Grizzly Bear Spring, Summer, and Fall – Habitat Suitability Models

Morice and Lakes Forest Districts IFPA

Prepared for:

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Executive Summary

Species – Habitat models are used to evaluate the potential in the Morice and the Lakes forest districts to provide suitable habitat for wildlife species that were selected by the Ecosystem group of the Morice and Lakes Innovative Forest Practices Agreement (ML-IFPA). The models generally define habitat suitability based on the provision of certain habitat attributes required for living and/or reproduction.

Unchanging environmental conditions (such as Biogeoclimatic subzone), location of infrastructure and development, and projected forest conditions (from the rules defined in individual scenarios), supply much of the basic information that can be used in the habitat supply models. There are other habitat attributes that are not directly provided by the available data layers that describe forest cover in terms of species composition and age. These habitat attributes are derived from information provided in the forest cover dataset and from data provided in the Predictive Ecosystem Mapping (PEM) using mathematical models and/or beliefs expressed in the Netica© conditional probability tables (Habitat Modeling report #1, in prep). Empirical relationships, scientific literature, and professional expertise are incorporated into these equations and/or tables to describe the changes in the state (e.g. abundance, density) of these habitat attributes through changes in forest succession and disturbance.

This report describes the development of the grizzly bear spring, summer, and fall habitat suitability model. For all seasons, the model is essentially a model of available forage (herbs, shrubs, berries, and salmon).

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INTRODUCTION

This report describes the grizzly bear habitat suitability model developed for the Morice and Lakes Innovative Forest Practices Agreement (ML-IFPA). The following document includes: 1) a species account for grizzly bear (*Ursus arctos horribilis*), 2) an outline of the logic used and assumptions made in the preparation of the model, 3) a description of the model structure and relationships used to build the model, and 4) an outline of model sensitivity testing and of the current level of validation.

SPECIES ACCOUNT AND HABITAT USE INFORMATION

Common Name: Grizzly Bear

Scientific Name: *Ursus arctos horribilis*

Species Code: M-URAR

Status: The Provincial Tracking Lists of the British Columbia Conservation Data Centre list grizzly bear as a **Blue** listed species requiring special management. It is classified as **Vulnerable** by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Distribution

Provincial Range

Grizzly bears are distributed throughout the province with the exception of Queen Charlotte and Vancouver Islands (Cowan and Guiget 1978). They are found in all biogeoclimatic zones except for Coastal Douglas-fir (CDF), Bunchgrass (BG) and Ponderosa Pine (PP) (Stevens 1995).

Elevation Range

Grizzly bears are found from sea level to alpine tundra within the province (Stevens 1995). The study area comprises elevation ranges from 0 meters to 1800 meters (Banner, 1993).

Provincial Context

The provincial population of grizzly bears is estimated to be between 10,000 and 13,000 (BC Government 1995). Work on Grizzly bears has been conducted in the Babine River drainage by a number of authors (Simpson 1990 and 1992, Hatler 1995). These studies looked at habitat use in ecosystems similar to those found in the study area (SBSmc2 and ESSFmc/wv).

Ecology and Key Habitat Requirements

General

Grizzly bears are large omnivores that occupy a wide variety of habitats in British Columbia and maintain a wide variety of behaviours to ensure their survival in those diverse habitats. Generalizations about how grizzly bears will use habitats for foraging, security, thermal, reproduction, and hibernation are difficult to make due to the flexibility in bear habitat use. It is important when looking at grizzly bear habitat use to understand that changes in social status, food availability, population, interactions with humans and natural disturbance can all affect the use of a particular habitat.

Foraging habitats for grizzly bears vary depending on the ecosystems that are available to the bear for use. Most grizzly bears in the interior portions of British Columbia occupy mountainous areas and rely on a variety of alpine and valley bottom habitats for food. Common food items include carrion, salmon, insects, many types of berries, grasses, nuts, and various roots (Zager and Jonkel 1983, Simpson 1990, MacHutchon *et al.* 1993). Grizzly bears forage by moving from known sources of food to other known sources of food, which they have learned originally as cubs and reinforced through experience. The types of foods used year to year may change due to availability and some grizzly bears will use the same areas as others but feed on different foods (Simpson 1990 and 1992, Hatler 1995, MacHutchon *et al.* 1993, Zager and Jonkel 1983, Hamilton *et al.* 1986).

The amount of area a grizzly bear will use as a home range is dependent on factors such as sex, age, social status, population levels, and habitat availability (LeFranc *et al.* 1987). Large male grizzly bears are highly mobile and can range over hundreds of kilometres a year, while sub-adults or females with cubs will maintain a much smaller home range, moving from habitat to habitat as they become productive (Simpson 1992, MacHutchon *et al.* 1993, LeFranc *et al.* 1987). The amount of overlap between adjacent grizzly bear home ranges is variable and dependent on the region, sex, age and reproductive and social status of the animal (LeFranc *et al.* 1987). Mace and Waller (1997) working in Montana, found that the amount of habitat overlap between adjacent females was between 0 and 94% (avg. 24%), that 76% of the females showed no territoriality between animals. Interactions between males and females showed that numerous female home ranges were enclosed in a male home range. Overlap zones for both females and males were shown to contain important habitat features such as avalanche chutes, grass/rock lands and shrub lands (Mace and Waller 1997).

Although variable, a general pattern of habitat use has been described by a number of authors that can be used as a model for seasonal habitat use for interior grizzly bears (LeFranc *et al.* 1987, Zager and Jonkel 1983, Zager *et al.* 1980b). These seasonal movements of grizzly bears are based on food resources but are highly variable and dependent on the sex, age and social status of the animal. The general pattern for grizzly bears is for them to den in the winter in steep, high elevation alpine or sub-alpine sites that have deep snow. In the spring, most grizzly bears will use low elevation south-facing areas that are snow-free and have newly emergent plants. Summer feeding areas are quite variable and can range from low elevation riparian areas to alpine meadows. During the fall, many interior grizzly bear populations take advantage of salmon spawning streams to obtain fish, as well as feeding on berries, roots and nuts on nearby slopes (Simpson 1990). Fall feeding is important for preparation for winter denning and has been considered by some authors to be critical (Servheen 1983, Zager *et al.* 1980b). Based on the distribution and observed use of habitats from studies along the Babine River (Turney and Pankras 1996, Hatler 1995, Simpson 1990), seasonal habitat use for grizzly bears are expected to show the following general trends:

- winter – hibernation dens in alpine and sub-alpine areas
- spring – low elevation south slopes, riparian forests and wetlands for early green vegetation and moose,
- summer – mid-elevation herbaceous habitats, north slopes for vegetation, low elevation river bottoms and fluvial benches for early berries, high elevation burns and openings for berries
- fall – large rivers for salmon and associated riparian forest areas for roots, late berries and fruits.

Security habitat is important for sub-adult bears and for females with cubs to avoid adult males, which will defend their territories from other males and will kill unknown cubs to bring the female into esterous (LeFranc *et al.* 1987). Dense, immature stands of conifer or deciduous trees are usually used for security cover along with dense shrub patches (LeFranc *et al.* 1987). Thermal habitats are usually used to provide shelter from heat in the summer months and include open water, snow patches, and beds in cool moist soils (LeFranc *et al.* 1987)

Breeding in grizzly bears takes place in the spring (May and June), with gestation periods ranging from 6 to 8 months depending on latitude (LeFranc *et al.* 1987). The cubs are born in late January to early February in the hibernation den (Zager and Jonkel 1983). The reproductive rate is the one of the lowest of all the land mammals in North America with litters ranging from 1 to 4 cubs and averaging 2 cubs (LeFranc *et al.* 1987). McLellan (1989) working in southeast BC found litter sizes averaged 2.26 cubs in 31 litters, while MacHutchon *et al.* (1993), working in coastal forests of BC reports 2.4 cubs per litter (n=8). The age at first reproduction averages 4 to 5 years and the average interval between litters is 3 years (LeFranc *et al.* 1987). McLellan (1989) found that the age of first reproduction was 6 .0 years (n=5) and ranged from 5 to 8 years. Offspring remain with their mothers for 26-28 months and learn much about foraging and habitat use from them.

Habitat Use – Life Requisites

The life requisite that will be rated in this model for grizzly bear is **Feeding**. The lack of extensive field verification of ecosystems and seasonal grizzly bear use limits the amount of detail that can be obtained from the model.

Hibernation (Birthing) – Winter

Hibernation takes place near treeline, below ridge crests, where snow levels are constant throughout the winter (LeFranc *et al.* 1987, Vroom *et al.* 1977). Den sites are found on steep slopes, with deep soils that are easy to excavate, have vegetation for roof stability and where snow will accumulate for insulation (LeFranc *et al.* 1987). Most dens are dug horizontally into the slope, and end in a chamber where grasses and other vegetation are used as a bed (Vroom *et al.* 1977). Areas of shallow soils, boulders or wet seepage are avoided (LeFranc *et al.* 1987), but caves in rock or cliff areas may be used if available (Vroom *et al.* 1977).

Females give birth during the winter in the hibernation dens, making secure, well-insulated den sites an important habitat feature.

Living – Growing

Feeding Habitat – Growing

Grizzly bears consume a variety of foods, including roots and green vegetation, small and large mammals, fish and insects. Their diets change seasonally and there can be large differences between individuals. Variation between years in crops of different foods can cause shifts in a bear’s use of its territory from year to year. Overall, the size of individual home ranges varies annually in response to variation in quality and abundance of food (Picton *et al.* 1985).

Seasonally important foods that are expected to be available to bears in the study area are shown below (Table 1). Grasses and sedges should be considered a 'staple' food of grizzly bears (Mace 1985).

Table 1. Food plants important to grizzly bears within the study area (*from* Ash 1985, McCrory *et al.* 1985, and Zager *et al.* 1980a).

Type of Food	Plant Species		
Fruits	*Arctostaphylos uva-ursi*	*Oplopanax horridum*	*Sorbus* spp.
	Cornus stolonifera	*Ribes* spp.	*Streptopus roseus*
	Disporum sp.	*Rosa* spp.	*Vaccinium* spp.
	Fragaria sp.	*Rubus* spp.	*Vibernum edule*
	Lonicera sp.	*Shepherdia canadensis*	
Stems and leaves	*Angelica* spp.	*Erigeron* spp.	*Ranunculus* spp.
	Aralia nudicaulis	*Fritillaria* spp.	*Smilacina* spp.
	Arnica spp.	*Gramineae* spp.	*Taraxacum* spp.
	Athyrium felix-femina	*Gymnocarpium dryopteris*	*Trifolium* spp.
	Carex spp.	*Heracleum spondylium*	*Urtica dioica*
	Cirsium spp.	*Osmorhiza* spp.	*Valeriana sitchensis*
	Epilobium angustifolium	*Polygonium* spp.	*Veratrum veride*
	Equisetum spp.	*Potentilla* spp.	*Viola* spp.
Roots and tubers	*Clintonia uniflora*	*Erythronium* spp.	*Lonicera* spp.
	Claytonia spp.	*Lomatium* spp.	*Sambucus racemosa*
Catkins	*Salix* spp.	*Alnus* spp.	*Populus* spp.

Spring Feeding Habitat

During spring, grizzly bears along the Babine River were found to feed on green vegetation, mainly horsetail, cow parsnip, grasses and sweet vetch (Simpson 1990). In Montana, Waller and Mace (1997) found that avalanche tracks were used extensively and in higher proportions than their availability over an 8-year period. Within the study area, high snow levels are likely to limit spring feeding habitat to areas in the lower portions of the ESSFmc that are south-facing. Forest openings such as meadows, wetlands, seepage areas and herb-dominated avalanche paths would be chosen if they are snow-free.

It is likely that most of the high quality spring feeding areas are found within the SBSmc2 forests at lower elevations along Gosnell Creek and the Morice and Thautil Rivers. These riparian areas typically have the most favourable conditions for succulent forb and grass production (Ash 1985). Based on winter moose surveys conducted in this study, moose are also found in these riparian areas and grizzly bears may select these areas to search for moose that were winter-killed or hunt-weakened animals, providing important food supplies in early spring (Simpson 1990, Green *et al.* 1997).

Summer Feeding Habitat

Summer feeding areas are the most variable of the seasonal habitats and the habitats that are used are dependent on factors such as food availability, sex and age of the bear, competition from other bears, and interactions with humans. Some grizzly bears may forage mostly in alpine and sub-alpine areas feeding on marmots, herbaceous and grassy vegetation and occasionally ungulates such as mountain goats, moose and caribou (LeFranc *et al.* 1987). Others will use mid-elevation herbaceous meadows, open forests or recently disturbed areas with high berry production or herb-dominated avalanche tracks (LeFranc *et al.* 1987). Waller and Mace (1997) found avalanche tracks were heavily used in summer along with shrub lands and cutblocks. The use of forested habitats is variable for grizzly bears, with both avoidance and selection occurring (see Waller and Mace 1997). In forested habitats, canopy closures of 20-50% are suggested as optimal for berry production (Ash 1985). Still other grizzly bears will use low elevation riparian and wetland habitats, which provide high value herbaceous plants throughout the summer, large rivers with early salmon runs, or open forest habitats with dense shrub and herb layers (LeFranc *et al.* 1987). Grizzly bears will also eat a wide variety of insects and larvae during the summer such as ants, wasps and bees (LeFranc *et al.* 1987).

For grizzly bears that use the study area, it is possible that all of the above strategies for foraging could be used during the summer. Incidental sightings and information from local resource managers, however, indicates that most grizzly bear use is in mid to upper elevation areas.

Fall Feeding Habitat

Fall feeding habitats, like summer feeding areas, are highly variable for grizzly bears. If salmon spawning areas are available, many bears from large areas will be drawn to the site to utilize this important food source. Where salmon spawning areas are not available, grizzly bears will feed on a range of foods such as berries (e.g. *Vaccinium sp., Oplopanax horridus*), roots, nuts, insect larvae, herbaceous plants, grasses and sedges (Simpson 1990, LeFranc *et al.* 1987).

It is likely that fall habitat use for many grizzly bears will be split between the abundant salmon spawning areas in the low elevation rivers outside of the study area and mid- to high-elevation berry areas within the study area.

Security Habitat – Growing

Security habitats are those that supply hiding cover from other grizzly bears or from humans. These are usually dense stands of coniferous or deciduous forests, or dense shrub habitats (Craighead *et al.* 1982). Security cover is very important for sub-adult bears and for females with cubs, and they may use less optimal foraging areas to ensure that they maintain adequate security cover (McClellan and Shackleton 1988). Open, high-value feeding habitats where cover is limited are used during the night, so that darkness can provide security cover to the bears using those habitats (Mattson *et al.* 1987).

Within the study area, optimal habitat areas for grizzly bears requiring security cover will be where feeding and security cover are in close proximity to each other. These will likely be in the forested wetland complexes and in riparian habitats along the main rivers of the study area. Tall shrub communities such as those found in avalanche tracks will also be important due to the interaction of foraging and security habitats.

Thermal Habitat – Growing

Thermal habitat for black bears is confined to providing relief in the summer from heat, as the winter hibernation den is used to provide thermal habitat during the winter (see Hibernation). Mature closed-canopy forests can provide thermal cooling because these forests can be several degrees cooler than an adjacent open area (Hunter 1990). Movement to higher elevations or north-aspect areas in the shade where the air temperature is lower may also provide relief from heat. A variety of microhabitats can also provide relief from heat such as open water (rivers, streams, lakes etc.), snow patches, shaded forest habitats and cool, moist soils (LeFranc *et al.* 1987). Thermal habitat can be quite small (small pool in stream, snow patch below rock bluff etc.) and impossible to map at a 1:20,000 scale. However, these sites are not likely to be limiting within the study area, and it is therefore unlikely that they are a major component in the habitat selection process.

Seasons of Use

Grizzly bear are year-round residents of the study area with hibernation habitat required in the winter and feeding, security, thermal habitats required from spring to fall. Table 2 summarizes the seasonal life requisite requirements for grizzly bear based on the seasons outlined in the Resource Inventory Committee (1998) for the Central Interior Ecoprovince.

Table 2. Life requisites by month and season for grizzly bear in the study area.

Month	Season	Life Requisites
January	Winter	Hibernation
February	Winter	Hibernation
March	Winter	Hibernation
April	Winter	Hibernation
May	Spring (Growing)	Living (Feeding, Security, Thermal)
June	Spring (Growing)	Living (Feeding, Security, Thermal)
July	Summer (Growing)	Living (Feeding, Security, Thermal)
August	Summer (Growing)	Living (Feeding, Security, Thermal)
September	Fall (Growing)	Living (Feeding, Security, Thermal)
October	Fall (Growing)	Living (Feeding, Security, Thermal)
November	Winter	Hibernation
December	Winter	Hibernation

Habitat Requirements Summary

A summary of the habitat requirements and seasons of use is listed below (See Table 3). This summary is the basis for development of the habitat ratings.

Table 3. Summary of habitat requirements for grizzly bear in the study area.

Life Requisite	Season	Specific Attributes Required	Structural Stages
Living (Feeding)	Spring	- South-facing forested habitats at lower elevations with good herbaceous plant growth	5 – 7
		- South-facing herbaceous avalanche tracks, low elevation meadows or wetlands	2 – 3
	Summer	- Alpine, sub-alpine and forest meadows and wetlands	2 – 3

Life Requisite	Season	Specific Attributes Required	Structural Stages
Living (Feeding)	Summer	- Herbaceous and shrubby avalanche tracks, especially north-facing	2 – 3
		- Open forest habitats with high berry production	4 – 7
		- Early seral stage forest habitats with high berry production in complexes with closed canopy forests	2 – 3 with 4 – 7
		- Moist forests with high herbaceous plant growth	5 –7
	Fall	- Open forest habitats with high berry production	4 – 7
Living (Feeding)	Fall	- Early seral stage forest habitats with high berry production in complexes with closed canopy forests	2 – 3 with 4 – 7
Living (Security)	Growing (Spring, Summer, Fall)	- Immature dense coniferous or deciduous forests, dense shrub habitats,	3 – 4
		- Mature forests with dense understory growth	5 – 7
Living (Thermal)	Summer	- Open water habitats, permanent snow,	n/a
		- Forested habitats with streams, forested habitats with seepage or depressions	4 – 7
Hibernation	Winter	- Steep, north-facing slopes in alpine and sub-alpine areas with deep moderately textured soils and vegetation	2 – 7

GRIZZLY BEAR SEASONAL HABITAT MODEL

Grizzly bears can use a wide range of habitat types and can modify their behaviours and movements to take advantage of changes in food availability. This variability makes the development of a suitability model difficult as nearly all vegetated habitats can be rated as moderately used for foraging and it is likely that at some point, a bear will use it. During spring, summer, and fall, habitat suitability for grizzly bear is largely dependent on the ability of the habitat to provide foraging opportunities. This model captures the more geographically predictable aspects of their diet based on what can be inferred from PEM mapping and freshwater salmon inventory data for each of these seasons. Thus, the output of each seasonal grizzly bear habitat model is a rating of forage habitat suitability.

Obtaining higher ratings for an ecosystem unit requires that there be other uses of that area, such as for security or thermal cover or that the food resources are so large that more than one bear is likely to take advantage of it at the same time (e.g. large berry areas, salmon spawning area). Another way that a higher rating could be achieved, would be if a habitat type was limited within the area for a specific life requisite function (e.g. hibernation, early spring feeding). Many authors have observed a decrease in habitat use by grizzly bears beside roads after the roads were constructed (see Hamilton *et al.* 1986, Mattson *et al.* 1987, Mattson 1990, McLellan and Shackleton 1988). These other aspects of habitat suitability could be addressed by a spatial analysis of available data at a later date.

Application of Model

Season: Spring, Summer, and Fall (foraging for all three seasons)

Habitat Areas: All landscape units in the Morice and the Lakes forest districts in central British Columbia.

Model Output: The model will grizzly bear seasonal habitat suitability value.

Verification Level: Verification of the model involved testing the belief net to ensure that the output is consistent with our expected output.

Assumptions/beliefs

The following section describes the logic and assumptions used to translate habitat variable information for grizzly bear to the variables and ecological relationships used to build the grizzly bear habitat suitability model.

1. Presence and abundance of shrubs and herbs are correlated with moisture and nutrient regime, as summarized by site series, and with structural stage. Shrub and herb presence and abundance ratings by structural stage were based on vegetation descriptions for the ecosystems as described in Banner *et al.* (1993) and Turney and Houwers (1998). For the herb-shrub and pole-young structural stages the vegetation potential and complex information from the MoF silvicultural tables were most useful.
2. Each combination of site series and structural stage (as derived by PEM) was rated for presence and abundance of preferred forage species for grizzly bear, (from the literature).
3. Seasonal vegetation phenology was assumed to vary by biogeoclimatic subzone. In general, higher elevation subzones have a shorter growing season due to cooler temperatures. These sites also generally have colder soils and snow cover both earlier in the fall and later in the spring.
4. River polygons with known salmon spawning areas were assumed to significantly increase grizzly bear forage suitability in the late summer and fall due to feeding opportunities on salmon. In late summer, spawning sites or areas where salmon congregate were assigned a high increase in grizzly forage suitability value within 200m of the known site. In fall, these same areas were assigned a moderately increase in forage suitability value.
5. Slopes greater than 50 degrees, for all three seasons, are generally of no to low value.
6. Aspect (warm, cool, or flat) affects herbaceous abundance during the spring season. Warm aspect habitats will generally have more abundant vegetation in the spring than other sites because they are snow free and warmer earlier than cool or flat sites. The seasonal herb adjustment node accounts for the affect of aspect on herb abundance.
7. All ecosystems are assumed to be either naturally regenerated from naturally disturbed sites, or, regenerated using standard silvicultural techniques following forest harvesting(e.g. planting with native species in proportion to natural levels, vegetation management at herb/shrub stage, spacing at pole sapling stages). While the earlier structural stages of managed stands are recognized as providing generally high forage values, their successional pathways are sped up such that these productive earlier stages do not last as long. Further, the older structural stages of managed stands are assumed to have less stand structure and fewer gaps, so that shrub and herb abundance are reduced. Consequently, the grizzly vegetation rating outputs for all managed stands were reduced by one third.

Grizzly Bear Spring, Summer, and Fall Model Description

The following section describes the spring, summer, and fall grizzly habitat suitability model (See Figure 1) and the assumptions used to define the relationships used in the model. The habitat suitability ratings should be interpreted at the landscape level and not used as a stand management interpretation. In this model iteration grizzly vegetation ratings have been modified by proximity to salmon in order to provide a rating of overall grizzly forage values. It is intended that a future iteration of the model will include a spatial evaluation of habitat configuration and the influence of road density, road use, and other factors that could potentially affect the value of habitat for grizzly bears by season.

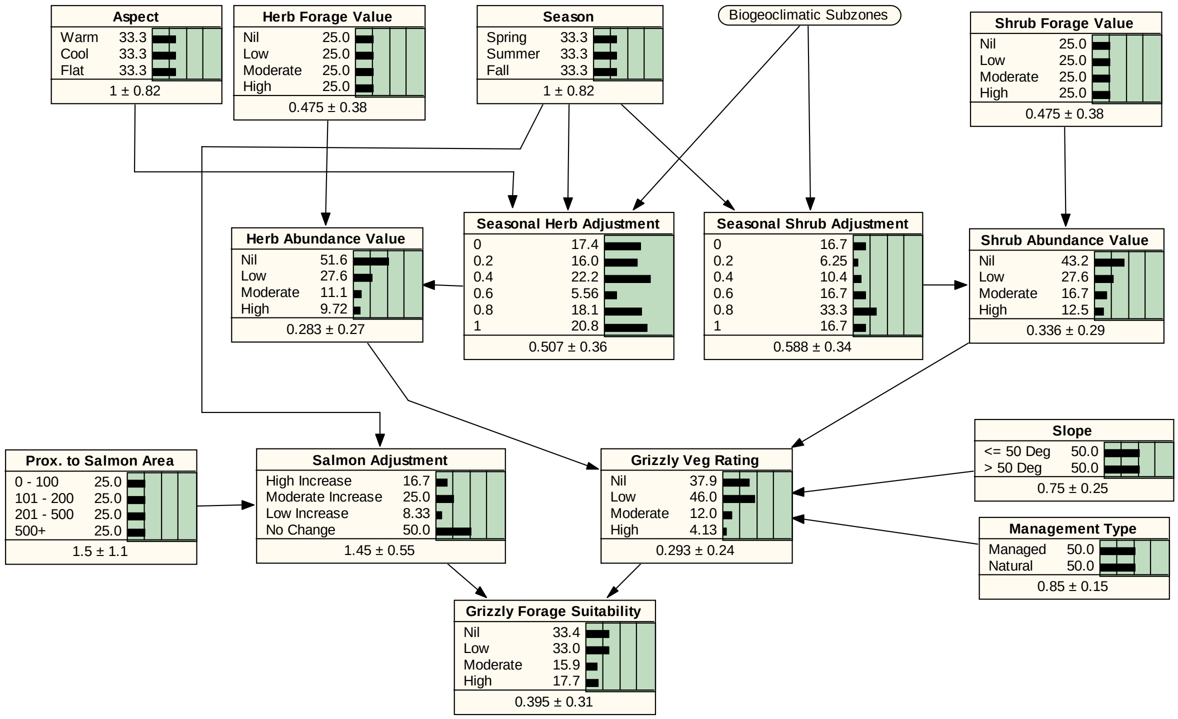

Figure 1. Habitat variables and ecological relationships used to build the grizzly bear forage suitability Bahesian belief model in the Netica© program.

Model Description

During spring, summer, and fall, habitat suitability for grizzly bear is largely dependent on the ability of the habitat to provide foraging opportunities, but also depends on distance to roads. The following section outlines the components of the model for grizzly bear in the Morice and Lakes forest districts and describes the relationships that were used to create the model.

Description of Network Nodes

The grizzly habitat suitability model is built such that the same model can be applied to all three growing seasons. Changes as a result of season are accounted for by a series of adjustment factors: seasonal herb adjustment, seasonal shrub adjustment, and, salmon adjustment. In the following section, when the spring, summer, and fall seasons are all relevant they will be referred to as growing seasons. If a comment is only relevant to one of these seasons, the season will be specifically referenced.

Grizzly Forage Suitability

Grizzlies eat a great variety of shrubs and herbs throughout the growing seasons, the proportions of which depend partly on plant phenology. Herb and shrub occurrence and abundance vary with season, biogeoclimatic subzone and site series. Grizzlies primarily forage on emerging herbaceous vegetation in spring and summer. From late summer to fall, foraging focus shifts to fruit-bearing shrubs, and, where available, salmon. Grizzly forage suitability values are output for spring, summer and fall, based on the same model. For all growing seasons, the grizzly forage suitability is a function of the overall grizzly vegetation rating and the salmon adjustment factor.

Example Relationship: **GFR = SA * GVR**

Where: GFR = grizzly forage suitability

SA = salmon adjustment

GVR = grizzly vegetation rating

Grizzly Vegetation Rating

For all growing seasons, the grizzly vegetation rating is based on the herb abundance value, adjusted for season of occurrence, and the shrub abundance value, adjusted for the season of ripening. Polygons with slopes greater than or equal to 50% have values reduced to nil. The grizzly vegetation rating are reduced by one third for managed stands, but left as is for naturally regenerated stands from natural disturbances.

Example Relationship: **GVR = max (SV, HV) * SLP) * MT**

Where: GVR = grizzly vegetation rating

SV = shrub abundance value

HV = herb abundance value

SLP = slope

MT = management type

Seasonal Shrub Adjustment

This node accounts for the effect of season on shrub forage abundance by biogeoclimatic subzone (See Figure 2). The development stage, or phenology, of vegetation by season, is assumed to be dependent on elevation, soils, snow depth and moisture.

Example Relationship: ***Conditional Probability Table***

Where: SSA = seasonal shrub adjustment

SEAS = season

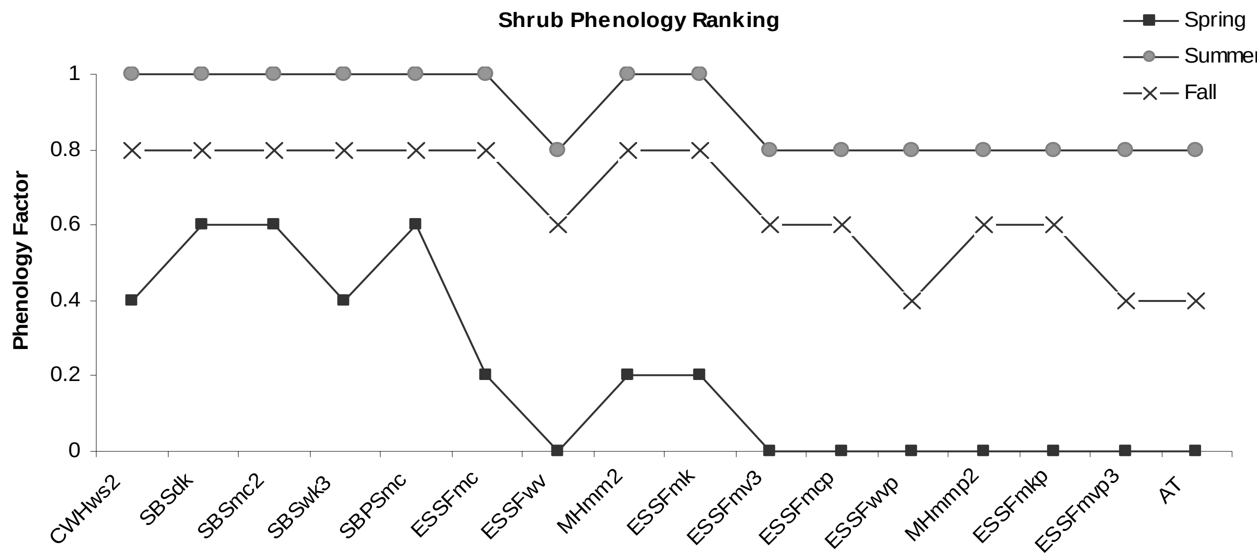

Figure 2. Seasonal adjustment factor for shrub forage species by biogeoclimatic subzone (based on vegetation phenological development).

Shrub Abundance Value

The shrub abundance value is based on the shrub forage value (rated by site series and structural stage), modified by the seasonal shrub adjustment factor, which is based on phenological stage.

Example Relationship: **SV = SSA * SFV**

Where: SV = shrub abundance value

SSA = seasonal shrub adjustment

SFV = shrub forage value

Shrub Forage Value

This is a parent node that takes the PEM site series and structural stage information and links it to a look-up table which rates each combination (of site series and structural stage) for its abundance of shrubs known to be preferred forage in the diet of grizzly bears. Listings of shrub occurrence and abundance by site series and structural stage were drawn from the vegetation tables and silvicultural guidelines in Banner *et al.* (1993) and from plot data from Turney and Houwers (1998). For the herb-shrub and pole-young structural stages the vegetation potential and complex information from the MoF silvicultural tables were most useful. Most shrub types are fruit bearing (i.e. *Vaccinium spp.*) and become important in the late summer and early fall.

Variable: SFV = shrub forage value

Seasonal Herb Adjustment

This node makes allowance for the effect of season on herb abundance (see Figure 3. Seasonal adjustment factor for herbaceous forage species by biogeoclimatic subzone (based on vegetation phenological development). For spring, aspect also influences the growth of herbaceous vegetation. Note that for sites < 10º slope (flat aspect sites), the phenological factor is the same as for cool aspect sites.. The development stage, or phenology, of vegetation by season, is assumed to be dependent on elevation, soils, snow depth and moisture. For spring, aspect also influences the growth of herbaceous vegetation. Biogeoclimatic subzone information (elevation) and aspect determine the degree of seasonal herb adjustment required.

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Example Relationship: ***Conditional Probability Table***

Where: SHA = seasonal herb adjustment

SEAS = season

SV = seasonal shrub adjustment

ASP = aspect

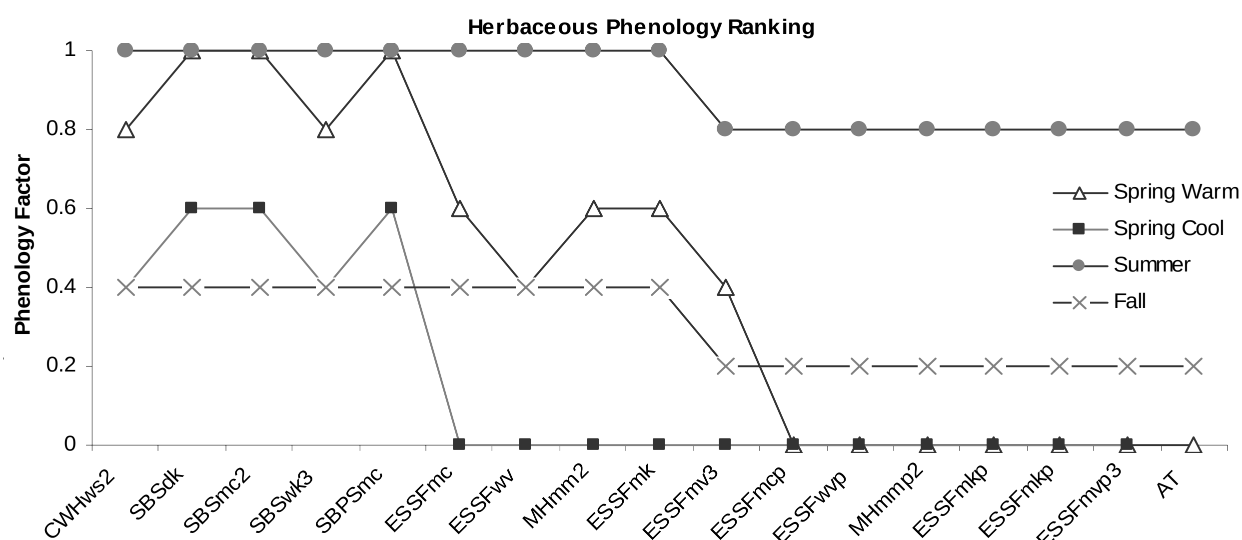

Figure 3. Seasonal adjustment factor for herbaceous forage species by biogeoclimatic subzone (based on vegetation phenological development). For spring, aspect also influences the growth of herbaceous vegetation. Note that for sites < 10º slope (flat aspect sites), the phenological factor is the same as for cool aspect sites.

Herb Abundance Value

The herb abundance value takes the herb forage value (rated by site series and structural stage), and modifies it by the seasonal herb adjustment factor, to reflect phenological stage.

Example Relationship: **HV = SHA * HFV**

Where: HV = shrub abundance value

SHA = seasonal herb adjustment

HFV = herb forage vValue

Herb Forage Value

This is a parent node that takes the PEM site series and structural stage information and links it to a look-up table which rates each combination (of site series and structural stage) for its abundance of herbaceous vegetation known to be preferred forage in the diet of grizzly bears. Listings of herb occurrence and abundance by site series and structural stage were drawn from the vegetation tables and silvicultural guidelines in Banner *et al.* (1993) and from plot data from Turney and Houwers (1998). For the herb-shrub and pole-young structural stages the vegetation potential and complexe information from the MoF silvicultural tables were most useful.

Variable: HFV = herb forage value

Season

The season node specifies whether the model is processing data for spring, summer, or fall. This node influences the salmon adjustment node, the seasonal herb adjustment, and the seasonal shrub adjustment. Essentially the same model is used for all three seasons, with adjustments made by biogeoclimatic subzone for plant phenology and timing of salmon runs.

Variable: SEAS = season

Biogeoclimatic Subzones

Phenology of herbs and shrubs is reflected in the seasonal herb adjustment and shrub adjustment factors by biogeoclimatic subzone. All of the subzones that are present in the Morice and Lakes forest districts are included in this node.

Variable: BEC = Biogeoclimatic subzone

Aspect

Aspect is simplified into: warm (136° to 270°), cool (271° to 135°), and "flat" (sites that have slope less than 10°). A flat aspect is presumed to have no impact on snow depth or conditions. Cool aspects are assumed to maintain higher snow depths relative to warm aspects, which experience higher melt due to warming. For spring, aspect influences the growth of herbaceous vegetation, and thus influences the seasonal herb adjustment.

Variables: ASP = aspect class

Management Type

This node indicates whether the polygon is the result of natural regeneration following a natural disturbance, or, assumes that standard silvicultural techniques have been applied following forest harvesting (e.g. planting native species in proportion to natural levels, vegetation management at herb/shrub stage, spacing at pole sapling stages). Managed stands results in a one third reduction in grizzly vegetation values, while naturally regenerated stands from natural disturbances do not affect vegetation ratings. (See model assumption #7.)

Variable: MT = management Type

Slope

The slope node is a parent node whose value has been extracted from the digital elevation model (DEM) and is read into the node as a numerical value. Once in the node, the values are interpreted into one of 2 classes: <= 50º and > 50º. A Polygon slope greater then or equal to 50% results in a drop in grizzly vegetation value to nil.

Variable: SLP = slope

Salmon Adjustment

This node accounts for the presence and potential importance of salmon as grizzly bear forage in each season. In spring the salmon adjustment does not apply. By mid to late summer and into the fall, salmon have aggregated at known pooling and spawning areas. During summer and fall the salmon adjustment either increases the forage suitability value within a certain distance of salmon areas or results in no change within a given distance of the salmon area.

Example Relationship: ***Conditional Probability Table***

Where: SA = salmon adjustment

PSA = proximity to salmon area

SEAS = season

Table 4. Adjustment factors applied by season to distance contours proximal to known salmon areas.

Proximity to Salmon Area (m)	Spring	Summer	Fall
0-100	No change	High increase	Moderate increase
101 - 200	No change	High increase	Moderate increase
201 - 500	No change	Moderate increase	Low increase
500+	No change	No change	No change

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Proximity to Salmon Area

Known salmon pooling and spawning areas were mapped in the GIS. The following distance to salmon area contours were created: 0m – 100m, 101m – 200m, 201m – 500m, and 500m+. The effects of these distances on the model are described in Table 4, above.

Variable: PSA = proximity to salmon area

Computing Output for Habitat Suitability

Grizzly bear habitat suitability will be the output from the model for each polygon based on grizzly forage ratings and proximity to salmon areas. An assessment of the spatial pattern, or configuration, of the habitat, and the impact of roads, still needs to be completed to be able to appropriately interpret habitat value for grizzly bear in spring, summer, and fall.

Sensitivity Analysis

Testing and Validation

The models should be viewed as hypotheses of species-habitat relationships rather than statements of proven cause and effect relationships. Their value is to serve as a basis for improved decision making and increased understanding of habitat relationships because they specify hypotheses of habitat relationships that can be tested and improved. There are several levels at which the models should be validated. The first is an ongoing process during model development during which we have tested the model to ensure that it is acting in a manner that we want it to. The second level is to test the model assumptions and output through field-testing or verification.

The grizzly seasonal habitat suitability model has been tested within Ardea. The next step is to have external reviewers examine the model and assumptions.

Research Needs for Model Verification

The performance of a model should be tested against population data, preferably estimates of density or reproductive success, to translate the perception of habitat quality or suitability into differential use of habitat (Brooks 1997). The spatial configuration of habitat will affect the spatial spread and use of a population in a heterogeneous environment (Söndgerath and Schröeder 2002). The output of this model provides a habitat suitability value, refined by proximity to salmon areas; however, the pattern and amount of the habitat with respect to caribou use is not evaluated, nor the impact of roads. The importance of the landscape structure varies according to the demographic characteristics of the population (Söndgerath and Schröeder 2002, With and King 1999).

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APPENDIX A: SUITABILITY RATINGS FOR SPECIES ACCOUNT MORICE AND LAKES FOREST DISTRICT

Ratings Scheme

A high level of knowledge of habitat use is available for grizzly bear in British Columbia; therefore, a 6-class rating scheme (Resources Inventory Committee 1998) was applied to the ecosystems: **1 = High, 2 = Moderately High, 3 = Moderate, 4 = Low, 5 = Very Low** and **6 = Nil**.

Provincial Benchmark

Ecosections: Kitimat Ranges (KIR), Nass Ranges (NAR) and Southern Park Ranges (SPK)

Biogeoclimatic Zones: AT, BWBS, CWH, ESSF, ICH, IDF, MH, MS, PP, SBPS, SBS, SWB

Habitats:

Interior habitats important to grizzly bears include: warm aspect herb-dominated avalanche tracks, herbaceous meadows, herbaceous wetland complexes, early seral stage forests dominated by *Vaccinium sp.*, sub-alpine parkland meadow complexes and riparian areas associated with high concentrations of spawning salmon.

Habitat Use and Ecosystem Attributes

A summary of the relationship between grizzly bear habitat requirements and the available information from the ecosystem map are provided below (See Table 5). This information is used to develop the habitat ratings in the section below.

Table 5. Summary of relationships between Terrestrial Ecosystem Mapping (TEM) attributes and life requisites of grizzly bear.

Life Requisite	Ecosystem Mapping Attributes
Living (Feeding, Security, Thermal)	site: ecosystem type, aspect, elevation, slope, structural stage
	soil/terrain: terrain texture, soil drainage
	vegetation: % cover by layer, species list by layer, % cover by species
Hibernation	site: ecosystem type, aspect, elevation, slope, aspect, structural stage
	soil/terrain: surficial material, terrain texture, soil drainage

Table 6. General habitat ratings for ecosystem units for grizzly bear within the study area.

General Habitat Types	Ecosystem Units	General Rating
Alpine and sub-alpine poorly or non-vegetated sites	BF, DL, EB, HM, TA	- very low or no value as living or hibernation sites due to lack of forage vegetation and not steep enough for denning
Alpine and sub-alpine krummholz	SK	- very low value for living due to lack of forage vegetation, high value for hibernation due to steep slopes, vegetation and suitable soils
Rocky or cliff habitats	RO, CL	- low value as living habitat due to lack of forage, low value as hibernation due to rocky soils
Forested ESSFmc parkland habitats	SP, FV	- moderate value as spring and summer living due to high herbaceous growth and available security and thermal cover

General Habitat Types	Ecosystem Units	General Rating
Moist, rich ESSFmc forested habitats	FO, FD, HG, FH	- moderate to moderately high value in spring, summer and fall living due to high herbaceous and shrub growth, along with security and thermal cover
Dry ESSFmc and SBSmc2 forested habitats	LC, FC, PH	- low value due to lack of forage vegetation
Vaccinium producing ESSFmc and SBSmc2 forest habitats	FB, HH, FT, SB	- moderate to moderately high value as summer and fall living at early and late structural stages due to moderate to high berry production
Moist, rich SBSmc2 forested habitats	TC, SO, SD, SH, SS	- moderate to moderately high value in as spring, summer and fall living due to high herbaceous and shrub growth, along with security and thermal cover
Non-vegetated forested sites	various	- little to no value due to lack of vegetation for foraging
Avalanche tracks	AC, AF	- moderate to moderately high value as spring living if south-facing and mid/low elevation, moderate to high value as summer and fall living
Wetlands and meadow habitats	AW, MM, WM, WW, BS, SF	- moderate to moderately high value as spring and summer living at low elevations, moderate value as summer living at mid and high elevations
Open water and snow habitats	PS, OW, RI, LA, PD	- very low value for thermal regulation during summer
Other non-vegetated sites	GB, CB, RP	- little to no value due to lack of forage vegetation and security/thermal cover

Reliability

Overall, this model is rated as moderately reliable for landscape and watershed level planning purposes. The habitat ratings for grizzly bears in most ecosystems in the Gosnell study area are considered to be moderately reliable for structural stages 5 (young forests), 6 (mature forests) and 7 (old forests). Most field sampling in forested habitats occurred within these 3 structural stages. We were unable to test the model assumptions or verify habitat suitabilities for the earlier structural stages, particularly structural stages 3 (shrub) and 4 (pole/sapling), because they were very poorly represented in most ecosystems in the study area.

Similarly, there were several ecosystems that were uncommon in the study area (see Turney and Houwers 1998). For example, within the SBSmc2 biogeoclimatic zone, over 80% of field sampling occurred in 4 ecosystem types: SB (44%), SH (19%), SO (11%) and TC (7%). Within the ESSFmc, the majority of field sampling occurred in 3 ecosystem types: FB (31%), HH (14%) and FO (11%). Sampling of many rare ecosystems was hindered by access logistics and their low rates of occurrence.

Habitat ratings for uncommon ecosystems and under-represented structural stages have low reliability and should be used with caution, as interpretations are based on very small sample sizes. Increased reliability may be achieved through more extensive surveys in the full complement of ecosystems and structural stages in other SBSmc2 and ESSFmc forests in the region. The lack of information on the number of grizzly bears using the study area limits model reliability. The ability to detect and distinguish between black bear and grizzly bear sign is limited and there are problems using sign as an indicator of habitat use (Ministry of Environment, Lands and Parks 1998). Seasonal field verification could increase the reliability of the model. If this model is to be use for operational planning purposes, more seasonal field verification is recommended.