Northern Goshawk (*Accipiter gentilis ??*) Habitat in the North Coast Forest District.

Foraging Area and Nest Area Habitat Suitability Models

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INTRODUCTION

This document describes habitat suitability models developed for the Northern Goshawk (*Accipiter gentilis*; hereafter goshawk) in the North Coast Forest District (NCFD). We developed models for the Nest Area and Foraging Area components of a goshawk territory and a third "Territory" model that combines Nest Area and Foraging Area ratings. Model structures are based on the Habitat Suitability Index (HSI) methodology (US Fish and Wildlife Service 1981). The models were developed based on the expert opinion of the authors, observed habitat characteristics at goshawk nest areas in the Coastal Western Hemlock biogeoclimatic zone (Banner *et al* 1993) in northwestern British Columbia, and relevant literature. The intended use of these habitat models is to assess the affect of different management scenarios within the North Coast Land and Resource Management Plan planning process on goshawk habitat supply. Habitat ratings that result from these models represent relative values suitable for comparisons across the NCFD area and for comparing habitat supply under different management scenarios. Ratings do not predict, or correspond to, absolute numbers of goshawks or territories. The models were developed specifically for the Coastal Western Hemlock (CWH), Mountain Hemlock (MH) and Alpine Tundra biogeoclimatic subzone variants found in the NCFD using inventory data available from the provincial Forest Cover and TRIM map databases. Application of these models to other areas or other data inventories should be adapted cautiously.

SPECIES ACCOUNT

Several documents provide compressive accounts of the ecology, management and conservation of the northern goshawk internationally (Squires and Reynolds 1997), provincially (Cooper and Stevens 2000) and regionally (Iverson *et al* 1996; Doyle and Mahon 2000; McClaren 2001). For detailed background information readers should refer to those documents. Below we provide a brief synopsis of that information. Following sections provide more detailed information specific to the construction of the models and relevant to the NCFD area.

Species Overview: Description, Distribution, and Ecology

The Northern Goshawk (*Accipiter gentilis*) is a raven-sized forest raptor with a circumpolar distribution, and is found in both temperate and boreal forests (Brown and Amadon 1989). In North America there are several morphologically different sub-species.

Within BC the larger *Accipiter gentilis atricapillus* is found on the mainland and the smaller red-listed *Accipiter gentilis laingi* is found on Vancouver Island and Queen Charlotte Islands (Campbell et al. 1990), and also possibly on the coast of the adjoining mainland (Cooper and Stevens 2000).

The goshawk is primarily adapted to forest habitats where its short, rounded wings, long tail, and powerful flying action make it an effective direct pursuit hunter, capable of quick acceleration and excellent maneuverability through the forest. Across their broad range goshawks take a variety of mid-sized forest prey ranging from small mammals and passerines to hares (Squires and Reynolds 1997). In western BC and on Vancouver and Queen Charlotte Islands its main prey are red squirrels, forest passerines (typically thrushes, woodpeckers and jays) and grouse (Roberts 1997, Ethier 1999, Doyle and Mahon 2001, Mahon and Doyle 2001). Near the coast Northwestern Crows and Marbled Murrelets are also taken (Lewis 2001). Goshawk nest areas are typically in mature/old growth coniferous stands that are even-aged and have a closed canopy and open understory (Squires and Reynolds 1997, Cooper and Stevens 2000).

Within homogenous mature forest habitat goshawks are relatively evenly distributed (Reynolds and Joy 1998) with the distance between territories being primarily driven by prey availability within landscapes (Doyle and Smith 1994, 2001). In interior BC the nest area spacing in the ICH and the SBS is 4-7 km (Mahon and Doyle 2001, Doyle and Mahon 2001), and on Vancouver Island and the Queen Charlotte Islands we see a spacing of around 7-10 km between pairs (McClaren 2001). Within heterogeneous habitat, such as is characteristic of the mountains and fjords of the North Coast, the distribution pattern of goshawks is unknown.

Taxonomy and Status

The sub-species of Northern Goshawk that occurs within the North Coast FD is unknown, as no specimens have been collected, or DNA tests conducted. Work on goshawks in the Kispiox Forest Districts, some 150 km inland, shows a goshawk that is smaller than the typical *A. g. atricapillus*, but slightly larger than the *A. g. laingi* found on the Queen Charlotte Islands (Taverner 1940). Work on Vancouver Island using radio telemetry indicates that *laingi* birds from the Island do cross over to the mainland (McClaren 2001). However, until DNA evidence is available and in the absence of a major geographic divide it is assumed that the birds on the mainland are indeed *A. g. atricapillus*.

A. g. atricapillus is designated "Not at risk" by COSEWIC at the national level and also as "Not at risk" (yellow listed (S4B S4N)) by the Conservation Data Centre at the provincial level. This sub-species is listed as an "Identified Wildlife Species" under the Forest Practices Code (IWMS 1999) however, due to its strong association with mature coniferous forests for foraging and nesting, and the possible impact to this habitat resulting from forest development.

Territory Components and Habitat Requirements

A goshawk breeding territory is classically described as having three hierarchical components: nest area, post-fledging area and foraging area (Reynolds et al. 1992). The nest area is the centre of breeding activities throughout the reproductive season – mid February to the end of August (Squires and Reynolds 1997). Once established goshawks exhibit a very strong fidelity to nest areas, often using them intermittently for periods of

years or decades (Reynolds 1983). The nest area usually includes multiple nest sites, plucking perches, and roosts, and remains the centre of activity for newly fledged young. The estimated size of nest areas ranges from 8 ha (Reynolds 1983) to 50 ha (McCarthy et al. 1989). From a sample of >40 nests in the ICH and SBS biogeoclimatic zones in the Prince Rupert Forest Region we estimated nest area size to be 24 ha (Mahon and Doyle 2000).

Despite significant variation in forest types used for nesting across their geographic range, key structural attributes are consistently selected by goshawk for nesting habitat. These attributes include mature/old-growth stand structure and relatively closed canopies with corresponding open understories (Kennedy 1988; Hayward and Escano 1989; Reynolds *et al*. 1992). At the regional level, selection of forest species composition is also evident (Mahon and Doyle 1999; Schaffer et al. 1999). A summary of stand characteristics for 16 known goshawk nest areas in the CWH biogeoclimatic zone in northwestern BC is provided in Table 1. Nest stands are dominated by western hemlock and are typically ≥ age class 8 (141 years), ≥ height class 4 (28.5 m), and ≥canopy closure class 5 (56%). Photographs of high quality and low quality nest area stands are provided in Figures 1 and 2, respectively. These characteristics are generally associated with the more productive site series (especially in the CWHvh2) in mid-lower slope positions. These habitats are generally constrained by climatic and geographic factors that limit their extent and result in linear distribution (bands) with respect to the fjordland geography that dominates the NCFD (Figure 3).

Table 1. Habitat characteristics of 16 goshawk nests areas in northwestern BC

			Forest Cover (%)*						**Canopy**
Nest Area	**District**	**BEC Zone**	**Hw**	**B**	**S**	**Cw**	**Age Cl,**	**Ht. Cl.**	**Cl. Cl.**
Cranberry	Kispiox	CWHws2	90		10		8	4	7
Kitsun's	Kispiox	CWHws2	70	30			9	3	5
Mill Creek	Kispiox	CWHws2	75	20		5	8	4	7
Ten Link	Kispiox	CWHws2	95	5			8	4	4
Upper Cranberry	Kispiox	CWHws2	85			15	9	5	6
Weber Creek	Kispiox	CWHws2	85	15			9	4	6
Marron	Kalum	CWHws2	95	5			9	4	7
Big Cedar	Kalum	CWHws2	1^{o}	2^{o}			9	4	7
Newton Creek	Kalum	CWHws2	1^{o}	3^{o}		2^{o}	9	4	4
Deep Creek	Kalum	CWHws2	1^{o}				8	4	5
Alder Creek	North Coast	CWHvm1	90	10			9	5	7
Ain	QCI	CWHwh1	55	5		40	9	4	5
Bonanza	QCI	CWH	1^{o}		2^{o}	3^{o}	9	5	6
Ian	QCI	CWH	1^{o}			2^{o}	9		6
Datlaman	QCI	CWHwh1	1^{o}			2^{o}	9		6
Survey	QCI	CWH	1^{o}			2^{o}	9		6

*For some Kalum and Queen Charlotte Islands nests the exact percent forest cover is not known and leading species status has been substituted (primary, secondary, etc.).

Figure 1. Example of a high quality goshawk nest area stand, with high canopy closure and open fly-ways through the mid and lower canopy layers.

Figure 2. Example of a poor quality goshawk nest area stand, with low canopy closure and diverse vertical stand structure within all canopy and shrub layers.

Figure 3. High quality nest area habitat, identifiable here as the darker stands in the lower slope positions, is limited in extent and frequently constrained in linear distributions within the NCFD.

Post-fledging areas (PFAs) are the areas used by juveniles goshawks once they have fledged from the nest but before they disperse from the area. Habitat within the PFAs is usually dominated by mature forest, similar to the nest area, though may include a broader variety of habitats. Preliminary work estimated PFA sizes at 170 ha (Kennedy et al 1994) to 240 ha (IWMS 1999). Detailed work we have conducted in the ICH and SBS indicates that the area used by the juveniles is really much smaller (average size = 17 ha) and appears to be inclusive within our definition of a nest area (Mahon and Doyle, in prep.). Based on this PFAs were not modeled as a separate territory component in this project.

The foraging area is the entire area used by the adults. Sizes for the foraging area during the breeding season range from 1500 ha (Bright-Smith and Mannan 1994) to 4000 ha (Doyle and Smith 1994) with a median size of approximately 2400 ha. No information is available on goshawk foraging habitat requirements specific to the North Coast. However, studies conducted in west-central British Columbia (Doyle and Mahon 2001, Mahon and Doyle 2001), on Vancouver and Queen Charlotte Islands (McClaren 2001; Chytyk and Dhanwant 1999, respectively), and in southeast Alaska (Iverson et al. 1996, Lewis 2001), all show that the goshawk diet is dominated by prey associated with mature forest (red squirrels, forest grouse and passerines). In addition, the two studies that have conducted radio telemetry studies on goshawk home range movement patterns on the coast (Iverson *et al*. 1996, McClaren 1999), both show that goshawks select mature forest habitat preferentially to its availability in the landscape. In other areas three studies confirm selection of mature forest for foraging by goshawks through intensive radio monitoring (Beier and Drennan 1997, Good 1998, Stephens 2001). These observations are further supported by goshawk studies throughout North America (Austin 1993, Doyle and Smith 1994, Beier and Drennan 1997, Squires and Reynolds 1997, Good 1998, Stephens 2001) and Europe (Widen 1989).

On a coarse landscape scale the above studies found foraging goshawks to select mature/old growth sites. Within this broad characterisation of foraging area, studies on prey abundance indicate that goshawks do not necessarily forage in areas where prey is most abundant (Beier and Drennan 1997, Good 1998, Stephens 2001), but rather in areas where prey is most available (Reynolds et al. 1982). This favours hunting primarily in mature/old growth forest areas with high canopy closure, and a clear understory, a habitat that allows goshawks to move freely under the canopy, allows good visibility of its prey and also provides ample perches from which it hunts (Squires and Reynolds 1997).

HABITAT SUITABILITY MODEL APPLICABILITY

Species: Northern Goshawk (Accipiter gentilis atricapillus)

Territory Components Considered: Nest Area and Foraging Area

Season: Models are applicable to the breeding season which lasts from mid February to late August (Squires and Reynolds 1997).

Geographic Coverage: North Coast Forest District

Habitat Types Covered: These models cover all forested and non-forested areas within the North Coast Forest District. Biogeoclimatic zones in the area include CWH, MH, and AT (Banner et al. 1993).

HABITAT SUITABILITY MODEL DESCRIPTIONS

Nest Area Habitat Variables

Stand Height

The structural maturity of a stand, and trees within a stand, form the fundamental basis for nesting suitability for goshawks. Individual trees must have large enough branches to support the nest structure. Suitable stands will have progressed through the self-thinning stage and be tall enough to provide open fly ways below the main canopy layer. "Structural Stage" (as classified in: BC Ministry of Environment, Lands and Parks and BC Ministry of Forests 1998) would probably provide the best scheme for categorizing this habitat variable, however it is not directly available in the existing inventory information. As a surrogate to structural stage we use stand height, or more specifically, projected stand height class. Initially we planned to use projected stand height, however, limited ground truthing indicated that the accuracy and precision of this data in the forest cover database was poor and that confidence in the data was no better than the projected height classes. Nesting suitability for the different projected height classes are provided below.

Height Class	Height (m)	Rating
1	0-10.4	0.1
2	10.5-19.4	0.4
3	19.5-28.4	.75
=>4	>28.4	1

In other Forest Districts we preferentially use projected age class to identify suitable mature forest structure. In the NCFD age class appeared to have frequent errors in the database and had poorer correlation to mature forest structure than height.

Canopy closure

After the fundamental requirement of a 'mature' forest stage, canopy closure is probably the single most important structural variable relating to nest area suitability. Virtually every study examining goshawk nest areas identifies canopy closure as a key attribute. Stands <30% canopy closure are generally too open for nesting. Optimal values, as represented from our observed sample of nest areas, are 45-70%. Corresponding suitability ratings for the canopy closure classes available in the forest cover database are provided below.

Canopy Closure Class	Canopy Closure %	Rating
0-1	0-15	0
2	16-25	0.2
3	26-35	0.4
4	36-45	0.8
5-7	46-75	1
8-9	>75	0.8

Tree Species

All known nest areas in the CWH in the Skeena Region are in hemlock leading stands. Suitability ratings in the following table are based on the associations of secondary species observed at nest areas. Suitability depends on the form and structure of the trees and the stands they make up, and can therefore vary with site and age. Hemlock seem to be preferred because they often form even-aged stands with closed canopies and open understories, and the branching pattern creates good nest platforms. Other species such as spruce and fir tend to have more broken canopies, greater vertical stand structure (with less open understories) and poorer branch structures for nests. Yellow cedar stands offer the lowest suitability due to tree form and the heterogeneous structure associated with stands it dominates.

Species	Rating
Yc	0.3
Cw	0.7
Pl	0.7
Ac, At, Ep	0.5
Ss, Sx, S	0.8
Ba, B	0.8
Dr	0.8
Hw,Hm, H	1

Overall stand forest type suitability ratings are calculated by multiplying the species rating by its percentage composition and summing the individual species ratings for all types in the stand.

E.g. $H_{70}B_{20}S_{10}$=.7(1)+.2(.8)+.1(.8)=0.93

Edges

Data from a sample of > 60 nest areas in the Kispiox, Lakes and Morice Districts indicates that goshawks tend to avoid locating nests near forest edges. Avoidance was relatively weak 50-100m from an edge but strong 0-50m from an edge. This pattern of selection was noted for what we defined as 'hard' edges. Hard edges occurred where mature forest met non-forested or early seral habitats and the difference in height was >10m. Hard edges occur around regenerating cutblocks, roads, human settlement/development, swamps, swamp forest, wetlands, brush patches, lakes, rivers and ocean.

Edge Distance (m)	Rating
0-50	0.4
50-100	0.8
>100	1
0-100 blended*	0.7

*Due to computational limitations the digital resolution of the GIS analysis may only be done at 100m pixel size. If this occurs a blended rating of 0.7 should be used in the model.

Several other variables were considered for the Nest Area model including slope, aspect, and site series, however these were not strong predictors from the sample of known nest areas and were therefore not included in the model.

Nest Area Habitat Suitability Model Equation

This nest area model follows a limiting factor, non-compensatory approach. From an ecological perspective this means that when the suitability rating of one variable decreases below its optimal range it decreases the overall suitability by that amount. Further, suboptimal ratings in two or more variables are combined, through a multiplicative function, to decrease the overall value. The function is non-compensatory in that the value

of one variable cannot compensate for a deficiency in another. The equation used to calculate the suitability ratings is:

Nest Area Suitability = Ht Cl Rating **x Can. Cl.** Rating **x Tree Sp.** rating **x Edge** Rating

Ratings resulting from this model are relative in nature. Due to over-riding demographic factors (population density and territory spacing) these ratings cannot be used to predict numbers of goshawks across the landscape.

Ratings can be categorized within a 4-class system for map themeing:

Ratings	Class
0-.249	Nil
.25-.499	Low
.5-.749	Moderate
>=.75	High

Based on our experience with a similar model and observed nest area habitat variation in the CWH in the Kispiox District we estimate that approximately 80-90% of observed nest areas would have a rating ≥0.75, 10-20% would have a rating of 0.50-0.75, and 0-5% would have a rating <0.50.

Foraging Area Habitat Variables

Height Class

Similar to the nest area model, though to a less dependent degree, mature forest habitats are the primary habitats goshawks forage in and we use projected height class to capture that requisite. Stands with height >37.4 m are expected to correspond to old growth characteristics that will provide the maximum biomass of available prey such as red squirrels, woodpeckers, jays and thrushes. Stands in lower height classes 4 and 3, are expected to have a mature forest structure with lower prey abundance and availability. Below height class 3, prey availability is assumed to greatly reduced due to high stem densities and thick foliage within the shrub and canopy layers.

Height Class	Height (m)	Rating
> 4	>37.4	20
4	28.5-37.4	15
3	19.5-28.4	10
< 3	<19.5	5

Age Class

In the Foraging Area model we also use projected age class as a correlate to structural stage. While still recognizing the problems with the age class variable discussed with the nest area model, we have chosen to include it as a variable in the Foraging Area model because the different model structure is less sensitive to errors. By including both age and height class we recognize them as being strongly correlated and the weighting they

influence on the model. Similar to height class we expect age class to approximate structural stage and have derived ratings based on the same rationale explained above for height class (Age class 8&9 ≈ old growth, 6&7 ≈ mature forest, 4&5 ≈ young forest, <4 ≈ herb/shrub – young forest.

Age Class	Age (years)	Rating
8 & 9	>140	20
6 & 7	101-140	15
4 & 5	61-100	10
< 4	<61	5

Canopy Closure

Moderate to high canopy closure tends to correlate to open understories which goshawks use as flyways while hunting. Stands with lower or higher canopy closures receive reduced ratings.

Crown Closure	Rating
5, 6, 7	20
4	15
3, 8	5
1, 2, 9	1

Elevation

Empirical telemetry data from Iverson *et al.* (1996) indicates that goshawks foraged less at higher elevations. 800m elevation corresponds to the transition between subalpine and alpine areas over most of the NCFD. In some areas alpine is an important foraging habitat to goshawks and alpine prey can contribute significantly to the diet (Doyle and Smith 1994). However, in this region the typical alpine prey is either absent (ground squirrels) (Banfield 1974), or at too low of an abundance to contributes significantly to the diet (ptarmigan) (Doyle and Mahon 2001, Lewis 2001).

Elevation	Rating
0 – 800m	10
> 800m	5

Slope

On the North Coast, lower gradient slopes are given a higher rating, as these are typically richer sites producing larger trees and are associated with higher prey densities. Steeper slopes may also have lower availability associated with them. Similar to elevation this factor is weighted lightly in the model.

Slope (%)	Rating
< 35	5
35 – 70	3
> 70	1

Shoreline

Headlands and fiords heavily bisect the North Coast FD and as a result much of the area is relatively close to the shore. In SE Alaska, which has a similar coastline, radio telemetry of foraging goshawks indicated that areas <300m from the shore were used significantly more than their availability (Iverson et al. 1996). Goshawks appear to use the forest edge as cover as they hunt the rich diversity of prey (northwestern crow, alcids, gulls, ducks) that are available along the shoreline, and which are common prey of goshawks in these areas (Lewis 2001). Consequently, areas < 300m from shore receive a higher habitat rating.

Distance from Shoreline (saltwater)	Rating
<=300	10
>300	0

Non-Productive & Non-Forested Habitats

Many non-forested habitats occur in the NCFD that may be used by goshawks to forage. Examples of these include wetlands, non-productive brush patches and alpine. While these habitats types may contribute significantly to goshawk prey in other areas (e.g. alpine areas discussed above) we are not aware of any situations in the NCFD where significant prey occur in these types to warrant a significant rating. Therefore, all polygons with a non-productive or non-forest descriptor should be rated according to the following general categories. For NP types and any other possible types that could overlap with the forested criteria above, the highest rating of either the additive model below or the rating of 25 from the following table should apply.

Type	Rating
All except below	25
R,GR,SAND,CL,L, G,RIV,U,	0

Foraging Area Habitat Suitability Model Equation

This foraging area model follows an additive, compensatory approach. From an ecological perspective this means that the suitability rating of multiple variables combine, through an additive function, to improve the overall rating of the habitat. This model is compensatory in that the value of any one variable does not uniquely affect the resulting rating and high values in one variable can compensate for low rating in another.

Foraging Area Suitability = Ht Cl rating **+ Age Cl.** rating**+ Can. Cl.** Rating **+ Elevation** rating **+ Slope** rating **+ Shoreline** rating

or

Foraging Area Suitability = Non-Productive/Non-Forested Habitat rating

Whichever is higher.

Ratings can be normalized on a scale between 0 and 1 and categorized within a 4-class system for map themeing:

Original Ratings	Normalized Ratings (0-1)	Normalized Ratings (0-1)	Class
<21	<0.266	<0.245	Nil
21 - 40	0.266-0.546	0.246-0.471	Low
41 - 64	0.546-0.866	0.472-.764	Moderate
>=65	≥0.867	0.765	High

Core Territory Model and Equation

Forested habitats within the NCFD are constrained between alpine and ocean in a highly linear distribution, resulting from the geographic pattern of mountains and fjords that dominate the landscape. This situation results in isolated and fragmented nest area and foraging area habitat relative to goshawk territory sizes. For example, a forest stand with a Nest Area Habitat Suitability rating of 0.9 that is at the back end of a valley surrounded by alpine has a much lower probability of being used than a similar stand in a low elevation stand surrounded by other mature forest stands. Fragmentation and isolation of goshawk habitat may also be greatly increased by forest development activities within this linear landscape. The "core territory" model attempts to quantify this level of stand isolation by modifying nest area suitability with the quality of foraging area habitat surrounding the nest area.

The first step of the territory model is to create a 'smoothed' Average Foraging Area layer. This process involves taking the average foraging area rating for a defined "window" (in this case equivalent to a foraging area size of 2400 ha) and applying it to a central pixel. The application is performed for every pixel in the study area resulting in a smoothed Average Foraging Area layer. Features that are not used by goshawks, such as lakes and ocean, were given a null value and not included in the moving window average.

The Core Territory rating was then calculated by combining the Average Foraging Area rating and the Nest Area rating following the equation:

Core Territory Suitability = Nest Area Suitability x Average Foraging Area Suitability

This model structure corresponds to a limiting factor approach, where Nest Area suitability is modified by the 2400ha Average Foraging Area suitability rating. Based on a review of the distribution of model results from the base case condition, the Core Territory ratings can be classified into a 4 class system according to the following table.

Core Territory Rating	Class
<.279	Very Low
.28-.379	Low
.38-.479	Moderate
>0.48	High

MODEL APPLICATIONS AND LIMITATIONS

Again, we emphasize the output of these models are relative habitat ratings suitable for comparisons across the NCFD area and for comparing habitat supply under different management scenarios. The ratings do not correspond to absolute numbers of goshawks or territories.

All models and component ratings are designed specifically for the NCFD and we strongly caution against the application of these models to areas outside of the NCFD without refinement of the models and component ratings to the conditions specific to those other areas.

The Nest Area model should provide an accurate prediction of suitability at the stand level, but cannot predict probability of use because demographic factors such as territory size and spacing play an over-riding role (i.e. once a Nest Area is established other stands within the territory are not likely to be used regardless of their suitability). Although only one goshawk nest area has been described in the NCFD, our level of confidence in the Nest Area model is relatively high based on a larger sample of nest areas in adjacent areas, and the structural similarity of forests in those areas to the NCFD.

The Foraging Area model is less sensitive to behavioral isolation of habitats and does represent a rough index of probability of use by goshawks. However, our overall confidence in the Foraging model is significantly lower than for the Nest Area model for several reasons. First, the Foraging Area model is really a multi-species prey abundance + prey availability model + goshawk use model. As such, it is a very general model that attempts to provide the best components and average component ratings for several factors, and in doing, loses specificity and accuracy with respect to any individual factor. Second, no local empirical data was available to support the assumptions built into the model. Third, prey abundance, prey composition and prey availability are known to vary considerably over time.

HABITAT SUPPLY ANALYSIS

Scale of Analysis

We recommend that habitat supply analysis should be conducted at two scales, the territory scale and Landscape Unit scale. Goshawk pairs are spaced relatively regularly through suitable habitat within a landscape. Habitat supply analysis is required at the territory scale in order to evaluate the distribution of habitat with respect to spacing pattern of the species.

Territory Scale Habitat Supply Analysis

Territory Polygon Delineation

Theoretical territory polygons were located randomly across the NCFD landbase using a territory algorithm implemented in SELES(Fall and Fall, 2001) according to the following rules:

Size: 4000m radius (~5000ha) corresponds to territory spacing distances observed on Vancouver Island (McClaren 2001).

Shape: Generally the territories should be circular. Ellipses with length x width ratios as large as 4:3 may be allowed to account for the linear nature of the NC landscape.

Start Locations: Territories should initially be seeded at lower elevations; this could employ either a BEC zone or elevation constraint. Territory centres must be on a forest site (i.e. not NP, NF types)

Territory Composition: Maximum 20% ocean allowed; maximum 15% river; maximum 40% alpine allowed. If a potential territory exceeds any of these criteria it should be dropped and re-seeded in new location. For the water limits, we are trying to avoid territories straddling inlets or the lower Skeena River >~1km in width. If the current limits do not achieve this objective, adjust as required.

Territory Overlap: up to **10**% overlap of adjacent polygons allowed (10% with each adjacent territory)

Optimization: Territory location (and orientation) should be random but any additional rules that can maximize the landbase covered by territory polygons should be used. If this requires some non-random rules or different seeding approach, then maybe we should do that as a fixed, reference territory coverage, in addition to random runs.

Sensitivity/Variation Assessment: To quantify the sensitivity and variation of the query results with respect to territory location, multiple runs (Monte Carlo sim) of the randomly seeded territory coverage should be conducted. (3 or 5 runs on the base case right now?) Don or Andrew should have a better sense of number of runs.

Manual Territory Option: If it is too onerous to generate territory polygons through SELES I could do it manually in about half a day.

Indicator Variables:

For each theoretical territory polygon the following information is to be reported

1) area weighted average (∑(polygon rating x polygon size)/size of study area)of
   a) nest area suitability,
   b) foraging area suitability
   c) core territory suitability
   To provide finer resolution to habitat supply analysis with respect to Nest Area suitability and Core Territory suitability we recommend that alpine areas and water be netted out of the relevant study area sizes when calculating area weighted averages. The reason for this is twofold. First, these areas do not contribute to potential nest areas, and second, they constitute a large enough portion of the NCFD that their inclusion will result in a dilution effect.

2) amount of area within each of the four suitability classes for
   a) nest area
   b) foraging area
   c) core territory

3) Average size of
   a) High value nest area polygons
   b) High value core territory polygons

4) area of:
   a) road edge,
   b) hard edge (from Nest Area model)
   c) protected areas,
   d) water (ocean, river, lakes),
   e) A+AF,
   f) other NF+NP,
   g) logged <30 years.
   h) of area of THLB

5) for each territory centre report
   a) BEC subzone,
   b) elevation,
   c) landscape unit

Territory Occupancy Criteria

In addition to assessment of the absolute values for the indicators listed above, habitat supply will be assessed under different management scenarios based on potential occupancy of the theoretical territories as outlined below.

Table 2. Threshold limits for potential occupancy of theoretical goshawk territories.

Potential Occupancy	Nest Area Condition*	Foraging Area Condition*	Core Territory Condition*
Unlikely	**<60 ha of High NA**	Average FA <0.36	**<60 ha of High CT**
Low	**60 ha of High NA**	Average FA >0.36	**60 ha of High CT**
Moderate	240 ha of High NA	Average FA >0.43	240 ha of High CT
High	480 ha of High NA	Average FA >0.50	480 ha of High CT

*Thresholds may be refined based on the results from the analysis of the current state scenario.

Table 3. Rationale for thresholds limits for potential occupancy of theoretical goshawk territories for nest area habitat suitability.

Potential Occupancy	Condition	Rationale
High	480 ha of High NA	Corresponds to 20% of 2400ha breeding HR*
Moderate	240 ha of High NA	Corresponds to 10% of 2400ha breeding HR
Low	60 ha of High NA	Meets basic requirement of 1 used and 1 alternate nest area, however occupation at this theoretical minimum requirement is rarely observed
Unlikely	**<60 ha of High NA**	Does not meet minimum nesting habitat requirement

*2400ha is the average breeding home range size which is used here as a subcomponent of the overall territory

Table 4. Rationale for thresholds limits for potential occupancy of theoretical goshawk territories for foraging area habitat suitability.

Potential Occupancy	Condition	Rationale
High	Average FA >0.50	Corresponds to equivalent of at least 1440ha high quality FA (60% of 2400ha breeding HR)
Moderate	Average FA >0.43	Corresponds to equivalent of at least 960ha high quality FA (40% of 2400ha breeding HR)
Low	Average FA >0.36	Corresponds to equivalent of at least 480ha high quality FA (20% of 2400ha breeding HR)
Unlikely	Average FA <0.36	Corresponds to less than 20% high quality FA within 2400ha breeding HR

Table 5. Rationale for thresholds limits for potential occupancy of theoretical goshawk territories for core territory suitability.

Potential Occupancy	**Condition**	**Rationale**
High	480 ha of High CT	Corresponds to 20% of 2400ha breeding HR
Moderate	240 ha of High CT	Corresponds to 10% of 2400ha breeding HR
Low	60 ha of High CT	Meets basic requirement of 1 used and 1 alternate nest area, however occupation at this theoretical minimum requirement is rarely observed
Unlikely	<60 ha of High CT	Does not meet minimum nesting habitat requirement

Landscape Unit Scale Habitat Supply Analysis

In addition to the territory scale analysis it may be useful to summarize habitat supply at the Landscape Unit scale, although this will not capture the issue of

Indicator Variables

1) area weighted average (∑(polygon rating x polygon size)/size of study area)of the following within each BEC zone:
   a) nest area suitability,
   b) foraging area suitability
   c) core territory suitability
   To provide finer resolution to habitat supply analysis with respect to Nest Area suitability and Core Territory suitability we recommend that alpine areas and water be netted out of the relevant study area sizes when calculating area weighted averages. The reason for this is twofold. First, these areas do not contribute to potential nest areas, and second, they constitute a large enough portion of the NCFD that their inclusion will result in a dilution effect.

2) amount of area within each of the four suitability classes for the following within each BEC zone:
   a) nest area
   b) foraging area
   c) core territory

3) Average size of the following within each BEC zone
   a) High value nest area polygons
   b) High value core territory polygons

4) area of the following within each BEC zone:
   a) road edge,
   b) hard edge (from Nest Area model)
   c) protected areas,
   d) water (ocean, river, lakes),

e) A+AF,
f) other NF+NP,
g) logged <30 years.
h) of area of THLB

POTENTIAL LRMP SCENARIO EXPERIMENTS

The following scenarios are potential experiments to assess the relationship between goshawk habitat supply and forest management.

1) Assess the potential impacts to timber supply of maintaining threshold conditions for occupancy of specified percentages of the theoretical territories. The target number(s) of occupied territories should be developed in conjunction with an assessment of how many territories meet threshold occupancy thresholds under the current state. Target numbers may include the current state number, and 50%, 75%, and 125% of the current state number. Assessment should consider Low, Moderate and High potential occupancy thresholds.
2) Assess changes to habitat suitability and potential occupancy of theoretical territories based on harvest method (clearcutting, variable retention, partial cutting)
3) Assess changes to habitat suitability and potential occupancy of theoretical territories based on harvest rotation (60, 140, 200 years)

ARC INFO PROGRAMING HISTORY

Nesting Area Suitability
The North Coast LRMP nesting area suitability model was originally captured by J. Warren (2001) in the program hsi_nogo_nc_nesting.aml for the forested attributes and by A. Waterhouse (2002) for edge effects. These programs were updated to run in raster and drafted into an updated version of the nesting program hsi_nogo_nc_nesting.aml (D. Morgan, December 20, 2002).

Forage Area Habitat Suitability
The North Coast LRMP forage area habitat suitability model was originally captured by J. Warren (2001) in the program hsi_define_ranks_nc_nogo.aml and by A. Waterhouse (2002) for shoreline and non-forested effects in shoreline.aml. The programs were updated to align the grids and to incorporate changes made to the nesting model algorithm (hsi_nogo_nc_forage.aml, D. Morgan, December 20, 2002).

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