DEVELOPMENT AND USE OF HSI MODELS

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1. INTRODUCTION

1.1 BACKGROUND

Habitat suitability index (HSI) models were developed for 35 species in the Foothills Model Forest of west-central Alberta (Table 1). A wide range of species were chosen for modelling including those which are old growth, mature or young forest specialists, generalists, hunted or trapped species, large ungulates and carnivores, important prey for other species, and threatened or rare species. These models were created by the joint efforts of Weldwood of Canada, Hinton Division, University of Alberta Department of Renewable Resources, Foothills Model Forest, Alberta Fish and Wildlife, and Beck Consulting. The models were put together during workshops involving biologists, foresters, faculty members, and computer programmers from the above companies. Each species model was developed using available literature and local expert advice. Each model was developed first verbally, then graphically, and finally mathematically. The models were later documented and refined by students in a special modelling class offered at the University of Alberta in the Department of Renewable Resources. Finally, the models have been edited and standardized by the Foothills Model Forest Habitat Analyst. The wildlife models will then be reviewed by wildlife managers, habitat modellers, and biologists. At the same time, testing programs to verify or modify the models are in progress for many of the species (Table 1).

These models were developed for use within the Foothills Model Forest (Figure 1), which includes the land areas within Jasper National Park, the Forest Management Area of Weldwood of Canada - Hinton Division, William A. Switzer Provincial Park, Cache Percotte Forest, and several provincial Forest Management Units. The forest areas within the Foothills Model Forest encompasses Boreal Foothills, Boreal Uplands, Montane, and Subalpine ecoregions (Strong and Leggat 1981). The models should also be broadly applicable to other habitat areas dominated by vegetation similar to that in this region, including pure deciduous, mixedwood and pure coniferous forest types, as well as wetland and riparian forests, meadows, shrublands, and areas regenerating after forest harvesting.

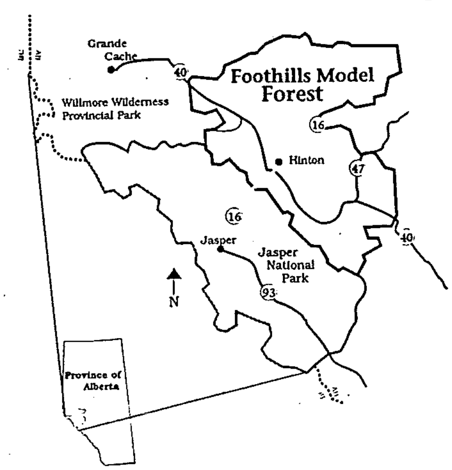

Figure 1. The Foothills Model Forest consists of 2.3 million hectares of land in west-central Alberta, centred around the towns of Hinton and Jasper. The land area is divided among different land-managing partners as indicated in the map. The forest ecoregions are also indicated on the map.

Table 1. Wildlife Habitat Models developed by researchers and associates of the Foothills Model Forest. Each model is described by a species name, and the status of the model development is indicated. Draft Model indicates whether a draft HSI model is completed and included in this report. Spatial Model indicates whether the model makes use of spatial features of the landscape such as distance to nearest road. Testing Program indicates whether the model is being evaluated by a field based program at the Foothills Model Forest.

	Common Name	Scientific Name	Draft Model	Spatial Model	Fine Filter	Testing Program
1	Barred Owl	*Strix varia*	X	X	X	X
2	Black Bear	*Ursus americanus*	X	X		
3	Boreal Owl	*Aegolius funereus*	X			
4	Brown Creeper	*Certhia americana*	X		X	
5	Chipping Sparrow	*Spizella passerina*	X	X		X
6	Clay-coloured Sparrow	*Spizella pallida*	X			X
7	Common Yellowthroat	*Geothlypis trichas*	X	X		X
8	Elk	*Cervus elaphus*	X	X	X	X
9	Fisher	*Martes pennanti*	X	X		
10	Flying Squirrel	*Glaucomys sabriuns*	X		X	
11	Golden-crowned Kinglet	*Regulus satrapa*	X			X
12	Great Gray Owl	*Strix nebulosa*	X	X	X	
13	Great Horned Owl	*Bubo virginianus*	X	X		
14	Grizzly Bear	*Ursus arctos*	X	X	X	
15	Hairy Woodpecker	*Dendrocopos nuttallii*	X			X
16	Hermit Thrush	*Hylocich guttata*	X			X
17	Hoary Bat	*Lasiurus cinereus*	X			
18	Long-toed Salamander	*Ambystoma macrodactylum*	X	X		X
19	Marten	*Martes americana*	X		X	X
20	Mink	*Mustela vison*	X	X		
21	Moose	*Alces alces*	X	X	X	X
22	Mule Deer	*Odocoileus hemionus*	X	X		
23	Northern Goshawk	*Accipiter gentilis*	X	X	X	X
24	Ovenbird	*Seiurus aurocapillus*	X			X
25	Pileated Woodpecker	*Dryocopus pileatus*	X	X	X	X
26	Red Squirrel	*Tamiasciurus hudsonicus*	X		X	X
27	Red-backed Vole	*Clethrionomys gapperi*	X			
28	Ruffed Grouse	*Bonasa umbellus*	X		X	
29	Savannah Sparrow	*Passerculus sandwichensis*	X			X
30	Snowshoe Hare	*Lepus americanus*	X		X	
31	Three-toed Woodpecker	*Picoides tridactyl*	X			X
32	Varied Thrush	*Ixoreus naevius*	X			X
33	Warbling Vireo	*Vireo gilvus*	X	X		X
34	White-tailed Deer	*Odocoileus virginianus*	X	X		
35	Winter Wren	*Troglodytes troglodytes*	X			X

1.2 RATIONALE AND GOALS OF HSI MODELLING

Habitat Suitability Index (HSI) models (USFWS 1981) estimate the value of habitat for wildlife species by relating a species' needs for food and cover to structural and spatial attributes of vegetation types within a defined area. Weldwood of Canada, Hinton Division, chose the HSI approach to predict changes to wildlife habitats associated with forest harvest and regrowth in their Forest Management Agreement (FMA) area in west-central Alberta (IRMSC 1990).

The goal of HSI modelling is to predict the amount of suitable habitat area for each modelled species. However, for many purposes it is useful to talk in terms of wildlife numbers rather than area of habitat. Thus, each model has associated with it a prediction of the number of animals (usually the number of adults or breeding pairs) of that species per unit area which would occur within fully suitable habitat. When multiplied to the total available habitat, this predicts the potential carrying capacity for the forest area. This is not a population density estimate as defined by population ecology techniques; it is simply the optimum number of animals which could be supported by a the available forest area. Thus, factors which limit population density estimates such as competition, predation, dispersal, seasonality, long term cycling, or past historic effects are not considered in this value. Observed population densities may be very different from the predicted carrying capacities. However, we feel that this prediction will be useful for aiding managers in understanding the results of HSI modelling.

In the Foothills Model Forest, HSI models will be used to predict changes in suitable habitat areas in relation to forest management objectives and practices. These objectives include forest harvesting and regeneration, other activities which alter forest land areas (e.g. mining, oil and gas exploration, road construction), as well as the effects of forest maturation in areas protected from natural disturbances. The modelling is referred to as Habitat Supply Analysis (HSA). The suitable wildlife habitat area predictions are called habitat units (HU), and these will be aggregated across many habitat types within a geographic information system (GIS) analysis. Then, by linking the models to forest growth and yield models, habitat structure development models, and a forest harvest and regrowth simulator, the models will be used to make temporal predictions of HU in relation to various management scenarios.

The harvest simulator may allow a planning forester to consider the effects of cutblock size, shape or distance between blocks, connectivity of remaining forest patches, time between forest harvesting passes, number of forest passes to fully harvest a compartment. This may also be linked with plans regarding the type of onsite harvesting (*e.g.* clearcut, shelterwood, diameter limited cut), and type of regeneration treatments, (scarified vs. non-scarified, planting vs. natural regeneration, thinning vs. not thinning). Each variation in the plan can then be tested to determine the effects on the wildlife habitat areas and carrying capacities, and the HSA results will allow the planner to determine if the habitat area for the wildlife species under investigation is going to decrease, increase, or stay constant in relation to these plans. If decreases are predicted it is then possible to set minimum habitat area objectives and run the models iteratively until the harvest plans allow for maintenance of the species at or above a required carrying capacity.

The HSA will thus allow harvesting proposals to be tested ahead of time to simulate the potential effects on the wildlife resource. The testing of various management scenarios will allow land mangers to optimize both the habitat area of each wildlife species and the level of harvest. This integration of wildlife needs with forest planning is one of the key components of Foothills Model Forest's Ecologically Based Decision Support System (Curry et al 1993).

Weldwood of Canada, Hinton Division, will implement model predictions as part of their 1998 forest management plan, and has selected 14 of the species for fine-filter planning. By tracking and maintaining the habitat of these 14 species, in cooperation with coarse filter planning (maintaining ecosystems) and applying adaptive management strategies, the forest industry hopes to maintain the ecological characteristics of the forest landscape.

2. MODEL DEVELOPMENT

HSI models describe the essential elements of the habitat of a particular species in units which can be evaluated on a Geographic Information System based on landscape level averages of stand habitat characteristics. HSI models relate habitat structure and spatial arrangement of habitat to the wildlife species' needs for growth, survival and reproduction. These needs include living space, shelter, food, and thermal or predation cover. Each habitat variable is first related to the species needs by a graphical function, ranging from 0 to 1, where 0 indicates an unsuitable condition, and 1 indicates the most suitable condition. See Box 1 for an example of HSI model development.

After the graphical relationships for a species are determined, these are combined in a formula that results in an index value ranging from 0 to 1, where the value 0 represents unsuitable habitat and the value 1 represents the most suitable habitat. Where spatial variables are used, the index may be determined only through graphical analysis on a GIS. For example, in the elk model, all habitat areas are first ranked for food and cover. Then, the value of the area for food is decreased if the food is not near cover, and vice-versa.

Once the index value is calculated, it is multiplied by the forest stand area to create a habitat unit (HU) which is measured in hectares of best equivalent habitat. A habitat unit with a value of 0.5 ha is assumed to support one half of the maximum carrying capacity of a hectare of perfect habitat. By summing up all the habitat units and multiplying by the habitat carrying capacity estimate for a perfect hectare of habitat, the model is able to estimate the carrying capacity of the wildlife species throughout a forest area.

Box 1. Development of the Pileated Woodpecker HSI Model

The habitat structures which most strongly relate to cover, nesting, and foraging were first determined by consulting wildlife experts and scientific reports. The Pileated Woodpecker's needs include large trees and snags to provide carpenter ants, their favorite food. They also need forest cover to avoid predation, and they require large deciduous trees or snags in which nesting cavities can be constructed.

Once the species needs were determined, the habitat variables were chosen from a list of variables available in local habitat inventories:

1. Deciduous Trees + Conifer Snags > 35 cm DBH per hectare
2. Mean Canopy Tree DBH (in cm)
3. Number of Snags > 16 cm DBH per ha
4. Percent Tree Canopy Closure

Graphical relationships between the structural variables and HSI Components were then developed, by consulting with experts or with the literature. These relationships varied from 0 to 1 (0 = unsuitable, 1 = optimum).

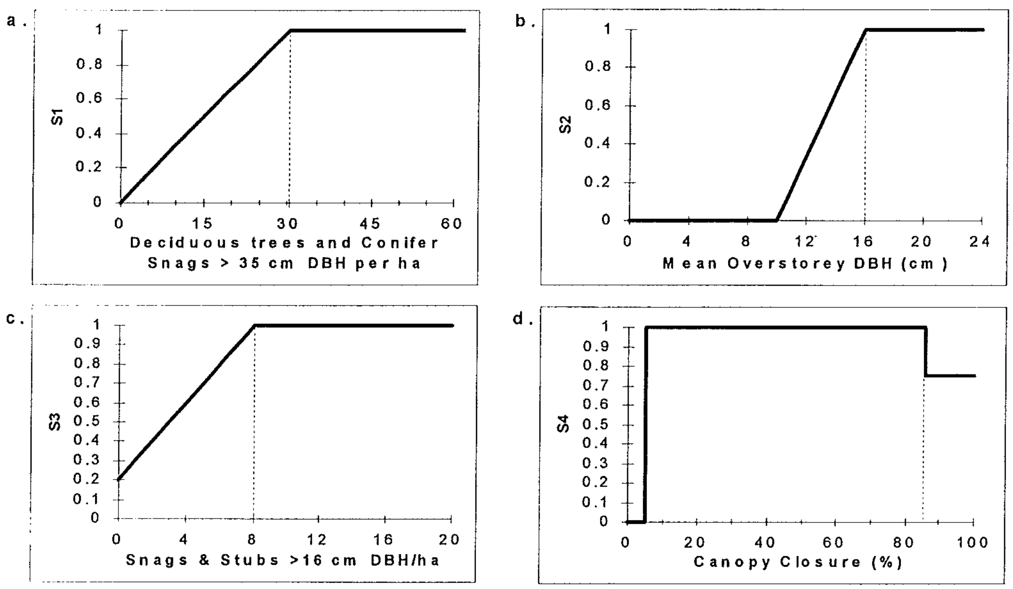

Figure 2. Pileated woodpecker model habitat components predicted from structural attributes within stands.

The HSI Equation is a combination of the index components such that each variable is weighted correctly and such that the final value still ranges from 0 to 1. In the Pileated Woodpecker model, two HSI equations were developed. The first predicts Nesting Habitat., and the second predicts Food Habitat. This was done because the woodpecker can nest in one area and feed in another.

HSI (Nesting/Roosting) = S_1 HSI (Winter Food) = $S_2 \times S_3 \times S_4$

Habitat Units were then calculated for the forest areas on which they are applied. In the Pileated Woodpecker model the nesting Habitat Unit value is calculated for each 1000 ha block of landscape.

If the Nesting HU value is < 10 ha, nesting is limiting and HU = (HU Nesting)/10 x Σ(HSI Food),

however, if Nesting HU > 10, then it is not limiting, and HU = Σ(HSI Food), for each hectare.

The Species Carrying Capacity was then determined by consulting scientific studies which determine the population density of a species in relation to different habitat areas. For the Pileated Woodpecker the Carrying Capacity estimate is 0.002 pairs per hectare. Thus, for every 500 HU's the model predicts 1 pair of woodpeckers.

2.1 HABITAT VARIABLE SELECTION

Selection of habitat variables is done by assessing the species' needs for living space, shelter, food, and thermal or predation cover and relating these to elements of the habitat structure in areas where the species is found. These variables must be measurable attributes of the forest which are readily available in inventories or which can be calculated from other relationships. The variables may be used directly or combined with other variables. For example, grass cover may be directly related to food availability, total shelter may require the sum of tree and shrub stem densities. Some variables may be included to restrict the model to work only in certain land classes; for example, canopy closure is often used to restrict the model to treed areas, or deciduous tree volume is used to restrict the model to mixedwood sites. Finally, some variables are spatial relationships such as the distance from food to cover, area of available habitat, or proportion of area containing habitat of a certain value.

In the Foothills Model Forest, there are currently 28 variables available for non-spatial HSI model development (Table 2). These variables were available in local forest and plant community inventories and were empirically related to stand age and forest types for the forest landbase within Weldwood's FMA (Bessie 1995). In addition to these variables, the choice for spatial variables is only limited by the spatial analysis ability of the GIS software.

Table 2. Habitat variables for which yield curves have been developed in the Foothills Model Forest.

VARIABLES	UNITS	DEFINITION
Conifer Volume	m^3 ha^{-1}	Total volume of stem, branch and leaf components of all conifer species
Deciduous Volume	m^3 ha^{-1}	Total volume of all stem, branch and leaves of all deciduous species
Pine Volume	m^3 ha^{-1}	Lodgepole Pine + Jack Pine Total Volume
White Spruce Volume	m^3 ha^{-1}	White Spruce + Engelmann Spruce Total Volume
Black Spruce Volume	m^3 ha^{-1}	Black Spruce Total Volume
Fir Volume	m^3 ha^{-1}	Subalpine Fir + Balsam Fir Total Volume
Aspen Volume	m^3 ha^{-1}	Aspen Total Volume
Balsam Poplar Volume	m^3 ha^{-1}	Balsam Poplar + Black Cottonwood Total Volume
Paper Birch Volume	m^3 ha^{-1}	Paper Birch + Paper Birch Hybrid Total Volume
Conifer Stand Height	m	Mean top height for all dominant and codominant canopy conifer trees
Deciduous Stand Height	m	Mean top height for all dominant and codominant canopy hardwood trees.
Crown Base Height	m	Mean height to the lowest point of a continuous tree crown
DBH	cm	Mean diameter at 1.4 m height of all dominant and codominant trees
Shrub Height	m	Mean height of the shrub layer, not of individual shrub stems
Shrub Stems	ha^{-1}	Number of shrub stems > 10 cm height.
Conifer Trees	ha^{-1}	Number of conifer tree stems > 5 cm dbh.
Deciduous Trees	ha^{-1}	Number of hardwood tree stems > 5 cm dbh.
Dec. Trees > 35 cm dbh	ha^{-1}	Number of hardwood tree stems > 35 cm dbh.
Snags	ha^{-1}	Total snags and stubs > 7.6 cm dbh
Snags > 16 cm dbh	ha^{-1}	Total snags and stubs > 16 cm dbh
Tree Canopy Closure	%	Projected horizontal coverage of canopy trees over the stand area.
Shrub Cover	%	Projected horizontal coverage of all shrub species over the stand area
Downed Wood Cover	%	Projected surface coverage of dead-fall logs which are > 7.6 cm diameter
Grass Cover	%	Cover of all grass species (Family Graminea)
Sedge and Rush Cover	%	Cover of all sedge and rush species (Cyperaceae and Juncaceae)
Herbaceous Cover	%	Cover of all broadleaf herbs, ferns, fern-allies and rhizomatous shrubs
Moss Cover	%	Cover of all mosses and liverworts
Lichen Cover	%	Cover of all ground dwelling lichens

2.2 GRAPHICAL RELATIONSHIPS

The relationships between the habitat variables and habitat suitability define HSI components which may range from 0 to 1. A variable which controls habitat suitability will range from 0 to 1, whereas one which modifies the suitability will range from a fractional value to 1. The decision as to whether or not the variable is sets a major constraint on habitat suitability will determine which curve type to choose. For example, if a species requires snags for feeding and the food increases to a maximum at 10 snags per hectare, the graphical relationship may look like Figure 3a (solid line). However, if the species can find at least half of its food needs from other sources, the presence of snags will only modify the habitat potential. Figure 3a (dashed line) shows this case, with the value set at a minimum of 0.5, then increasing to 1.

Typical curve shapes are demonstrated in Figure 3b. Two important distinctions determining curve shape are whether the change between values is linear or instantaneous. Linear increases (or decreases) are used when there is a continuous change in habitat suitability in relation to the habitat variable. Instantaneous changes are used whenever there is a threshold value which is achieved or this may be used when a variable based on classes over a continuous range is presented as a curve rather than a histogram. The optimum value may appear at low values, at high values, at central values, or at both ends but not centrally (not shown). Another curve shape option is to use a statistically determined regression curve over the range of the variable, which may or may not be linear (not shown).

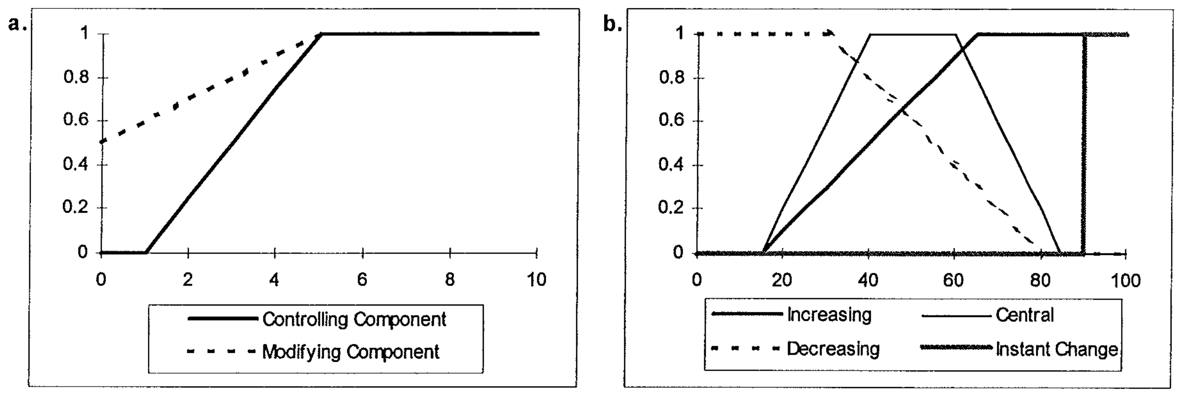

Figure 3. Various curve shapes used to demonstrate principles for developing HSI components. a) This graph demonstrates the difference between modifying and controlling components. b) This graph illustrates the different curve forms employed throughout the HSI models.

2.3 EQUATION DEVELOPMENT

Once a set of variables is chosen and graphical models outlining the relationship between the variables and the HSI components are determined, the next step is to combine the components in one or more equations to calculate the HSI and the habitat units. The form of the equation must reflect the manner in which the species makes use of the different variables in its habitat. There are three main guidelines for determining how an equation should be put together based on the biology of the species. First, level of interaction between components determines how to combine components (adding or multiplying), second, compensation by one component for another determines whether to allow one component to increase the effect of another component, and third, differential value of one component relative to another determines the weighting to apply to individual components.

2.3.1 Level of Interaction

Interaction implies that the use of one component is influenced by the presence of another component. Some components are used by a species completely independent of the use of another component, while other components are used only in the presence of each other, and of course the interaction may be somewhere between these two extremes (Table 3). Where complete interaction occurs, the equation should reflect this by multiplying the HSI components together. Then, if one value is equal to 0, the equation will always yield a 0 value, and the combined value is progressively higher as each one increases towards 1. Where interaction does not occur, the HSI components should be averaged together by the arithmetic mean or added together with the constraint that the value not exceed 1. In this case, the equation will always give an HSI value > 0 as long as 1 of the HSI components is > 0.

Table 3. Examples of Independence and Interaction, for a species which forages on grass and shelters under shrub cover. Grass cover is represented by component S_1 and Shrub Cover by S_2. Applicable equation forms for reflecting the level of interaction are given.

Independence	Partial Interaction	Full Interaction
Use of grass for feeding does not change in presence of shrub cover	Species feeds on grass whether shrub cover is present or not, but use increases under shrub cover	Use of grass for feeding only occurs under shrub cover
$HSI = Min[1, (S_1 + S_2)]$ $HSI = (S_1 + S_2) / 2$	$HSI = Max (S1, (S_1 \times S_2)^{0.5})$	$HSI = S_1 \times S_2$ $HSI = (S_1 \times S_2)^{0.5}$

2.3.2 Compensation Between Components

Some components are able to compensate for the absence (or reduced value) of another component, while other variables cannot do this. Compensation may be unidirectional, bi-directional, and may be full or partial (Table 4). When compensation does not occur, the variables are simply added, averaged or multiplied together as in the last section. If compensation occurs, the equation must allow the compensating variable to increase the HSI value independent of the compensated variable.

Table 4. Compensation between components is demonstrated with appropriate equation forms for an example of a bird species which nests in aspen trees (S_1) and/or snags (S_2), depending on the abundance of these components.

Compensation Direction	Full Compensation	Partial Compensation	No Compensation
Bi-directional	The species will nest in either aspen or snags, and the number of nest spots increases with the combined total. $HSI = Min[1,(S_1+S_2)]$	The case to the left exists but the value of one of the variables is less than the value of the other. $HSI = Min[1,(S_1+0.5xS_2)$	The species only uses aspen, and if there are no aspen, the site is not used even if there are snags. $HSI = S_1$
Unidirectional	The species nests only in aspen when present, but if aspen are not present they choose snags. $HSI = S_1$ <u>or</u> $HSI = S_2$ if $S_1 = 0$	The case to the left exists but only a fraction of the snags are useful. $HSI = S_1$ <u>or</u> $HSI = 0.5 \times S_2$ if $S_1 = 0$	Not Applicable
Value Dependent Direction	The species chooses snags or aspen depending on the which is more abundant or larger. $HSI = Max (S_1,S_2)$	The case to the left exists but the value of one of the variables is less than the value of the other. $HSI = Max (S_1, 0.5 \times S_2)$	Not Applicable

2.3.3 Averaging Techniques

The result of averaging is always to produce an intermediate value between two or more variables. Averaging is best used in HSI models when an animal is selecting a habitat based on the mean quality of 2 or more resources, such as food, cover, and shelter, rather than the value of each resource separately. Two averaging techniques commonly employed are arithmetic and geometric means. The arithmetic mean gives each component the value of 1/n times the input value, where n = number of averaged components and adds the values together. The geometric mean gives each component the value of $a^{1/n}$, then multiplies the results. For 2 variables, the square root is first taken, then they are multiplied.

Averaging techniques may be used for the different levels of interaction, as seen above but should only be used when the result should be in-between the two values. Finally, although averaging is sometimes thought to act as a form of compensation it is not. The reason is that for compensation to occur, the relative value of each component needs to change in relation to the value of the components. In averaging, the relative value only changes in relation to the number of components being averaged. For a simple geometric mean of two variables the value of component 1 is always the square root of the value. The confusion lies in the fact that the square root of a fraction of 1 is always a larger number than the fraction itself. However, despite the supposed compensation which occurs when the geometric mean is employed, when one of the components equals 0 the result also equals 0, and compensation by definition must be able to increase the overall value when one component is low or lacking. Averaging may also be seen as a form of weighting (see below).

2.3.4 Relative Value of Components (Weighting)

Component weighting is used whenever it is perceived that one component has a greater relative value than another. Because the resultant HSI must be bounded by 0 and 1, the weight is usually given as a fraction. For example, if a species utilizes grass (S_1) and forbs (S_2) for food, but grass is twice as valuable as forbs for energy content, then the weighting factor on S_2 would be ½.

Averaging values is the same as weighting the values all equally, since $(S_1 + S_2)/2 = S_1/2 + S_2/2$ and $(S_1 \times S_2)^{0.5} = S_1^{0.5} \times S_2^{0.5}$. The weighting by this method can also be made to vary according to the importance of the variable to the outcome of the HSI. For example, if $HSI = (S_1 \times S_2)^{0.5} \times S_3$, then $HSI = S_1^{0.5} \times S_2^{0.5} \times S_3$. In this equation the value S_3 has the most influence on the outcome of the HSI because an equivalent change in the value of S_1 or S_2 has a smaller effect of the value of the HSI than the same change in the value of S_3.

2.4 CALCULATION OF HABITAT UNITS

Habitat Units (HU) are the calculated end product of the HSI modelling process and when a single HSI equation for a species is used, the HU are determined by adding up the HSI values multiplied by the area of each forested polygon. For some species, multiple HSI models are used to determine HSI for nesting, HSI for food, HSI for cover, etc. In these cases, the HU equation combines the individual HSI values in a complex formula which often involves graphical analysis on a GIS. As an example, the elk model first calculates three HU values (food, thermal cover, hiding cover) and these are combined with the formula $HU = \min(5/3HU_{Food}, 10HU_{Thermal}, 5/2HU_{Hiding})$

2.5 ESTIMATE OF CARRYING CAPACITY

The final step in the determination of habitat models is to produce relationships between the Habitat Units and the Potential Carrying Capacity of the areas for which the HSI model is applied. The carrying capacity estimate for a fully suitable hectare of habitat is determined through field observation or by literature review of the species. In most cases this value is the maximum population density of breeding adults observed at a study site. This perfect hectare density is then multiplied to the habitat units to give the carrying capacity for each forest stand, and these may be summed across the entire landscape of interest.

3. FURTHER STEPS REQUIRED FOR IMPLEMENTATION OF HSI MODELS

Four additional steps must be completed before HSI models can be implemented within the Foothills Model Forest.

3.1 PEER REVIEW STAGE

This is necessary to obtain opinions from wildlife and modelling experts on the ability of the models to work correctly. Reviewers may suggest changes to the habitat variables which are important or they may suggest changes to the relationships or equations. The peer reviewed models are then rewritten (if necessary) to reflect the knowledge gained from these experts.

3.2 MODEL VERIFICATION WITHIN THE FOOTHILLS MODEL FOREST

Model verification is a field testing stage in which researchers observe animals in their natural habitats and compare the structural components of those habitats to the surrounding habitat. Researchers determine whether the models have the correct habitat variables, whether the graphical relationships between variables and habitat suitability are performing correctly, and they determine if the model equation is defined adequately. Finally, the researcher may obtain new population density estimates to provide a better estimate for the carrying capacity for the local area. If a researcher alters a model it must once again be subjected to the peer review process.

3.3 APPLICATION OF MODELS FOR MANAGEMENT PLANNING

Methods of implementing the models must be developed. At present there is a set of computer programs which compute the habitat units and carrying capacity values. These need to be integrated into each management agencies GIS along with needed tools such as harvest simulators and land use planning tools. Several test runs need to be completed to demonstrate the kinds of outputs which are possible from the models and a test area and species set needs to be chosen for making a set of land use plans which optimize both wildlife habitat and forest resource uses.

3.4 MODEL RESULT VERIFICATION

The final step in the HSI modelling approach again involves the verification of performance. Continuous monitoring of the wildlife resource is necessary. Differences between target habitat supply or carrying capacities may require adjustments in the application of the models or adjustments to the models directly. If some wildlife species do not relate well to the model predictions, more sophisticated modelling approaches may be required such as population or age structure modelling.

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