Vegetation Library Run: Current silviculture & harvesting

Output Indicators:
- bear habitat
- boreal owl habitat
- caribou habitat
- marten habitat #1
- marten habitat #2
- moose habitat
- overstory age
- overstory crown density
- overstory height
- overstory species composition
- volume of harvest

Before running the model, it is necessary to specify a set of parameters that will define the scenario. Users can manipulate variables of time, space, vegetation models and wildlife models. To begin, users must specify the number of years for which the system should predict the effects on wildlife. In the example above, the user has selected a temporal extent of 150 years.

Next, the user needs to select the spatial extent. By clicking on the scroll arrow in this field, a drop-down list box of spatial extents is displayed, as is shown in the screen below. A database of available spatial extents would be maintained using the *Spatial Extent* choice under the **File** menu as described earlier.



Start Run

Number of Years: 150

Spatial Extent: management unit 2

The model can make predictions over a range of spatial extents, from a single stand to the entire Model Forest. In the example above, the user has selected *management unit 2* as the area under analysis.

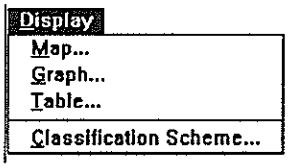
Clicking on the scroll arrow in the *Vegetation Library Run* field will also display a drop-down list box, from which users can select an output run from the vegetation model to use with this scenario. In this example, the user has selected to run the system using the vegetation model run called *Current silviculture & harvesting*. A database of available vegetation library runs would be maintained using the *Vegetation Library* choice under the **File** menu (as described earlier).

Finally, users can indicate which output indicators they would like to have the model calculate for this scenario.

Pressing *Start* will start the model run. Selecting the choice *Abort Run* under the **Run** menu will terminate the model run.

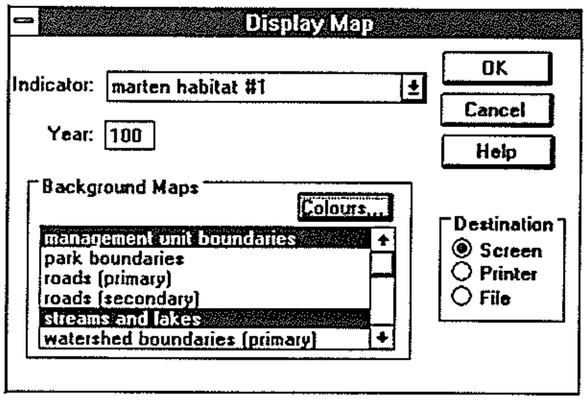
Display Menu

The choices under the **Display** menu allow users to view the results of the model run in mapped, graphical, or tabular form.



Display Map

Once a model run has been completed, users can view the results of the run in mapped form. When *Map* is chosen under the **Display** menu, the following screen appears:

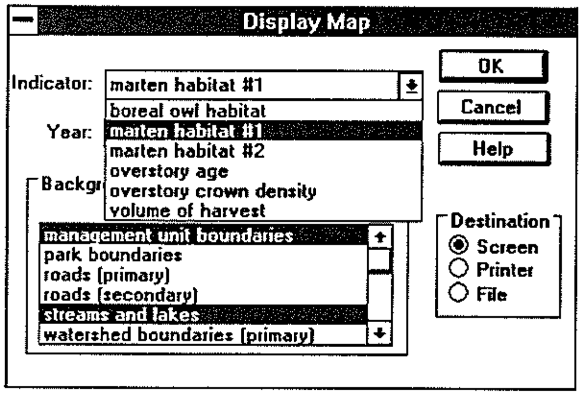


Indicator: marten habitat #1

Year: 100

Destination: ● Screen ○ Printer ○ File

Users begin by specifying which indicator they would like to view in mapped form. By clicking the scroll button to the right of a text box, a drop-down list of indicators will appear, as is shown in the screen below.



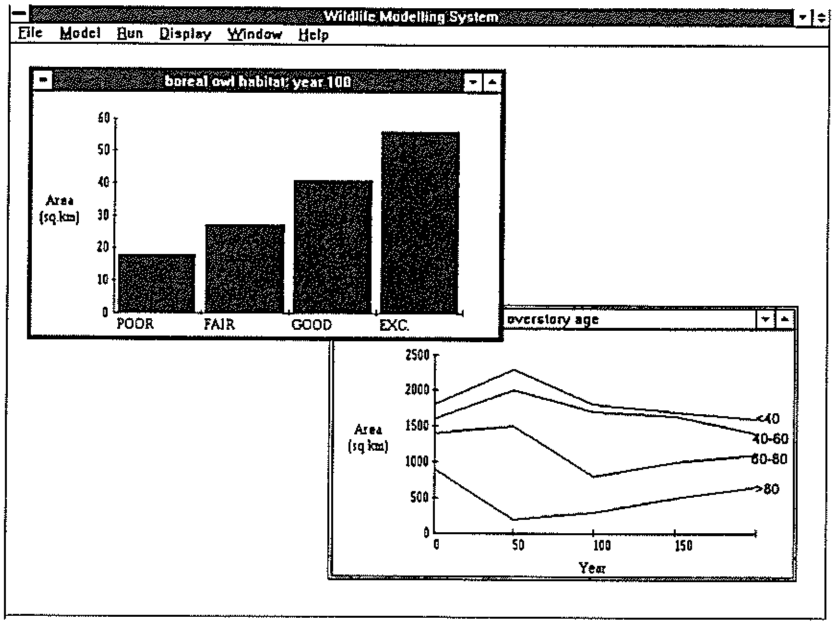
Indicator: marten habitat #1

Destination: ● Screen ○ Printer ○ File

In the example above, the indicator *marten habitat #1* has been selected. Users must next specify the year for which they wish to view the output of the model. Finally, users can select one or more background maps. Users have the ability to set map colours and to view the map on screen, save it to a file, or send it to a printer.

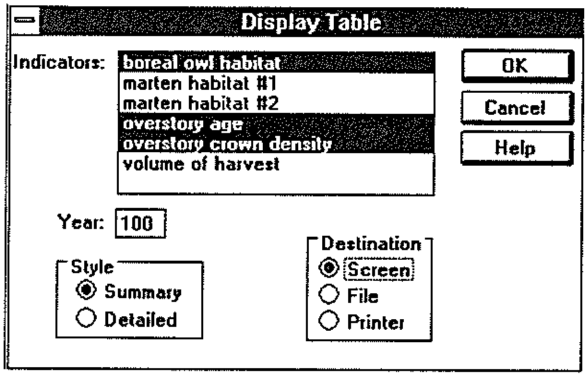
Display Graph

Results of the model run can be displayed in graphical format. As with *Display Map*, users select the indicator they would like graphed. Two types of graphs can be displayed: histogram or line graph. In the example below, a histogram of boreal habitat for the year 100 is displayed alongside a line graph displaying overstory age over the run of the model from year 0 to year 200.



Display Table

Results of the run can also be displayed in tabular format.



Indicators:
- boreal owl habitat
- marten habitat #1
- marten habitat #2
- overstory age
- overstory crown density
- volume of harvest

Year: 100

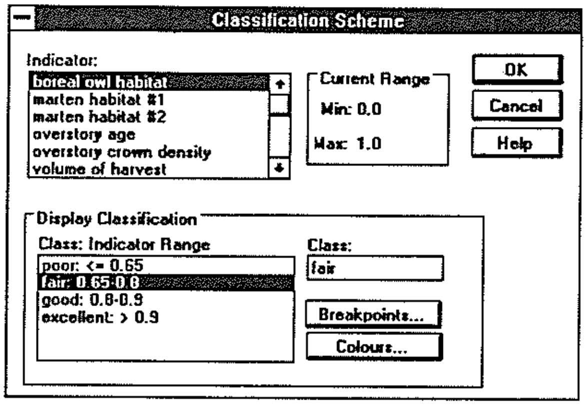
Style
● Summary
○ Detailed

Destination
● Screen
○ File
○ Printer

Users can choose between two types of tables. The first is a summary report. The summary report will display the indicators as they change over five-year intervals. Users can also to choose to view the model output in a detailed report. Unlike the summary report, which looks at how the indicators change over time, the detailed report offers a snapshot examination of one specific year.The detailed report displays indicators as they change from stand to stand for one particular time step.

Classification Scheme

The *Classification Scheme* option allows users to modify how the results are displayed.



Indicator:
boreal owl habitat
marten habitat #1
marten habitat #2
overstory age
overstory crown density
volume of harvest

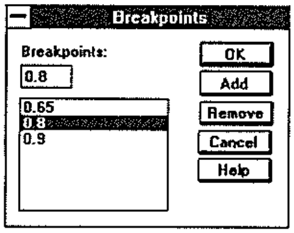
Current Range
Min: 0.0
Max: 1.0

Display Classification
Class: Indicator Range
poor: <= 0.65
fair: 0.65-0.8
good: 0.8-0.9
excellent: > 0.9

Class: fair

For each indicator, users are shown the range of values for the last model run. For example, for boreal owl habitat, the range might be from 0 to 1. For an indicator like overstory age, the range displayed might be from 0 years to greater than 200 years. For display purposes, values within each indicator's range need to be assigned a class or score, as is shown in the bottom half of the *Classification Scheme* screen.

In the example above, ranges of values for the boreal owl habitat indicator have been assigned a classification ranging from poor to excellent. Users can easily modify these breakpoints by selecting ***Breakpoints***. The following screen will appear.



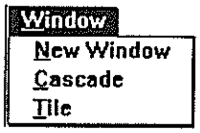
Breakpoints: 0.8
0.65
0.8
0.9

To add a new breakpoint, users enter the breakpoint into the text box and select ***Add***. When they return to the *Classification Scheme* screen they will need to assign a class to this breakpoint, such as *very good*.

Note that these breakpoints differ from those described earlier for HSI models, and are used only for display purposes in maps, graphs, and tables. The values that are set in the *Classification Scheme* screen for each indicator will be applied to all of the display formats. This helps to maintain consistency and uniformity in the displayed results, regardless of whether they are displayed in graph, tabular, or mapped form.

Window Menu

The options under the **Window** menu allow users to view the results of multiple runs side by side.



These options will allow users to customize how the display windows of the model output appear on their screen. For example, a user may wish to run the model using two different vegetation runs: one at current levels of silviculture and harvesting, and a second at maximum silviculture levels, in order to trace the effect this will have on boreal owl habitat. Using the functions in the **Window** menu, users can open several windows within which to view the results of several indicators for each of the two runs.

Pressing ***Cascade*** will cause the display windows to overlap, leaving the title bars visible. Pressing ***Tile*** will resize the display windows and arrange them one on top of the other so that the entire contents of each window are still visible.

Help Menu

An on-line help facility for the system will be available.

6.0 Literature Cited

Brazil, Joe, and Kathy Knox. 1994. A Habitat Suitability Index for the Boreal Owl (Aegolius funereus) for the island of Newfoundland. Unpublished manuscript. Prepared by the Newfoundland Wildlife Division. 4 pp.

Holling, C.S., ed. 1978. Adaptive Environmental Assessment and Management. Toronto: John Wiley & Sons. 377 pp.

Walters, C. 1986. Adaptive Management of Renewable Resources. New York: Macmillan Publishing Company. 374 pp.

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Phone: (905) 508-0860
Fax: (905) 508-0863

March 29, 1994

Mr. Darren Fillier
Wildlife Habitat Biologist
Western Newfoundland Model Forest Inc.
89 West Valley Rd.
Corner Brook, NF
A2H 2X4

Dear Darren:

Please find enclosed a bound and unbound copy of the report entitled *Design Document for a Wildlife Modelling System*. In writing this report we have tried not only to capture the results and consensus of the workshop, but also to provide an initial description of how the system might actually look to the user. This preliminary design is not intended to be a definitive view of how the system will eventually look; rather, we expect and hope that it will act as a starting point for further discussion, and that it will be modified and refined in the future.

While we are confident that the design document will provide you with a good understanding of how the system will eventually work, there is only so much of the system's functionality that can be captured in a report. You will find that the design document includes a number of mock-ups of menu choices and screen designs. In order to produce these mock-ups, we have actually created a prototype version of the system's software interface (which currently runs under Microsoft Windows). Our past experience has shown us that demonstrating the actual prototype software product, in-person, can often provide much more insight than just a report.

With this in mind, we suggest the following course of action as a follow-up to this project for finalizing the system design:

(i) Circulate the preliminary design document to all of the workshop participants and solicit their feedback.

(ii) Arrange a 1-day meeting with a small group of representatives from the Model Forest, Newfoundland Wildlife Division, Newfoundland Forest Service and ESSA (similar to scoping meeting for this project?). Colin Daniel, who developed the interface software, and myself (if budget permits) would attend the meeting from

ESSA. At this meeting we would:

- demonstrate and fully explain the actual prototype software;
- answer specific questions about the system design;
- review feedback from those who reviewed the design document but were unable to attend the meeting; and
- discuss potential modifications to the preliminary system design.

(iii) Update the design document to reflect any changes to the preliminary design agreed upon at the meeting.

We feel that this plan of attack would provide you with an effective means of further enhancing the design of the wildlife modelling system, and ensuring that a broad consensus regarding the system's functionality is maintained. Demonstrating the software in-person should provide potential users with a better understanding of the proposed system design, leading to a more focussed discussion of the modifications and refinements that might be required. ESSA's involvement in this work would be in addition to that of the current project. We estimate that the cost for ESSA's involvement in these steps would be approximately $5,000-$7,000 (depending upon whether one or two of us attend the meeting).

Both Colin and I are excited about many of the ideas that surfaced at the workshop and in the subsequent design document. We believe that the decision support initiative you are embarking upon here is state-of-the-art for forest resource management, and look forward to working with you further in the near future to turn these ideas into reality. If you have any questions about the design document, or would like to discuss any of the ideas for future work outlined above, please give Colin or me a call. I look forward to hearing from you again in the near future.

Sincerely,

Chris Wedeles

c.c. Colin Daniel, ESSA
Joe Brazil, Wildlife Division
Ken Curnew, Wildlife Division

Forest, Wildlife, and Freshwater Resources Research Initiatives in Insular Newfoundland

Corner Brook, Newfoundland, June 21-22, 1994

The Model Forest Coordinator of the Canadian Forest Service, Newfoundland and Labrador Region, invites you to attend a workshop on "Forest, Wildlife, and Freshwater Resources Research Initiatives in Insular Newfoundland" on June 21-22, 1994 in Corner Brook. This is open to anyone who is conducting, or has recently conducted, research in Newfoundland related to forestry, wildlife, or freshwater resources.

The purpose of this workshop is to provide an overview of the research being carried out in insular Newfoundland relating to forest, wildlife and freshwater resources. This workshop will provide the opportunity for a sharing of knowledge between researchers and managers.

Topic areas include, but are not limited to:

Wildlife
- mammals (large and small)
- avifauna
- biodiversity

Forest Site Classification (FEC)
- Remote sensing
- Successional modelling

Salmonid/Water Quality
- fish habitat and populations
- water quality/quantity

Other
- soil arthropods and forest insects
- nutrient balancing
- computer modelling

If you would like to present your work at this workshop or attend as an observer, please inform Brian Bonnell by April 29, 1994. I have attempted to distribute this to all persons with a potential interest in this area. However, in the event that I have overlooked someone, please circulate this notice amongst your colleagues.

Brian Bonnell
Model Forest Coordinator
Canadian Forest Service - Newfoundland and Labrador Region
89 West Valley Road
Corner Brook, Newfoundland
A2H 2X4

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Notes Regarding

Wildlife Modelling System Design Workshop

Corner Brook, NF

March 1 - 3, 1994

Brian Bonnell
CFS

Darren J. Fillier
WNMF

SPECIAL NOTE: This document was produced utilizing the notes taken by the authors during the March 1-3, 1994 workshop. It was written up independently from the ESSA document. It should also be noted that the authors' notes were also given to ESSA for their review.

1.0 Introduction

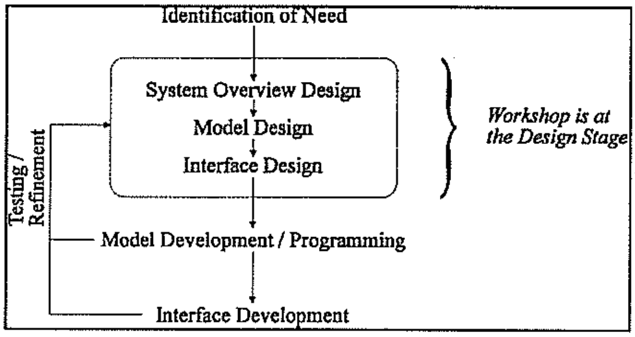
No wildlife modelling, with respect to the development of decision support systems (DSS), has been carried out in Newfoundland. The need for such modelling systems to aid managers in their pursuit of a more wholistic management framework and process has been identified by the Western Newfoundland Model Forest (WNMF). Consequently, individual research projects have been initiated within the WNMF for a variety of identified indicator species to provide the information necessary to develop such wildlife models. The individual species' population and habitat models are to be incorporated into a larger wildlife modelling system which, in turn, is a component of an overall DSS for the WNMF. This DSS is to be utilized to aid managers in the integrated resource management (IRM) process currently under development by the WNMF Management Group.

The WNMF Management Group has set as one of its objectives, the production of a comprehensive integrated resource management plan by March 31, 1997. Consequently, a DSS tool, if to be utilized in the development of that IRM plan, has to be functional at least a year previous to this.

The Wildlife Modelling System Design Workshop was initiated in order to begin the process of designing and developing the wildlife modelling component of the DSS. Further background to the workshop is contained in the 17 February 1994 letter of invitation.

The objective of the workshop was "To begin the process of system design for a wildlife modelling system for the Western Newfoundland Model Forest".

Figure 1 provides a schematic overview of the process to be followed in the development of the wildlife modelling system (WMS).



At this stage in the development of the WMS, the focus has been on the design level and not on actual programming of models. This workshop was to provide the input for a system design document which would define a conceptual view of the WMS as outlined by the various researchers and managers who participated. The system design document developed by ESSA provides a WMS framework which may require further refinement and modification to meet the requirements of the wildlife modelling system component of the DSS. Once consensus regarding the system design has been reached, the next step in WMS development can proceed. The next step is actual model development (i.e. programming) and subsequent testing and refinement (Figure 1).

The workshop consisted of several exercises to aid the participants in identifying their view of a WMS. The first exercise consisted of defining the boundaries of the system (e.g. issues, actions, indicators, space, time). After this initial phase, subgroup discussions were held on the vegetative and wildlife components that were to comprise an overall WMS. The needs and requirements of a user interface and outputs of the WMS were discussed. The workshop ended on a discussion of the work priorities to be undertaken in order to construct the wildlife modelling system.

2.0 Bounding the System

The intent of the bounding exercise facilitated by ESSA, was to define the limits within which the system was to be designed. These limits centred around the issues to be examined, the actions to be simulated, the indicators to be predicted, and the space and temporal aspects within which the modelling system will operate.

2.1 Issues

The issues component of the bounding exercise was to allow the participants an opportunity to identify their major concerns with system development. These issues aid in the identification of an overall system design at a very generic level (e.g. flexibility, scope of project, generic needs assessment). This discussion resulted in a long list of outstanding issues related to DSS development for the Western Newfoundland Model Forest.

- Timber Allocation: Two paper companies control most of the land. Do we make the assumption that they can cut 'x' amount of wood annually? Will or should the amount be a constant?
- Quantification of Habitat: How do we quantify habitat for various species?
- Linkage / integration of individual models (input/outputs, language, design)
- Integration of species models
- Address spatial constraints: Landscape level modelling
- Standardization: A need for standards for database design/development and model design/development(establish set of ground rules for all modellers); (everyone to know what dealing with, where to head; equipment, users, database,...)
- Interactions between and amongst species and habitat (i.e. one species may impact on another, etc.)
- Objective versus constraint type management (i.e. objective type mgmt: set goals/objectives for a wide variety of factors and try and achieve them - very difficult)
- Data Availability: In development of models, generally need long time frame of data for good model - do we have that data/time.
- Who will the users of the system be?
- How to integrate fish and fish habitat into the modelling system
- How simple/complex will model be? (keep it manageable/user-friendly; be realistic)
- Bring existing knowledge to bear and newly collected to test
- Flexible - ability to examine a variety of options for differing objectives (i.e. timber mgmt, wildlife mgmt)
- Accounting for other changes in the environment (cumulative effects, hydro development, etc) - external influences and unplanned events
- Scope of project: is this for MF or larger land base (i.e. portability to other areas or specific to WNMF?)
- Accuracy of databases being inputted into model (i.e. at what scale)
- Holistic or indicator species approach? How to proceed?
- Clear definition of assumptions and they need to be made explicit and tested
- Should set up a modelling sub-committee
- How to deal with heavy resource demands

2.2 Actions

This component of the workshop provided the participants with the opportunity to identify the factors within the WMS that the users can manipulate. The models within the system will identify the perturbations throughout the biological and managerial system being modelled.

- Identify/specify desired forest structure; age class distribution (indicator); setting Annual Allowable Cut (AAC) target
- Specify width of buffer/riparian zone

- Be able to input harvesting, fire, insect damage (not necessarily predicting these, but input area damaged); most likely part of vegetation model
- Hunting, snaring - harvest of big game, etc.
- Harvesting - different methods (even aged, uneven aged, pattern); different levels (AAC target); within riparian areas
- Weather (snow); short-term climate, i.e. several years
- The number, location, and type of stream crossings
- Access roads
- Silvicultural treatments (e.g. thinning, planting, vegetation control)
- Habitat enhancement (identify species' population-habitat interconnectivity)
- Human intervention (e.g. tourism)
- Slope and aspect

2.3 Indicators

The indicators are the predictions stemming from the operation of the WMS and the interactions defined within it. Management decisions are aided through an examination of the information produced through WMS runs; the predictions do not make the decisions (e.g. a prediction could be the population density of a species, the manager would use this information to define hunting levels). The indicators identified in the workshop are as follows:

- productive capacity of habitat (incl. fish): numbers/km^2; numbers of individuals/biomass
    - availability vs suitability; quality of habitat; spatial considerations must be considered and factored in; for one or more species (marten, moose, raptors, bear, caribou, salmon, trout, songbirds, cavity nesters, furbearers, hare, grouse, bats)
- Stream / water quality (sedimentation, quantity, etc)
- Biodiversity
- Wood volume (harvested)
- Age class distribution
- Population numbers/density - by species, age, etc (i.e. distinction between carrying capacity vs populations)
- Recreation

2.4 Space

The spatial (extent and resolution) aspect to be addressed with the WMS was reviewed.

- How large an area to be predicted at one time (extent); WNMF area 707,000 ha
- Resolution - if use stands then 40 000 forested stands in WNMF; this creates problems with respect to spatial considerations and hardware requirements

: vegetation dynamics on a stand level; stand aggregation based upon Forest Ecosystem Classification (FEC) may be required to alleviate the potential resolution problem

: population (should/will) not be done on a stand level? watershed level? landscape?

- Aspatial modelling was not considered an option

2.5 Time

The temporal component of the WMS (i.e. how far into the future were predictions to occur) is another important consideration in the overall system design.

- Time horizon (extent): 120-240 years
- Resolution: how often are predictions to be made (day by day or every 10 years); for first 20 years (1 year increments); beyond 20 years (~5-10 year increments); annual with reports on 5 year increments

3.0 Other Issues

There were several issues which were raised throughout the bounding exercise which did not fit into one of the bounding categories.

3.1 What is a modelling system?

Because of the diversity of interests and backgrounds represented in the modelling process, the need for the establishment of a common language and common understanding of the concepts being discussed was clearly identified.

A model is a conceptualization of how we see a *piece* of the natural resource system working (i.e. the relationship between one species and its habitat). A modelling system consists of a variety of interlinked models (i.e. a number of species and intervention effects on their populations and habitat).

An example of such a modelling system is the Hemlock Looper Decision Support System developed by the Canadian Forest Service. Although not directly related to wildlife, the conceptual framework around which the Looper DSS was constructed will be similar.

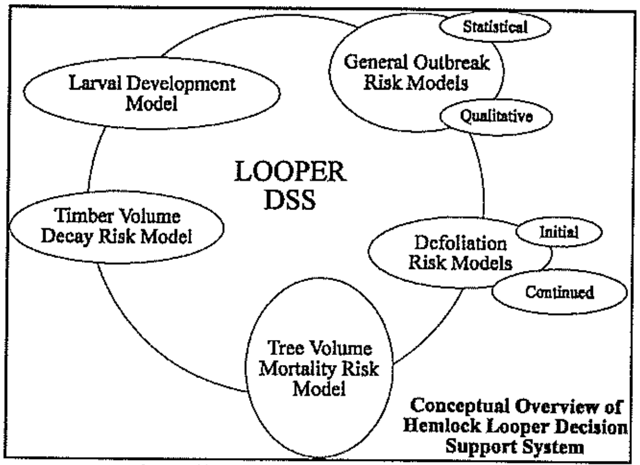


Figure 2: EXAMPLE OF A MODELLING SYSTEM

The linkage between each discrete piece in the wildlife modelling system (species model, harvest scheduler, etc) provides an overview of the relationships between those pieces. The interconnectedness of the individual models must be ensured in order to accurately define the larger picture of resource (value) management.

3.2 Users of the System

A brief discussion of who would be the users of the system occurred. The participants indicated that they wished the system to be developed for use by managers, planners, and researchers. Irregardless of who uses the system, at the end of the day, the users have to discuss their results in light of what is best for their respective authority in addition to the other values represented around the table. A Decision Support System (DSS) is just a tool available to managers to aid them in doing their job - managing the variety of forest values.

3.3 Hardware Requirements

The topic of hardware platforms from which the WMS would run surfaced periodically throughout the workshop. The PC platform was identified as being preferred due to the availability of the PC; the workstation was identified as being required for spatial modelling. Several options were identified and the relative merits of each discussed: a PC-workstation link; PC only; workstation only. Due to the limited capabilities of the PC to handle large quantities of spatial data, the PC only option was quickly dismissed. No decision was reached as to the platform(s) to be utilized.

3.4 Model Linkages within WMS

An interaction matrix was constructed to identify which models can/will influence others within the Wildlife Modelling System. The individual species' and vegetation models were condensed into a simple matrix consisting of wildlife and vegetation. This was used to aid in the identification of the information flows from one model to another model (e.g. vegetation to wildlife; wildlife to vegetation). Subgroups were formed to discuss the information links both between and within the two identified components of wildlife and vegetation.

4.0 Vegetation Subgroup

4.1 Indicators (to be predicted by vegetation model)

In order to make an assessment of habitat quality for the wildlife species being modelled, the following indicators were identified as having to be made by the vegetation model:

cubic metres harvested
age class distribution
crown cover (%)
height
spatial arrangement of sites
understory vegetation
ground cover vegetation
overstory vegetation
successional stage
coarse woody debris
snags - size/age
volume - basal area
FEC

4.2 Succession Model

The Canadian Forest Service and Memorial University of Newfoundland are currently collaborating to produce a series of successional rules based on the Damman forest site types. The current weakness in this is the lack of information regarding the temporal aspect of the transition from one site type to another; the vegetation change can be predicted with a great deal of accuracy, but the time it takes for that change is still unknown. The Canadian Forest Service is attempting to address this temporal unknown.

The focus with the current research has been on succession after intervention (i.e. harvesting). With some further analysis, the data being collected can be utilized in determining, on a preliminary basis, the successionary patterns for non-intervention scenarios. However, some additional research is required to identify the time lag between successional transitions and to further refine the patterns of non-intervention succession.

4.3 Timber Supply Models

Currently, the two timber supply models being examined by the Data Standards and DSS Working Group of the WNMF are GISFORMAN+ and HSG, with GISFORMAN+ being recommended to the Management Group. These are both spatial models which track forest development (mainly overstory and standing volume over time) on a stand level resolution. Such a model can generate outputs related to growing stock (standing volume), volume harvested, age class distribution, overstory vegetation (i.e. percent composition by tree species) every five years by stand. The individual stands are tracked over time and aged through the use of successionary patterns generated by yield curves (volumetric increment over time). The AAC is predicted using this information.

Although GISFORMAN+ does predict stand development on a five year increment, at this time it only records the first and last increments. Therefore, modification of the program would be required. Further modification would also be required for the program to track height and crown cover development over time.

GISFORMAN+ has the potential to track habitat quantity for five independent wildlife species. An essential component of such a process would be the quantitative definition of species' habitat in both structural and spatial terms. These definitions would define habitat windows on the volumetric yield curves utilized by GISFORMAN+ allowing for tracking habitat supply through time. Although not directly linked with population objectives, this approach allows for the achievement of habitat objectives for a species within timber management planning. To date, this process has not been employed in Newfoundland.

The understory (including ground cover and coarse woody debris) and snag components of forest structure are not currently tracked by GISFORMAN+. The Damman forest site types can identify the presence and absence of certain indicator ground species but cannot determine the volume of those species present on a site. A rough estimate of the quantity of understory species could be made at this time using the FEC, however more research would be required to refine these estimates. GISFORMAN+ could be modified to track the understory component in a similar manner as that of the overstory (i.e. through yield curves). A second approach would be the development of a parallel model which would track the forest site type for each stand.

Currently, the vegetative model component can, in addition to setting harvest and silviculture levels, set size and adjacency guidelines for even-aged fibre management. Uneven-aged management regimes are difficult to spatially model given the current structure of GISFORMAN+. The width of riparian zones would not be modelled; the landbase boundaries would be modified before making a model run. GISFORMAN+ does have the capability to track successionary change within defined riparian zones. This permits examination of riparian zone (buffer) management through intervention to perpetuate desired successional seres within zones or tracking of zone status over time without intervention.

5.0 Wildlife Subgroup

The initial discussion held by the wildlife subgroup focused on the indicator species approach to wildlife management within the WNMF and a review/update of the species being looked at. The consensus was toward the creation of habitat suitability indices (HSI) for each species and a subsequent population interlink to this habitat quantifier. This would be possible through a habitat-related carrying capacity linked with demographics. Further discussion centred on the development of a generic population model to be interwoven with HSI models as an alternative to the aforementioned population/habitat interlink process for the species under consideration.

The preliminary boreal owl work by Joe Brazil and Kathy Knox of the Newfoundland Wildlife Division was utilized to exemplify a HSI approach for a given species within the WNMF. Through data collected in North America and Europe on the boreal owl, parameters which could be used in describing the suitability of various stand types as spring and summer habitat were identified with respect to the mensurational data contained on forest type maps. These attributes were assigned a numeric value ranging from unacceptable to preferred. Through analysis of such stand attributes by a scoring system and prorating, a HSI value was derived for each stand. Although this approach allows only a "snapshot" of boreal owl habitat in successionary time, it does allow for the quantification of habitat. The point was made regarding the need, and subsequent work being conducted, for refinement of the habitat description for local (WNMF) conditions.

The need for a similar approach for the other wildlife projects within the WNMF was identified. The next step of interlinking this HSI model approach to vegetative modelling to allow successionary rules to alter habitat over time was discussed. A consensus was not reached regarding how this was to be done. The HSI models should allow for the easy modification of the variables, formula and relationships as research results become available. This modification potential of HSI models would allow for minimal "gaming" through adjustments and refinements in the individual HSI within the overall modelling process.

The link between HSI and populations was recognized as being difficult but essential. A generic population model component was deemed necessary even though such a model would be difficult and time consuming to construct. Some demographic components of such a model would include predation, hunting, poaching, competition, cycles, prey, and HSI for other species. Consequently, the model could estimate a HSI derived carrying capacity and use the demographic information present or collected for the species to generate a population estimate through either density or total numbers. Of high merit is the construction of population models to be interlinked with the habitat quantification process for each species. This is being addressed for some species and was suggested to be examined for all the WNMF indicator species. Again no consensus was achieved regarding how to proceed.

Aquatic models were briefly discussed regarding a HSI approach, population interlink, and effects of intervention upon the aquatic system. It was agreed that the aquatic model component is to be "flagged" as part of the overall wildlife modelling system but the specifics of how this is to be integrated was not discussed. Similarly, biodiversity and its respective measure was also discussed but again no consensus was reached on how to proceed.

6.0 User Interface

As is illustrated in Figure 3, the User Interface is one component of the overall Wildlife Modelling System.

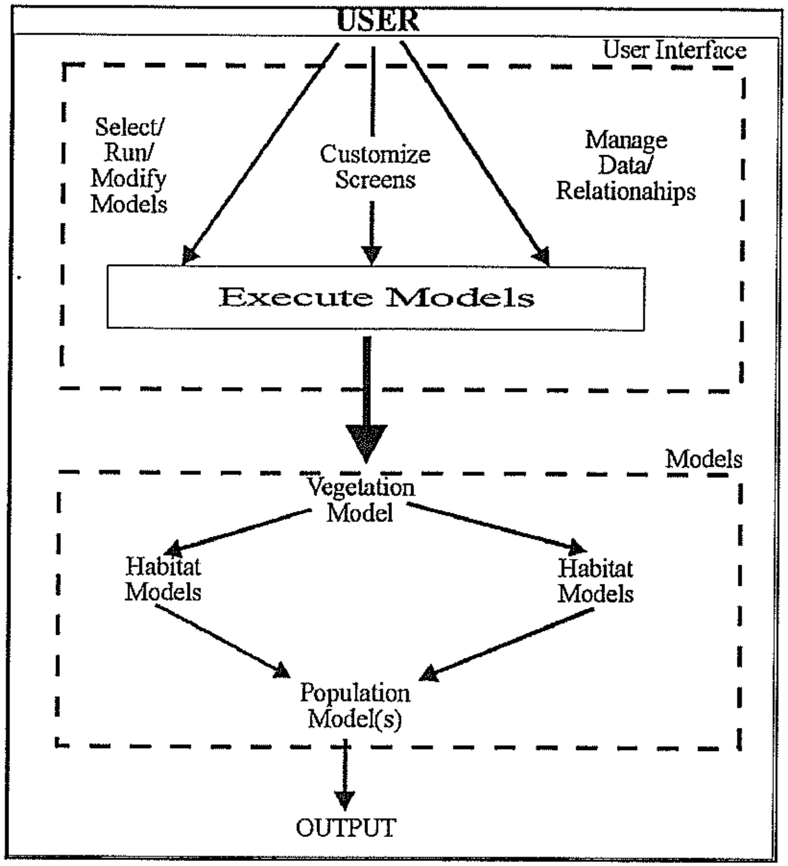


Figure 3: CONCEPTUAL OVERVIEW OF WILDLIFE MODELLING SYSTEM

Some of the key points raised during discussions were:

- Vegetation/harvest data not to be directly manipulated by wildlife researchers
- Gaming not necessary with vegetation/harvest models
- Library of runs from vegetation/harvest model
- Scenarios
- Expert "in the loop" to develop libraries/scenarios
- Interface to allow access to wildlife parameters
- Vegetation/harvest model available via the expert "in the loop"

7.0 Output

This is an overview of the various types of output which the workshop participants indicated they would like to see/need in order to make decisions.

- varying scales of maps (i.e. landscape to stand)

- various graphs (i.e. histograms, linear)
- tabular outputs (screen, printer, file)

8.0 Priorities

- FEC map completion (NFS,WNMF: George Kitchen, summer 1994)
- Historical Harvesting Database (WNMF, Derek Mercer, summer 1994)
- Developing attribute list for FEC map (non-timber attributes) (WNMF)
    - developing relationships (currently rough estimates for some things available)
    - parameters to be collected not yet defined
- Identify HSI wish list and what information is needed to develop HSIs
- FEC successional model (CFS,MUN, summer 94)
- Decision on timber supply model to be used
- Accessibility attribute for stands
- Resolve spatial succession of stands using FEC info
- Decide upon aggregate spatial units for mapping output
- Classify fish habitat data
- Establish hardware connections (i.e. network, workstations)
- Identify project leader (wildlife coordinator)
- Initiate software development
- Identify how to proceed with WMS development

Where to from here?