EXTENSIVE SURVEY AND EVALUATION OF A PREDICTIVE HABITAT MODEL FOR THE FLAMMULATED OWL (*OTUS FLAMMEOLUS*) IN THE KAMLOOPS FOREST DISTRICT

Prepared for
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and North Thompson Indian Band

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Abstract

An extensive Flammulated owl (*Otus flammeolus*) survey, guided by a GIS-based predictive habitat model, was conducted throughout the Kamloops Forest District during May and June of 1998. The main goals of this survey were to further delineate the distribution of Flammulated owls in the District, to test the habitat model's ability to predict the occurrence of Flammulated owls and to differentiate between different habitat classes (high, medium, low and nil habitat classes) described by the model on the basis of numerous stand structure attributes.

During 25 nights of surveys, 337 Flammulated owls were detected at a total of 340 survey stations. Flammulated owls were found to be more or less evenly distributed within the District with the exception of one area: few birds were located in the northeast portion of the area surveyed. Relative abundance of Flammulated owls at survey stations was not correlated to average habitat values surrounding each survey station as determined by the predictive habitat model. Stand structure and habitat parameters measured were for the most part not significantly different between habitat classes. These results suggested that the current Flammulated owl predictive habitat model requires adjustment. Modifications to the model are recommended. These include re-evaluation of the use of some habitat variables, addition of other variables, and modification to the step down procedure.

Acknowledgments

We would like to thank Charlene Higgins, South Thompson Tribal Council, for her confidence in our ability to bring this project to successful completion. We would also like to thank Tina Donald, North Thompson Indian Band (NTIB), for administering the contract and providing us with two extremely competent field assistants. Special thanks to Dwayne Eustache and Clint Donald (NTIB) for their invaluable work during the project. We would also like to thank Vanessa Craig for her assistance in data collection. Cascadia Natural Resources Management Inc. were cooperative in coordinating a parallel project in the Merritt Forest District. They also provided GIS support throughout the project. We are grateful to John Surgenor, Michael Burwash, Rick Howie, and Dave Low, (Ministry of Environment, Lands and Parks) for their interest, input and support during this project. Alan Norquay (Ministry of Environment, Lands and Parks) provided us with exceptional help with respect to the proper use of GPS equipment both in Kamloops and Vancouver. Fred Bunnell (UBC), Bob MacDonald, Dave Huggard (Ministry of Forests) and Gordon Lester (J.S. Thrower Ltd.) provided us with valuable input. This study was made possible through funding from Forest Renewal BC.

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Introduction

The Flammulated owl is a small forest-dwelling, insectivorous owl that is found in coniferous forests in western North America (McCallum 1994a, Reynolds and Linkart 1987). Prior to the early 1980s little was know about the distribution of this species in North America. In particular, prior to 1980 there were only 6 records of this species in B.C. (Howie and Ritchey 1987). Since then, extensive inventory and research projects throughout the species range have shown that this species is wide spread, and is often locally abundant (McCallum 1994b). The species is, however, considered to be a habitat specialist due to its association with specific forest types (open fir and pine forests; Howie and Ritchey 1987, Campbell et al. 1990, Reynolds and Linkart 1992, van Woudenberg 1998) and specific structural attributes (e.g., large live trees, vacated woodpecker cavities, open spaces between trees to promote habitat for phytophagus insects (McCallum 1994), and Douglas-fir thickets for security cover (van Woudenberg 1998), all of which are subject to modification by human land use such as logging, firewood cutting, forest fire suppression, and ranching. Decreases in the abundance of Flammulated owls have, in fact, been shown to be a result of forest harvesting and stand conversions (Marshall 1988, Franzreb and Ohmart 1978). One of this species' life history traits that is of concern regarding the management of habitat is its relatively low fecundity and unvarying fertility (i.e., superabundant food does not lead to increased fertility; McCallum 1994b). As a result, this species appears to lack the high fecundity to recover quickly from population declines caused by habitat alteration, which theoretically could then lead to local extirpation and potential extinction (McCallum 1994b). It is because of these factors the Flammulated owl is considered Blue-listed in British Columbia.

In B.C. this species has been found in numerous biogeoclimatic subzones including BGxh3, BGxw2, PPxh1, 2; IDFdk1, 2, 3, 4; IDFdm2; IDFxh1, 2; IDFxm, IDFxw, within the Williams Lake, 100 Mile, Kamloops, Merritt, Vernon, Lillooet, Pentiction, and Boundary Forest Districts (B.C. Conservation Data Centre 1998, Cannings and Booth 1997, Roberts and Matthewson 1997, van Woudenberg 1998, St. John 1991, Williams and Woodward 1989). Attempts to manage habitat for this species in BC have, for the most part, been haphazard. Recently, a computer model was designed to predict the presence of suitable Flammulated Owl habitat and is to be used in the management of this species throughout the Southern Interior. This model utilizes biogeoclimatic information, forest cover data, and TRIM data to predict potential Flammulated owl habitat (Christie 1998). The model uses a rating scheme to classify individual forest cover polygons as to their potential for supporting Flammulated owls. Initial ratings are based on the potential of specific biogeoclimatic subzones to support Flammulated owls. The rating scheme utilizes a secondary rating adjustment to initial habitat suitability ratings. Polygons are rated as either high, medium, low, or nil based on the effects of variables used in the model. The variables used in the model, and their effects on the rating of specific polygons "were valued based on field data, literature, and field experience working with the Flammulated owl" (Christie 1998).

This study was initiated to test the validity of this model. We tested this model in two ways: by conducting nocturnal owl surveys and by sampling forest stand structure in each of four Flammulated owl habitat suitability classes. Call playback surveys were conducted in the Kamloops Forest District (KFD) where survey routes were guided by the predictive model. Areas that contained large patches of different habitat classes were preferentially sampled in order to assess the occupancy rate of calling Flammulated owls.

Habitat data were collected in each of the four Flammulated owl habitat classes. These data were collected for two distinctive purposes. The first was to examine the variability of forest attribute data as they relate to variables deemed important from the model construction perspective (slope, aspect, crown closure, stand tree species make up). In addition, we also collected forest stand structure data in order to examine specific questions that pertain to variation in stand structure that is not implicit in forest cover data (e.g., stocking density of different diameter classes of trees).

Study Area

This study took place within the bounds of the KFD in south central British Columbia (Figure 1). This district has an area of approximately 1.3 million hectares covering a wide range of coarse landscape types. The North and South Thompson Rivers and their tributaries wind through the hot, dry grasslands that are characteristic of most of the relatively wide valleys. As elevation increases, the grassy slopes give way to forests of Ponderosa Pine (*Pinus ponderosae*) and interior Douglas-fir (*Pseudostuga menziesii* var. glauca). At greater elevations these species are replaced predominately by Lodgepole *Pine (Pinus contorta*) and Spruce (*Picea* spp.). Western Red Cedar (*Thuja plicata*) and Western Hemlock *(Tsuga heterophylla*) can be found in relatively great abundance at the higher elevations in some of the wetter eastern sections of the district. Biogeoclimatic zones within the district include Bunchgrass (BG), Ponderosa Pine (PP), Interior Douglas Fir (IDF), Montane Spruce (MS), Engelmann Spruce-Subalpine Fir (ESSF), Sub-Boreal Spruce (SBS), Sub-Boreal Pine Spruce (SBPS), Interior Cedar-Hemlock (ICH) and limited Alpine Tundra (AT).

Given the reported preference of Flammulated owls for mature Ponderosa Pine and Douglas-Fir forests (Howie and Ritcey 1987, Williams and Woodward 1989, van Woudenberg 1992, McCallum 1994a) this study concentrated on the PP and IDF zones of the district. Surveys were conducted in specific sub-areas that represented a wide range of habitat class values as derived by the predictive Flammulated owl habitat model developed in 1997/98 (Christie 1998).

Figure 1. Study area of 1998 Flammulated Owl survey in the Kamloops Forest District showing subarea boundaries

Methods

Owl surveys

Owl surveys were conducted throughout the KFD between May 15 and June 19, 1998. A total of 38 survey transects comprising 340 survey stations were completed in this time. Survey routes were distributed throughout the district to ensure wide geographic coverage. Furthermore, routes were selected in areas that represented a variety of habitat class values within a reasonable area such that the route could be easily completed within one or two nights. Initially we intended to sample only large coloured polygons (i.e. those polygons that could have accommodated several survey stations). However, due to problems in accessing sufficient numbers of large uniform polygons, we sampled areas that contained large blocks of a mosaic of habitat classes. In some cases survey routes could not be completed due to excessive creek or highway noise.

Call playback surveys were conducted along survey routes that were located during the afternoon and early evening of each survey night. Survey stations were situated along the survey routes at 500-m intervals. Only one visit was made to each calling station during the study. Surveys were conducted by 2 two-person teams traveling largely by vehicle from dusk to approximately 3 am. Surveys were only conducted on relatively calm nights and never during heavy rain. If specific survey stations (particularly chosen large uniform habitat class polygons) could not be accessed by vehicle these stations were visited on foot where possible. Once a survey team reached a survey station, they quietly set up equipment to prepare for the call playback procedure. Weather resistant portable cassette players (Panasonic model no. RQ-SW5) attached to compact speaker systems (Sony model no. SRS-T50) were used to broadcast calls. After set-up, five minutes were spent listening for spontaneously calling owls. If no Flammulated owls were detected within this period, Flammulated owl calls were broadcast for 30 seconds in three directions at 120° intervals. Calls in each direction were separated by 30-second pauses. After the call broadcasts were completed, an additional 5 minutes were spent listening for induced Flammulated owl calls. The time, species, estimated distance to calling owl and compass bearing to calling owl were recorded on standard data forms (see Appendix 1; Survey Description Form, and 2; Observation Record Form) for each owl detected. Additional direction and distance estimates for a subset of detected owls were recorded from other points (offsets) along the survey route in order to obtain triangulation estimates for these owl positions. For 48 of the detected Flammulated owls precise positions were obtained by walking in on calling owls and identifying the trees that they were calling from. Coordinates of all survey stations, offset locations and exact owl positions were recorded using hand-held Global Positioning System (GPS) receivers (Trimble Geo Explorer II).

Vegetation surveys

Twelve spatially separated areas were selected for vegetation sampling. Each selected area contained four different Flammulated Owl Habitat Value Class polygons (one in each of the High, Moderate, Low and Nil classes) that were sufficient in size to allow for the placement of three tree plots and one snag transect within them (dimensions for both are described below). The polygons that were large enough to accommodate this intensity of sampling within the selected areas were numbered and then one polygon of each Habitat Value Class was selected at random for sampling. Tree plots and snag transects were placed at random positions within sampling clusters or along transects within the selected polygons. Choice of randomization procedure depended on the geometry of the selected polygons. Sampling clusters were used in polygons that were relatively small and square or circular. In these cases a point near the center of the polygon was selected and 3 tree plots were located at random compass bearings and distances (between 50 and 200 m) from this point. Starting points for snag transects were located at a fourth point selected in the same manner. Sampling transects were used when selected polygons were more linear in nature (rectangular or elliptical) or large enough to accommodate a linear transect. In these cases a starting point within the polygon boundary was selected, a transect was laid out along the long axis, and tree and snag plots were placed at random distances (between 50 and 200 m) from each other along the transect. If randomly selected plots landed on roadways, the position of the plot was adjusted to avoid the roadway. Standard data forms were used to assist in data collection (Appendix 3, Tree Plot Description; Appendix 4, Tree Measurements; Appendix 5, Snag Plot Measurements).

Three circular tree plots of 12.6-m radius (0.05 ha) were used to assess stand structure and composition. Physical characteristics of each tree plot were assessed and recorded. These included: slope, aspect, slope macroposition, slope mesoposition, percent canopy closure (and canopy closure class), dominant and subdominant tree species (including relative contribution to crown closure), presence and coverage of thickets, presence and coverage of shrubs, presence and coverage of grass, evidence of forest management activities and evidence of fire. See Appendix 3 for more detailed descriptions of data categories.

Within tree plots all trees > 10 cm diameter at breast height (dbh) were measured and assessed (species, dbh to the nearest cm, height class, snag class, bark condition, woodpecker foraging sign, presence of nest cavities). The height of one or several trees representing the canopy height classes was measured. The age of one tree in the dominant layer was also determined by taking a core sample and counting the tree rings in the field. All trees < 10 cm dbh and greater than 1.3 m in height were tallied by species and were categorized as to whether they were alive or dead.

Linear transects were used to determine snag densities and other stand characteristics not accounted for in the tree plots. All snags greater than 30 cm dbh and all veteran trees within a 20x100-m transect (0.2 ha) were measured and recorded as per Appendix 4. In addition to these tree counts, presence, age and intensity of spruce budworm damage and cattle grazing was assessed within the transects. Finally, thicket area was assessed by measuring every patch of thicket within the transect area. Coordinates of all tree plot centers and the origin of snag transects were recorded using hand-held GPS receivers (Trimble Geo Explorer).

Analysis

Owl data

Using GPS data and through Geographical Information System (GIS) analysis, we calculated the total area of each Flammulated owl habitat class in the KFD. Using the same methods, we calculated the amount of each area we surveyed based on the makeup of each habitat class at each survey station (within a 250-m or 500-m radius of each calling station). We then calculated the proportion of each habitat class within the entire KFD that we actually sampled during the 1998 field season.

Differences in detection rates between geographical areas were tested using a non-parametric one-way analysis of variance (Kruskal-Wallis ANOVA). A follow-up one-way ANOVA and Tukey's HSD test was used to establish which subareas exhibited significantly different detection rates (statistical software used for all analyses is SPSS for Windows Ver. 8.0; SPSS Inc.).

To determine potential biases in our assessments of distances to calling owls, we compared our estimated distances to calling owls with actual distances (derived through GIS analysis of GPS data) using linear regression analysis. Only those data from Flammulated owl observations that were actually pinpointed by walking in to owls and had GPS positions with an acceptable accuracy were used for this analyses. Accuracy of GPS locations varied and actual owl distances derived from owl and survey station location estimates that had standard deviations (SD) in excess of 10 m were excluded from the analysis.

The area around each calling station typically consisted of various contributing habitat classes (Figure 2). To determine if owl numbers were influenced by the mosaic of habitats around survey stations, we calculated an 'average habitat value' for each calling station. To do this we calculated the area (m^2) of each habitat class within a 250-m and 500-m radius plots centered around survey stations using GIS analysis. The area of each habitat class within these circular plots was converted to proportions and was subsequently weighted by the appropriate factor as determined by the predictive model (High=3, Moderate=2, Low=1, Nil=0). The weighted values were then summed to determine an average habitat value for each survey station. We used 250-m and 500-m radius circles for three reasons: problems with pseudoreplication, small sample size (in terms of numbers of owls included in the analysis), and decreased accuracy of distance estimation for owls in excess of 300 m from plot center (see owl detection distance estimate analyses). Using 500 m radius circle to calculate an average habitat value results in a considerable amount of overlap of habitat from adjacent survey stations. In addition, there is also a high probability that the subsequent regression analysis would result in the double counting of owls from 2 adjacent survey stations (Figure 2). To minimize the problems of double counting and overlap of habitat from adjacent stations, we calculated average habitat values around a 250-m radius centered at survey stations. This analysis resulted in minimizing the chances in double counting owls, but it also reduced the number of owls that we included in the regression analysis because a proportion of owls were detected at distances greater that 250 m (a radius of 500 m incorporated 99% of the owls that were detected, whereas a radius of 250 m included only 62% of the owls encountered).

We then used regression analysis to explore the relationship between average habitat values and the number of owls estimated to be within 250 and 500 m from calling stations. We also performed Pearson correlation analysis between the area of individual habitat classes and owl numbers at each calling station to determine if any one habitat class was influencing the distribution of owl numbers.

Using the same procedure, average habitat values were also calculated for 250-m radius circles centered around Flammulated owl walk-in sites. Once again, only walk-in sites with an acceptable level of GPS location accuracy (SD within 10 m) were used in this analysis. Average habitat values were then divided into six equal habitat values classes (0-0.5, 0.51-1.00, 1.01-1.50, 1.51-2.00, 2.01-2.50, 2.51-3.00). We then plotted the proportion of owls in each habitat value class to determine if exact locations of Flammulated owls showed any tendency towards higher predicted habitat values.

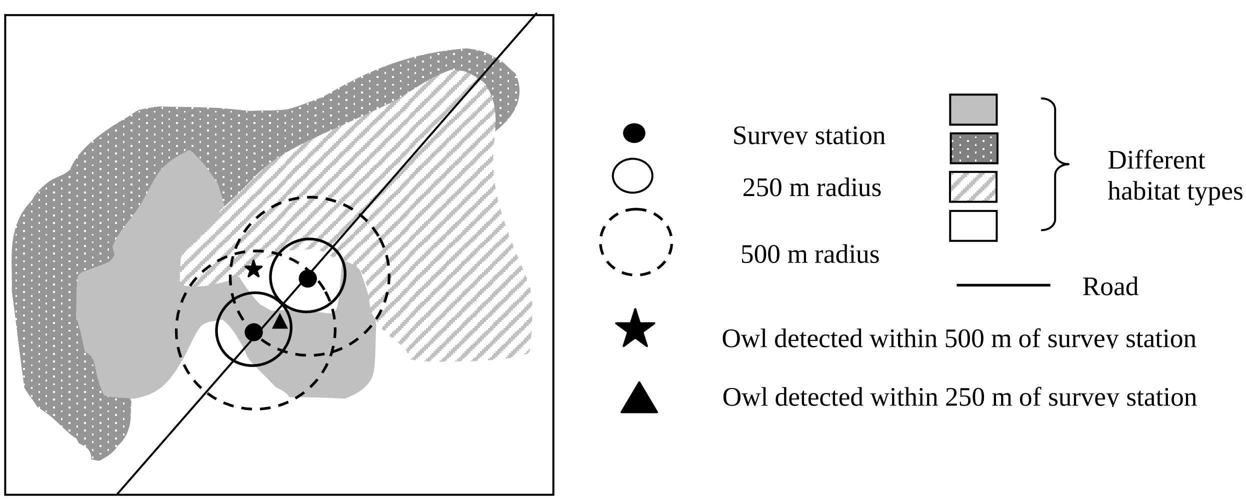


Figure 2 Diagrammatic representation of how average habitat values were calculated and rationalization of why 250 and 500 m radius circles around owl survey stations were chosen in the analysis.

Vegetation data

To examine the make-up of the overall stand in terms of overstory vegetation, we calculated and plotted the proportion of trees (>10 cm) by species in each habitat value class based on data derived from the 0.05 ha circular vegetation plots. In this summary deciduous tree species (Trembling aspen, *Populus tremuloides*, and Birch *Betula paperifera*) were combined and represented as hardwoods. We summarized and plotted mean stocking densities (stems/ha) of all live trees, live Douglas-firs, and Ponderosa pines by diameter class in each of the four habitat value classes.

Due to low numbers of snags within the 0.05 ha circular vegetation plots and the 0.2 ha snag transects, statistical comparisons of stocking densities of different diameters and specific physical characteristics of snags (e.g., decay classes) could not be completed between habitat value classes. For this reason, density of snags was summarized by their characteristics for all 0.05 ha and 0.2 ha plots in order to estimate availability of suitable nesting structures at a landscape level.

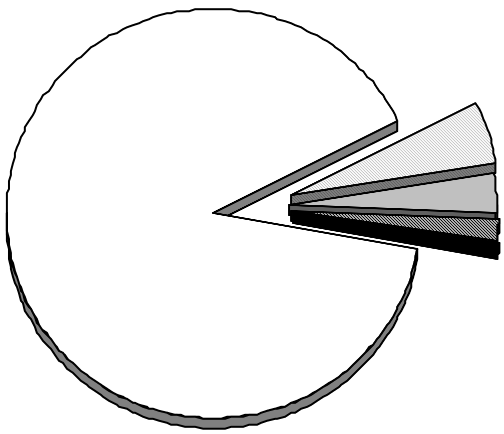
Due to numerous violations in the assumption of homogeneity of variance, we used Kruskal-Wallis ANOVAs to examine potential differences between the four habitat classes in the following habitat variables: arcsine transformed percent cover of shrubs, grasses, and canopy closure, and the stocking density (stems/ha) of: all trees, small trees (<10 cm dbh); large trees (> 10 cm dbh), and large live conifers and large dead conifers (> 30 cm dbh). We also used non-parametric ANOVAs to examine the number of thickets and the area that they covered (m^2) along snag transects. To examine these data using a more powerful method of analysis, we also performed the same analyses using one-way ANOVAs (ANOVAs tend to be relatively robust to violations in the assumption of homogeneous variance). These analyses yielded the same results, and are reported only where a significant habitat class effect was evident. Where habitat class effects were significant, Tukey's HSD multiple comparison test was used to determine where differences occurred.

Results

Owl surveys

Of the landbase available in the KFD (approximately 1.32 million ha), 90% (1.18 million ha) was classified as having "nil" habitat value for Flammulated owls according to the predictive habitat model developed by Christie (1998). Low, medium, and high potential Flammulated owl habitat represented 3%, 2% and 0.4% of the landbase, respectively (Figure 3). The total area that was surveyed during this project (based on an assessment of an area 500 m in diameter around each calling station; approximately 19,000 ha), consisted of 52 % nil, 23% low, 20% moderate, and 5% high quality habitat. In terms of proportions, this represents 6% of the total nil area in the KFD, 11% of the low, 17% of the moderate, and 18 % of the high quality habitat (Figure 3).

Area of Each Habitat suitability Class within the Kamloops Forest District



FLOW Habitat Rating	Area (ha)	(%)
Nil	1,180,252	89.7
Control	65,897	5.0
Low	41,230	3.1
Moderate	22,770	1.7
High	5,743	0.4
TOTAL	1,315,892	

Area Surveyed

FLOW Habitat Rating	Area (ha)	(%)	Proportion of Habitat Rating Class Surveyed (%)
Nil	6,205	32.7	0.5
Control	3,533	18.6	5.4
Low	4,430	23.4	10.7
Moderate	3,778	19.9	16.6
High	1,009	5.3	17.6
TOTAL	18,955		1.4

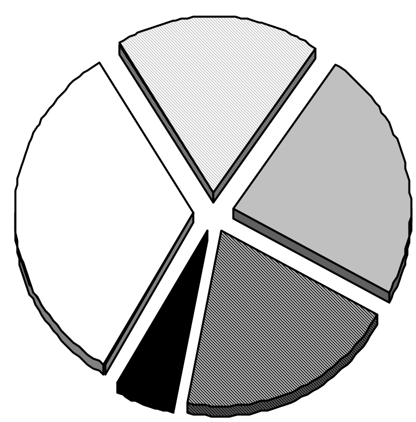


Figure 3. Summary of extent of survey in relation to habitat classes and proportion of each area surveyed during the 1998 Flammulated owl survey in the Kamloops Forest District. Areas are approximations limited by GPS accuracy.

During 25 nights of surveys a total of 337 Flammulated owls were detected at 340 survey stations. This represented an average of 0.99±0.06 owls/calling station and 1.6 owls/100 ha (based on 337 owls being detected in approximately 19,000 ha surveyed). The number of owls at each calling station ranged from 0-5 owls (Table 1). In addition, a total of 4 Great-horned (*Bubo virginianus*), 5 Northern Saw-whet owls (*Aegolius acadicus*), 17 Barred owls (*Strix varia*) and 15 Poorwills (*Phalaenoptilus nuttalii*) were detected during our surveys.

Although the detection rate of Flammulated owls was relatively even across most district subareas (A,B,C,E; Figure 1), it was considerably lower in area D relative to all others (Table 1, Kruskal-Wallis ANOVA: χ^2=60.6, P<0.001; one-way ANOVA: $F_{4,335}$=13.3, P<0.001). Only 11 owls were detected at a total of 54 stations in area D and no owls were detected at almost 90% of the stations surveyed there. In contrast, the other subareas had zero detections at only 25-35% of the stations surveyed.

Table 1. Summary of owl numbers detected at individual survey stations and average detection rates for five geographical areas surveyed in the Kamloops Forest District during 1998.

Flammulated owl detection density at individual survey stations						
Number of Flammulated owls detected at each station	Number of stations in each subarea (% in Brackets)					
	A	B	C	D	E	All
0	24 (24)	17 (35)	11 (37)	48 (89)	28 (25)	128 (38)
1	40 (41)	19 (40)	11 (37)	4 (7)	52 (47)	126 (37)
2	20 (20)	6 (13)	6 (20)	1 (2)	22 (20)	55 (16)
3	10 (10)	6 (13)	2 (7)	1 (2)	7 (6)	26 (8)
4	1 (1)				1 (1)	2 (1)
5	3 (3)					3 (1)
Total # of Stations	98	48	30	54	110	340
Flammulated owl detection rates (owls/survey station)						
	Overall detection rate in each subarea					
	A	B	C	D	E	All
Mean	1.31	1.02	0.97	0.17	1.10	0.99
SE	0.12	0.14	0.17	0.07	0.08	0.06

A significant positive correlation was found between actual and estimated distance to calling owls (Figure 4). The slope of the relationship is, however, less than one indicating that estimated distances tend to be lower than actual distances. Furthermore, as distance to calling owls increases, our ability to accurately estimate distance to calling owls decreases (Figure 5). In particular, as actual distance exceeds 300 m, our estimates of distance become very inaccurate.

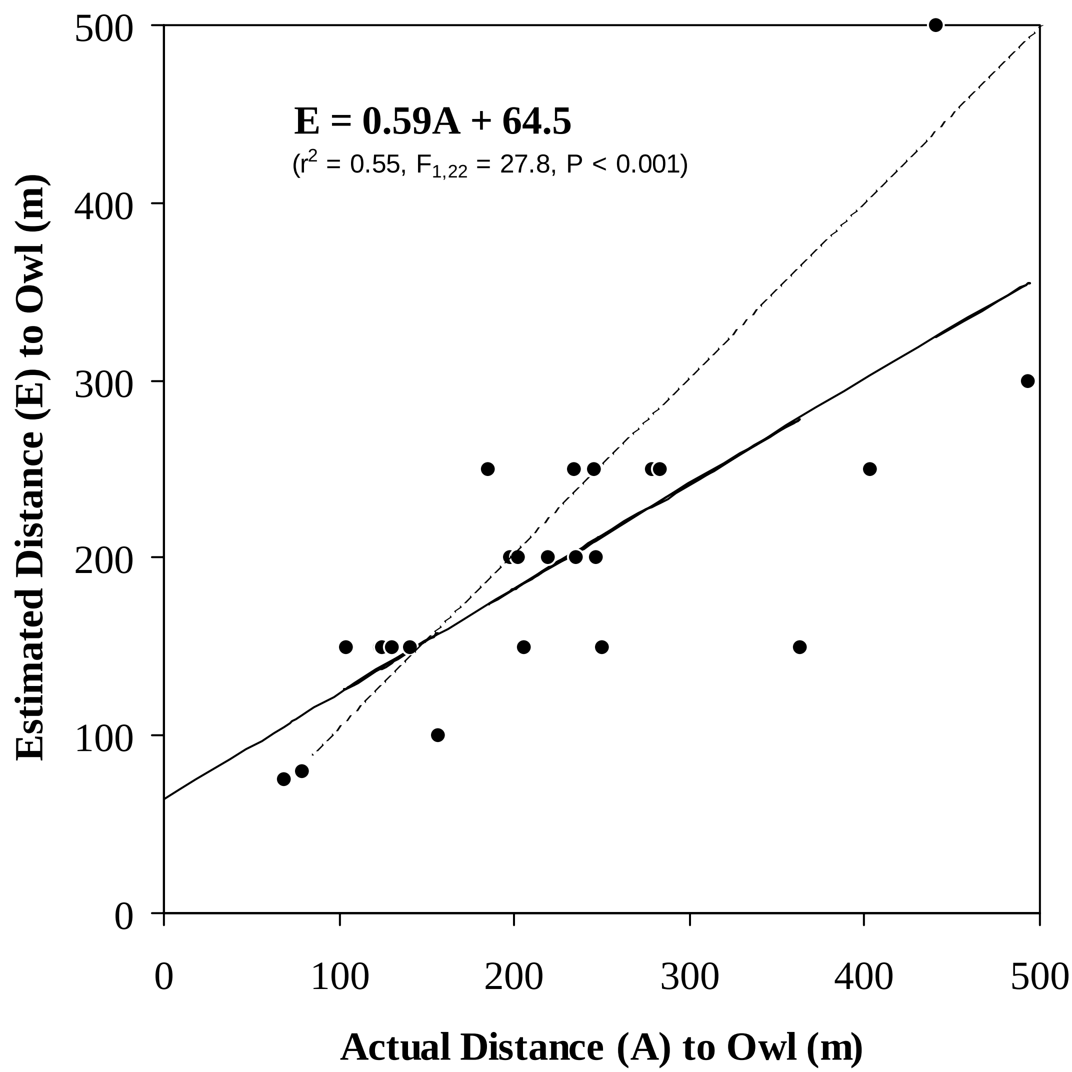


Figure 4. Relationship between estimated and actual owl distances for 24 Flammulated owls detected in the Kamloops Forest District during 1998.

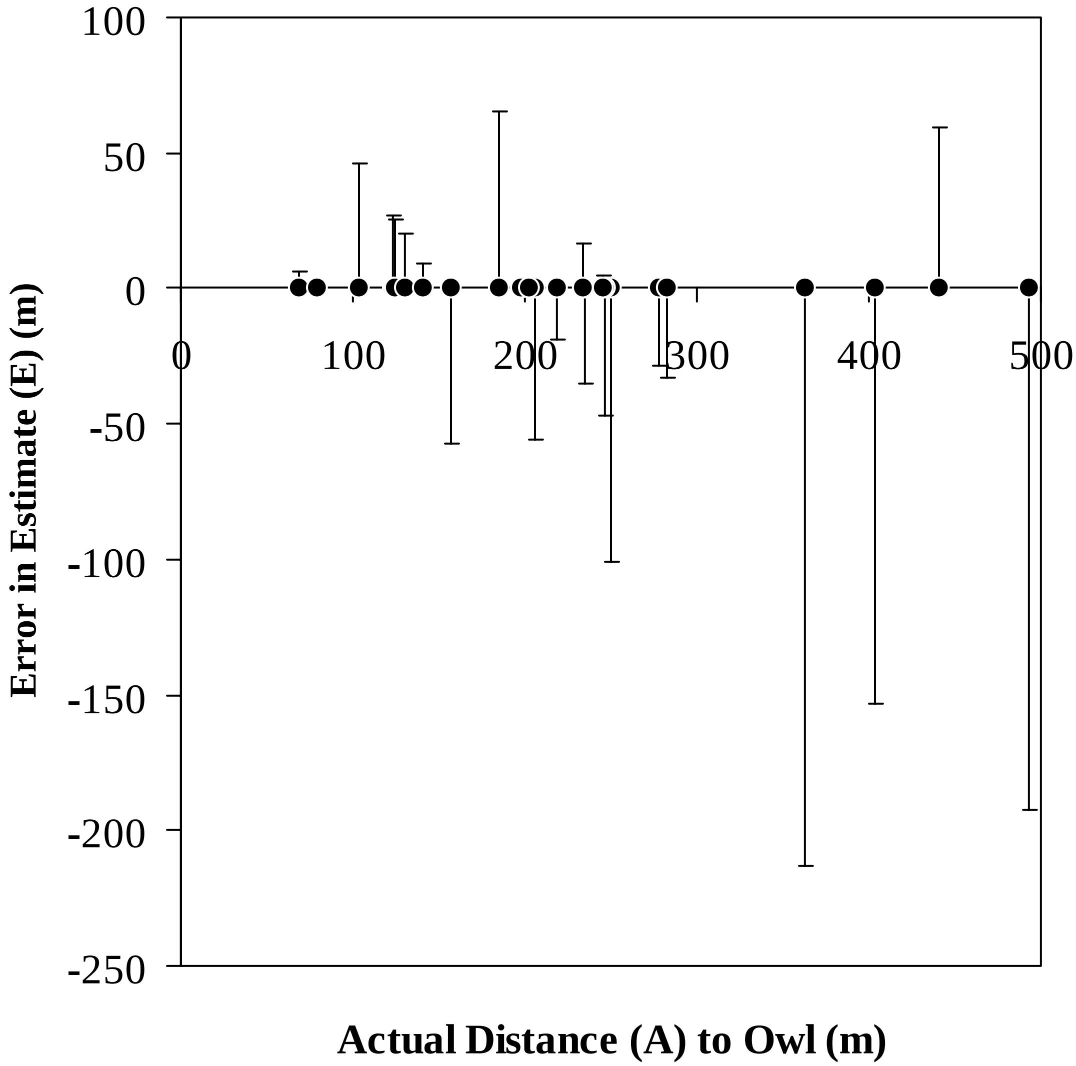


Figure 5. Magnitude of error in distance estimates as a function of actual distance for 24 Flammulated owls detected in the Kamloops Forest District during 1998.

We found that there was poor correspondence between the number of calling owls at each calling station and the average habitat value calculated for both 250 and 500 m radius plots centered around calling stations (Figures 6 & 7). This is contrary to our expectation that calling stations with a higher average habitat value would support higher numbers of owls given that a higher average habitat value would contain a greater proportion of higher quality habitat.

Because there was poor correspondence between the number of calling owls at each calling station and the average habitat value around those stations, we examined the potential role that any one habitat class within both 250 and 500 m from survey stations may play in influencing the number of owls detected. Pearson correlation analyses were unable to determine if any one habitat class was driving owl numbers as correlation coefficients were low in all instances. (Table 2).

When we plotted the percentage of owl locations that occurred in each of the six average habitat value classes at owl walk-in sites (n=24), we found that the greatest proportion of these owl locations tended to have low average habitat value classes (Figure 8). Very few owls were detected in areas that represented good habitat as defined by the predictive model (e.g., average habitat values >2.00). These data are based on a relatively small sample size and should therefore be treated with caution.

Table 2. Pearson correlation coefficients and levels of significance (2-tailed) examining the relationship between the total number of Flammulated owls within 250 and 500 from each calling station and the area of each habitat class within 250 and 500 m of plot center.

		Total Area of			
Radius	Statistic	Nil Habitat	Low Habitat	Moderate Habitat	High Habitat
Within 250 m	Pearson Correlation Coefficient	-0.036	-0.004	0.050	-0.010
	Level of Significance	0.516	0.940	0.359	0.857
Within 500 m	Pearson Correlation Coefficient	-0.105	0.081	0.054	0.004
	Level of Significance	0.056	0.141	0.323	0.941

Vegetation surveys

Stands in each of the four habitat classes were predominately made up of Douglas-fir (Figure 9). Ponderosa Pine was the next most abundant species in all habitat classes. Lodgepole Pine, Spruce, and hardwoods (Aspen, Birch) occurred infrequently in the forest canopy. Stands that were surveyed showed a characteristic inverse J-shaped distribution with respect to the stocking densities of the five tree diameter classes. There were far more stems in the lower diameter classes than in larger diameter classes (Figure 10). The distribution of diameter classes for live Douglas-fir showed similar patterns (Figure 11). Ponderosa Pine had very low stocking densities in all diameter classes and generally showed a similar pattern of diameter class stocking density (Figure 12). When we examined the stocking densities we

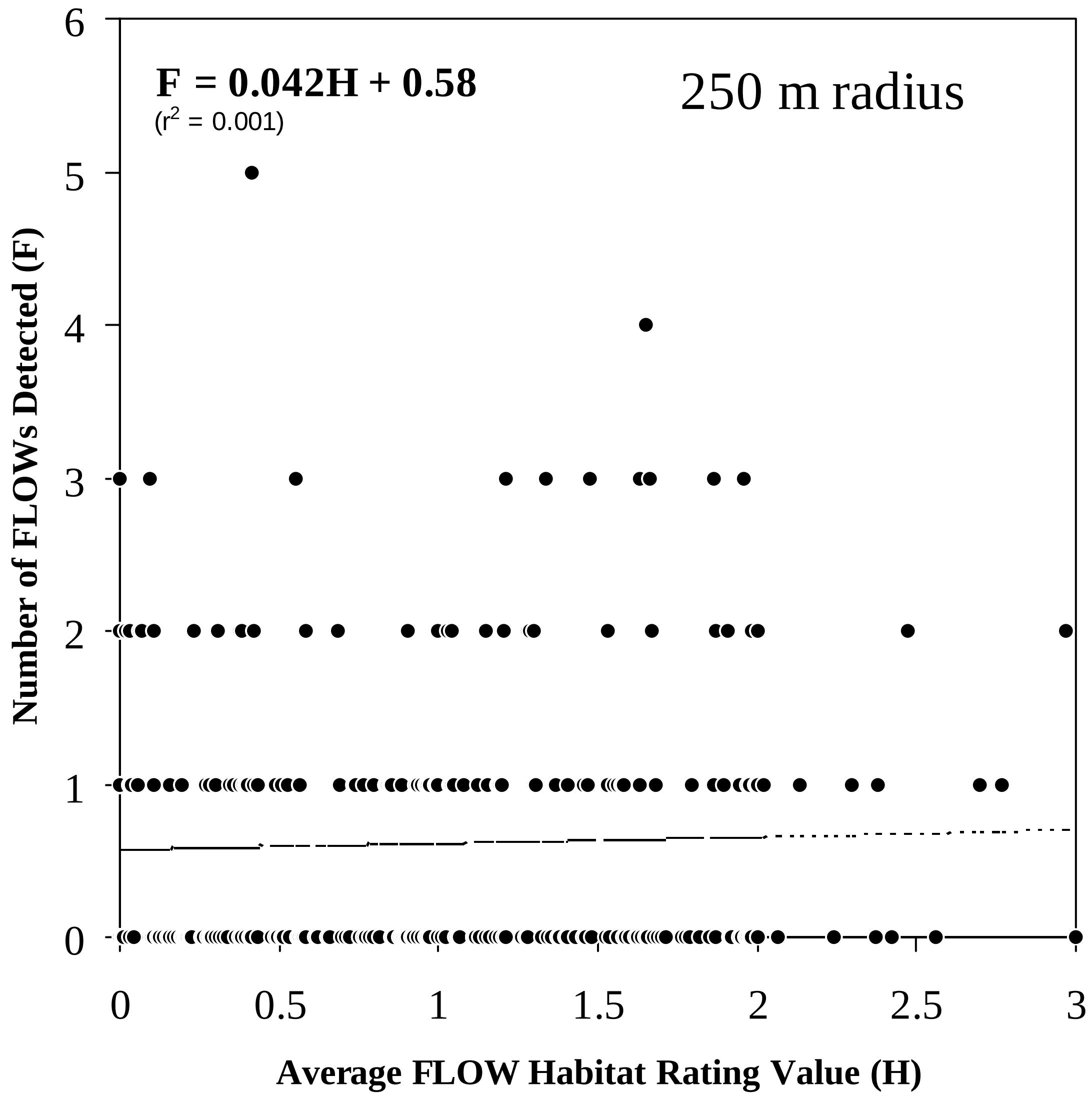


Figure 6. Relationship between average habitat value within 250 m of owl survey stations and the number of owls detected at each station in the Kamloops Forest District during 1998 (n= 341).

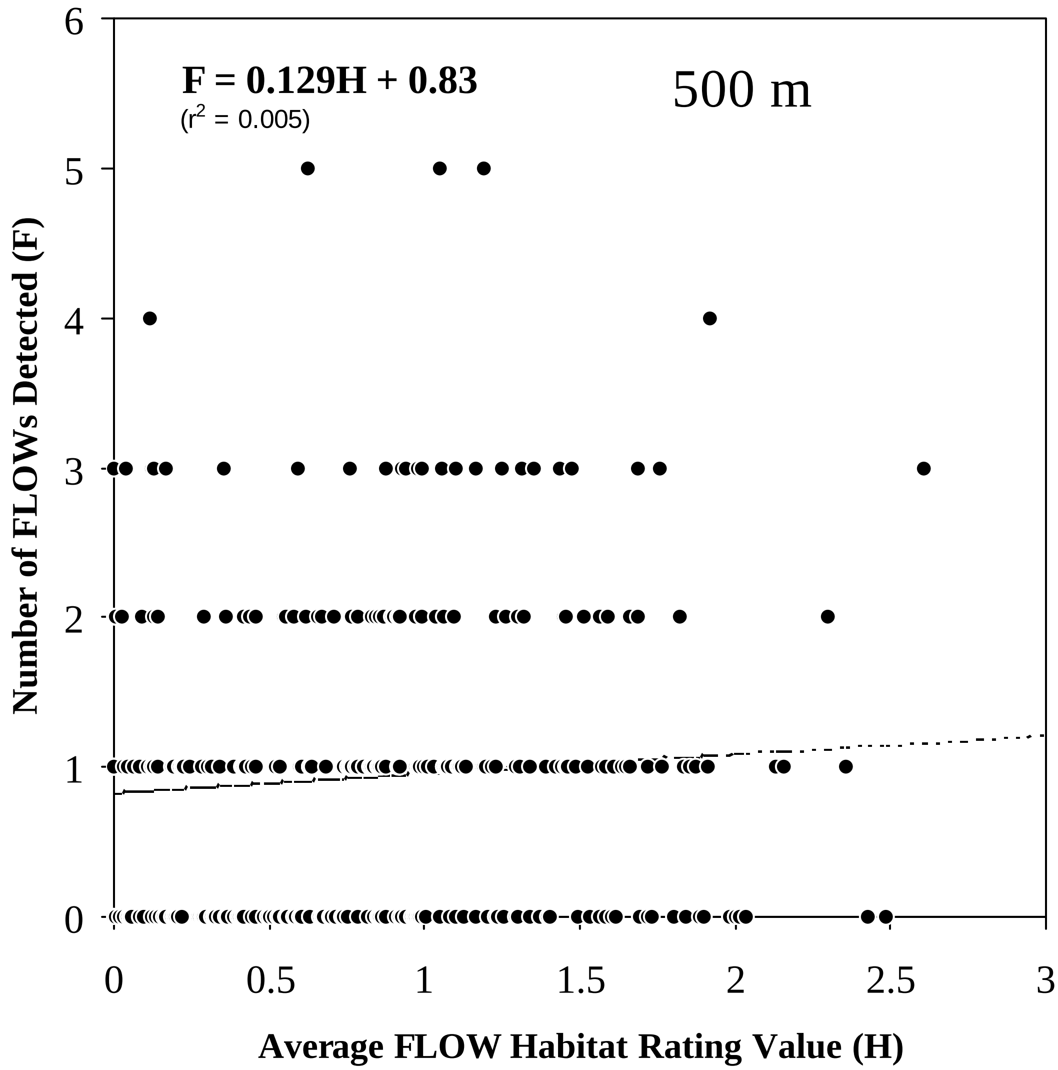


Figure 7. Relationship between average habitat value within 500 m of owl survey stations and the number of owls detected at each station in the Kamloops Forest District during 1998 (n=341).

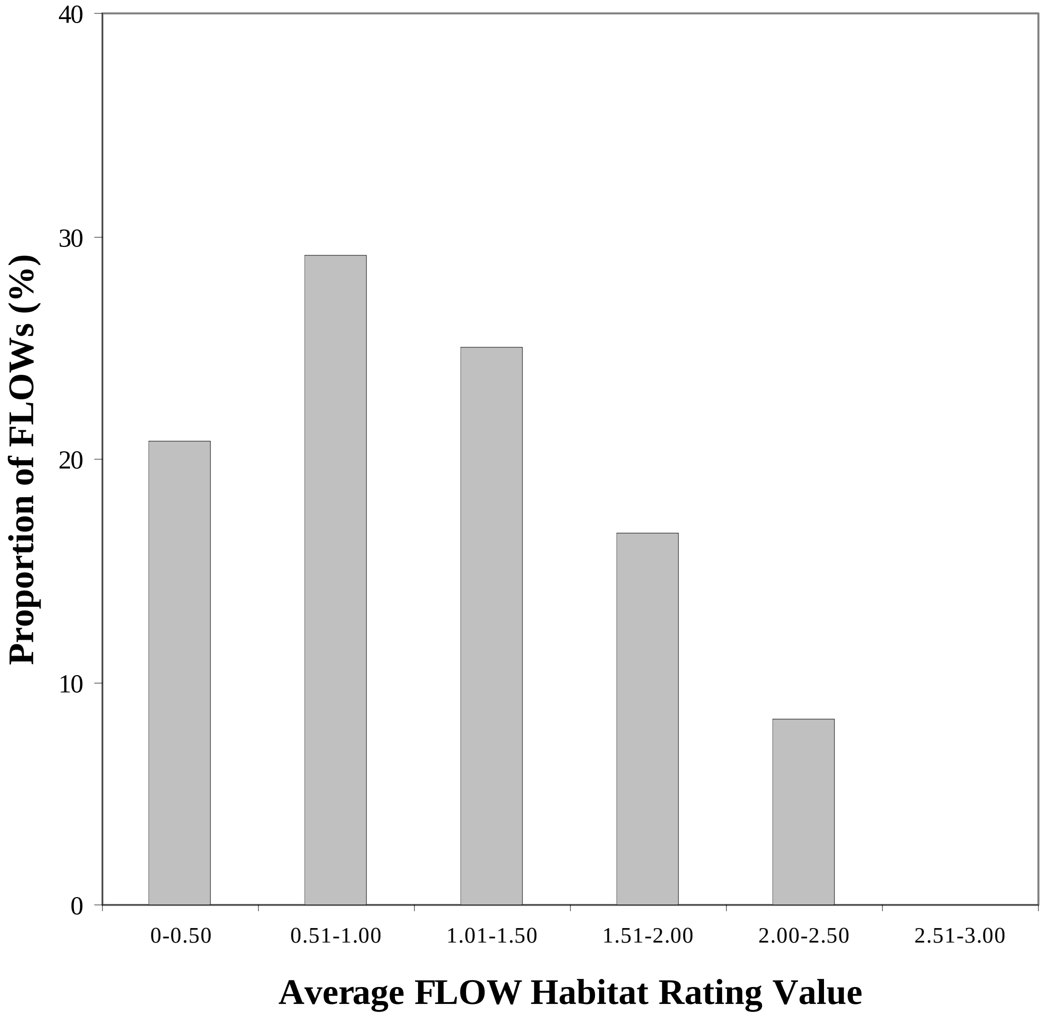


Figure 8. Distribution of average habitat value classes amongst 24 accurately identified Flammulated owl locations found in the Kamloops Forest District during the 1998 survey.

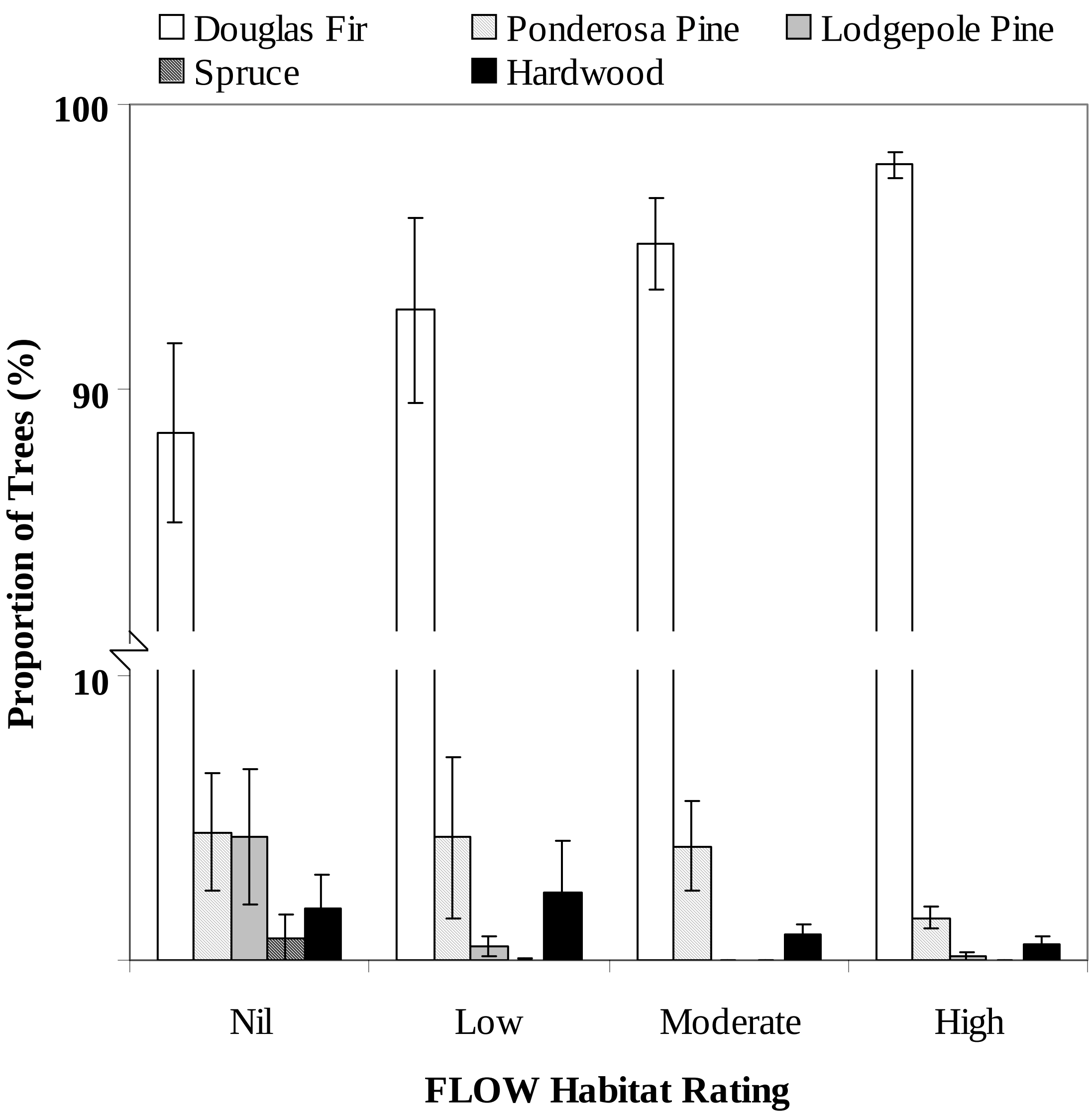


Figure 9. The mean proportion of dominant trees by species in each of the four habitat classes examined.

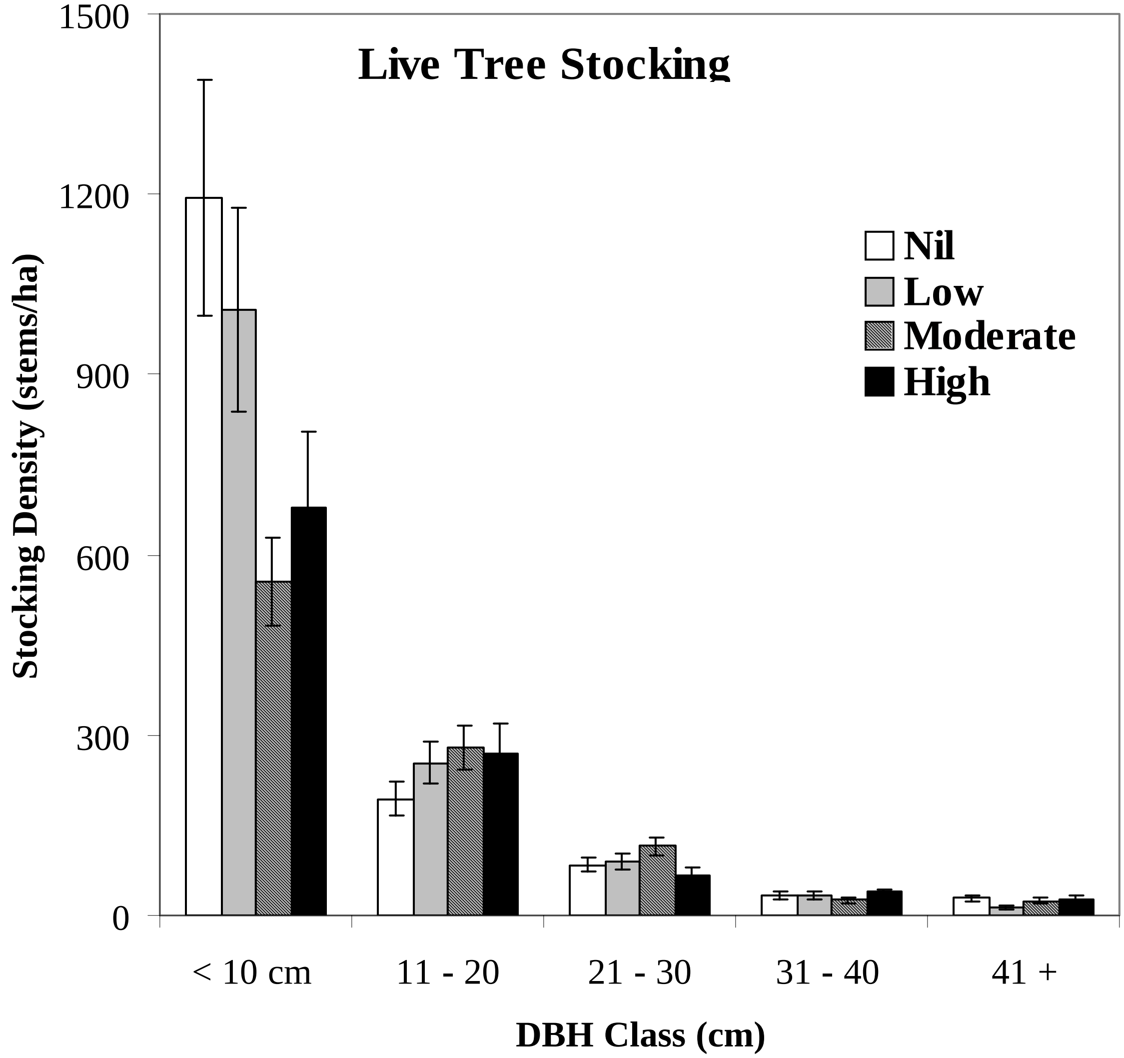


Figure 10. The stocking density of live trees by diameter class in each of the four habitat classes examined.

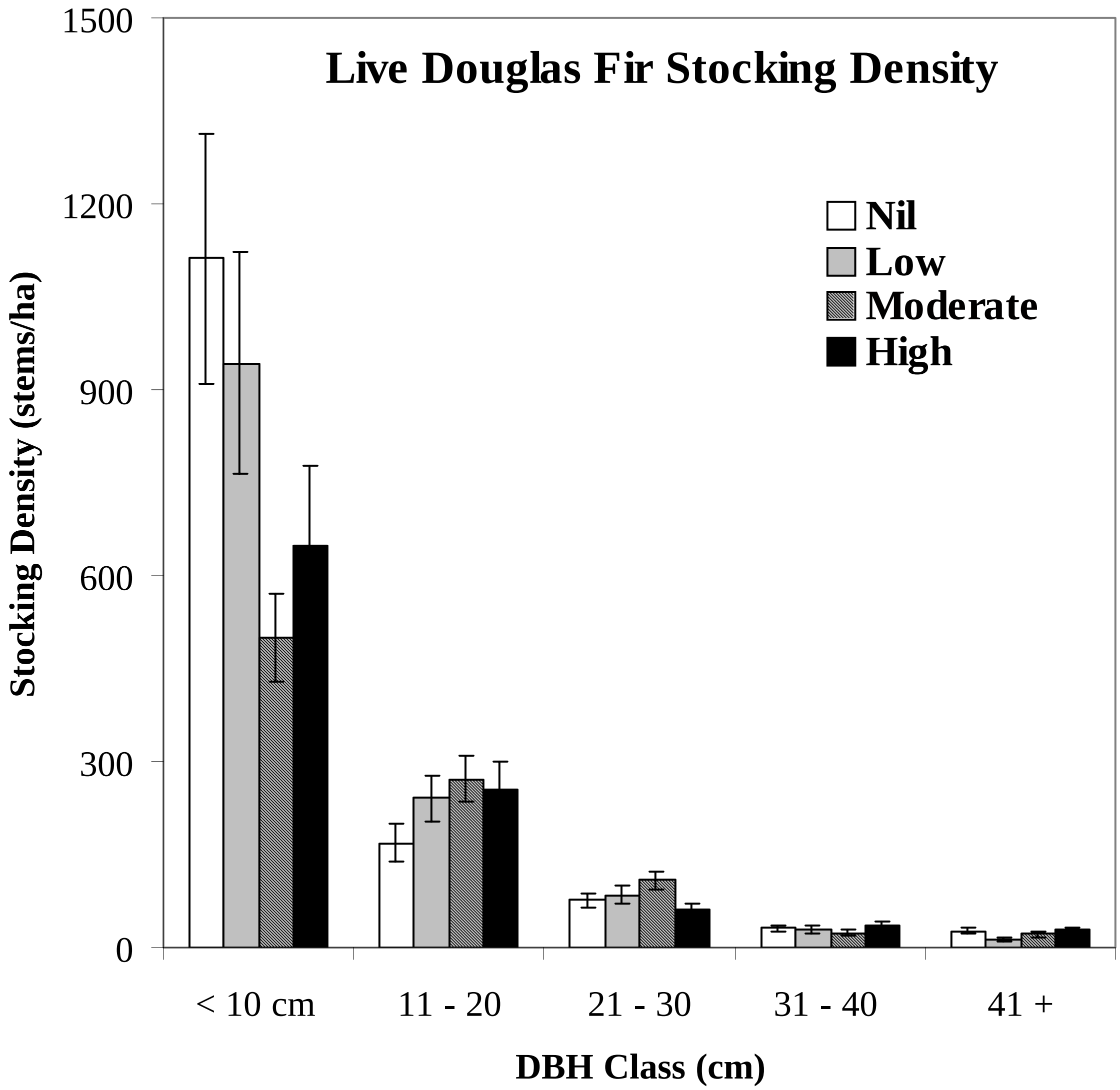


Figure 11. The stocking density of live Douglas-firs by diameter class in each of the four habitat classes examined.

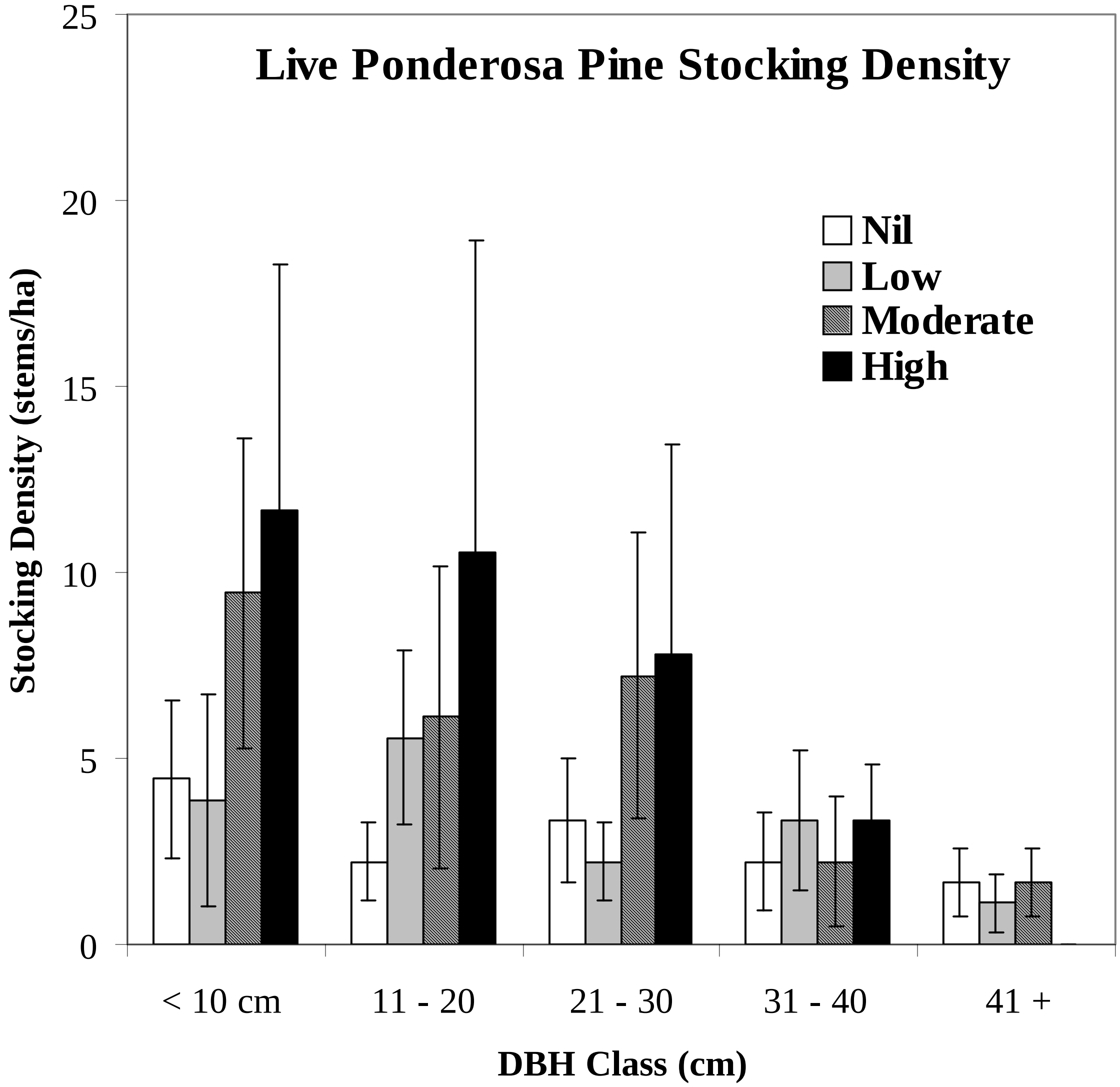


Figure 12. The stocking density of live Ponderosa pines by diameter class in each of the four habitat classes examined.

found that there was no significant difference in the densities of all trees combined, small trees (< 10 cm dbh), all trees >10 cm dbh, or live conifer trees > 30 cm dbh, between any of the habitat classes we examined (Table 3).

Table 3. Summary statistics (means and standard errors) and results from Kruskal-Wallis ANOVAs examining the stocking density (stems/ha) of trees in each of the four habitat ranks (n=36)

	Habitat Class								Statistic	
	Nil		Low		Moderate		High			
Variable	Mean	SE	Mean	SE	Mean	SE	Mean	SE	χ^2	p
All trees	1683.3	214.1	1533.9	203.4	1294.4	111.2	1282.8	154.8	1.89	0.59
Trees <10cm dbh	1306.7	203.8	1127.2	187.5	801.1	88.7	849.4	130.4	2.13	0.55
Trees >10cm dbh	376.7	37.2	406.7	45.2	493.3	42.7	433.3	56.2	3.87	0.27
Live conifers > 30cm dbh	62.8	8.2	47.2	7.1	49.4	7.4	66.1	8.9	3.41	0.33
Dead Conifers >30cm dbh	8.3	2.6	2.8	1.4	8.3	2.4	9.4	2.5	6.22	0.10

Snags, particularly large diameter snags, tended to occur at low stocking densities. Of the over 3000 trees > 10 cm dbh measured in the 0.05 ha circular plots, we recorded only 231 snags (32 snags/ha). The majority of these snags were Douglas-fir that were in the smaller diameter classes (Table 4). Ponderosa pine snags were uncommon regardless of diameter class. In general, those snags in larger diameter classes tended to be in shorter height classes (Figure 13), and were in later stages of decay (Figure 14). When we examined all snags > 30 cm dbh, we found that there was no significant difference in the stocking density between any of the habitat classes we examined (Table 3). It should be noted that, although no statistical difference was determined, large diameter snag density in low quality habitat was about 1/3 of that in all other habitat classes. In snag transects we recorded a total of 74 snags greater than 30 cm dbh (10.3 stems/ha). Of these, most were in smaller height classes (Figure 15).

Very few of the snags that were recorded in both the 0.05 ha circular and 0.2 ha linear fixed area plots contained woodpecker cavities (3 and 16%, respectively). Snags with woodpecker cavities tended to be Douglas-firs, have relatively large diameters, were in shorter height classes, and were in the later stages of decay (e.g., decay classes 6-8; Table 5).

We found that there was no significant difference in percent cover of shrubs, or overall crown closure between any of the owl habitat classes we examined (Table 6). The percent cover of grass on the other hand was significantly higher in nil habitat compared to high quality habitat (p=0.04, Tukey's HSD test; Table 7). We found that there was no significant difference in the area covered by thickets between any of the habitat classes we examined (Table 8). The number of thicket patches was significantly higher in the low habitat class relative to all other habitat classes (Table 8).

Table 4. Distribution (total N) and density (stems/ha ± SE) of snags encountered in all 0.05 ha circular fixed area plots by species and diameter class

	Diameter Class (cm)							
Tree species	10-20		21-30		31-40		40+	
	N	dens.	N	dens.	N	dens.	N	dens.
Douglas-fir	135	18.8 ± 3.1	23	4.2 ± 0.9	20	2.8 ± 0.7	28	3.9 ± 0.8
Ponderosa Pine	2	0.3 ± 0.2	0	-	2	0.3 ± 0.3	2	0.3 ± 0.2
Lodgepole Pine	1	0.1 ± 0.1	0	-	0	-	0	-
Hardwoods	18	2.5 ± 1.0	0	-	0	-	0	-

Table 5. Distribution of snags that contained woodpecker cavities from 0.05 ha tree plots and 0.2 ha snag transects

		# snags by species		Diameter (cm)		# snags in each class: Height class				Decay class							
Survey Method	# snags	# Fd[1]	# Py[2]	Mean	SE	1	2	3	4	1	2	3	4	5	6	7	8
0.05 ha circ. plots	8	7	1	44.2	7.4	5	3	0	0	0	1	0	1	0	2	2	2
0.2 ha transects	12	8	3	52.1	6.4	8	2	1	1	0	2	0	2	0	2	1	5

[1]Fd = Douglas-fir [2]Py = Ponderosa Pine

Table 6. Summary statistics (means and standard errors) and results from Kruskal-Wallis ANOVAs examining the percent cover of shrubs and overall crown closure.

	Habitat Class									
	Nil		Low		Moderate		High		Statistic	
Variable	Mean	SE	Mean	SE	Mean	SE	Mean	SE	χ^2	p
Shrub Cover	16.1	3.4	20.1	3.6	11.2	2.2	19.1	3.3	4.06	0.26
Crown Closure	34.8	3.2	34.3	3.4	40.3	3.3	33.2	3.2	2.83	0.42

Table 7. Summary statistics (means and standard errors) and results from 1-way ANOVA examining percent cover of grass.

	Habitat Class									
	Nil		Low		Moderate		High		Statistic	
Variable	Mean	SE	Mean	SE	Mean	SE	Mean	SE	$F_{(3,143)}$	p
Grass Cover	59.6	4.7	57.7	4.6	52.3	4.4	41.9	4.9	8.31	0.04

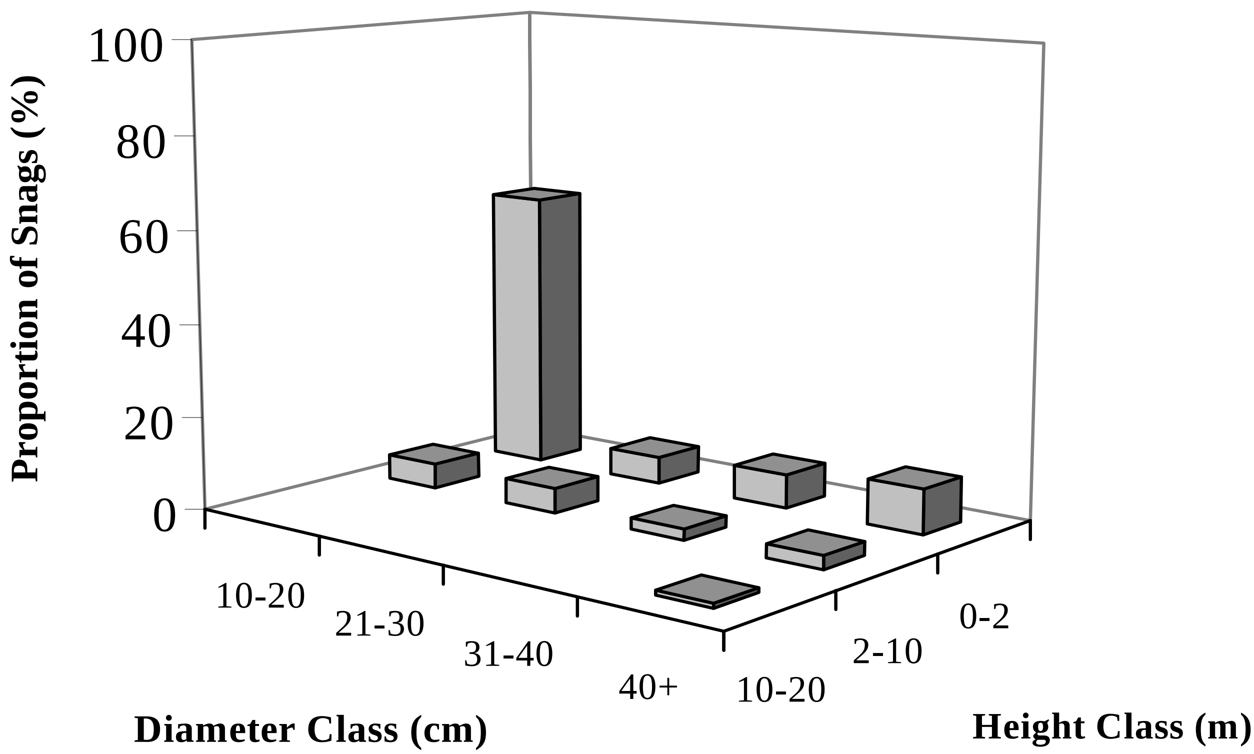


Figure 13. The proportion of all snags encountered in 0.05 ha circular fixed-area plots in each height class and diameter class.

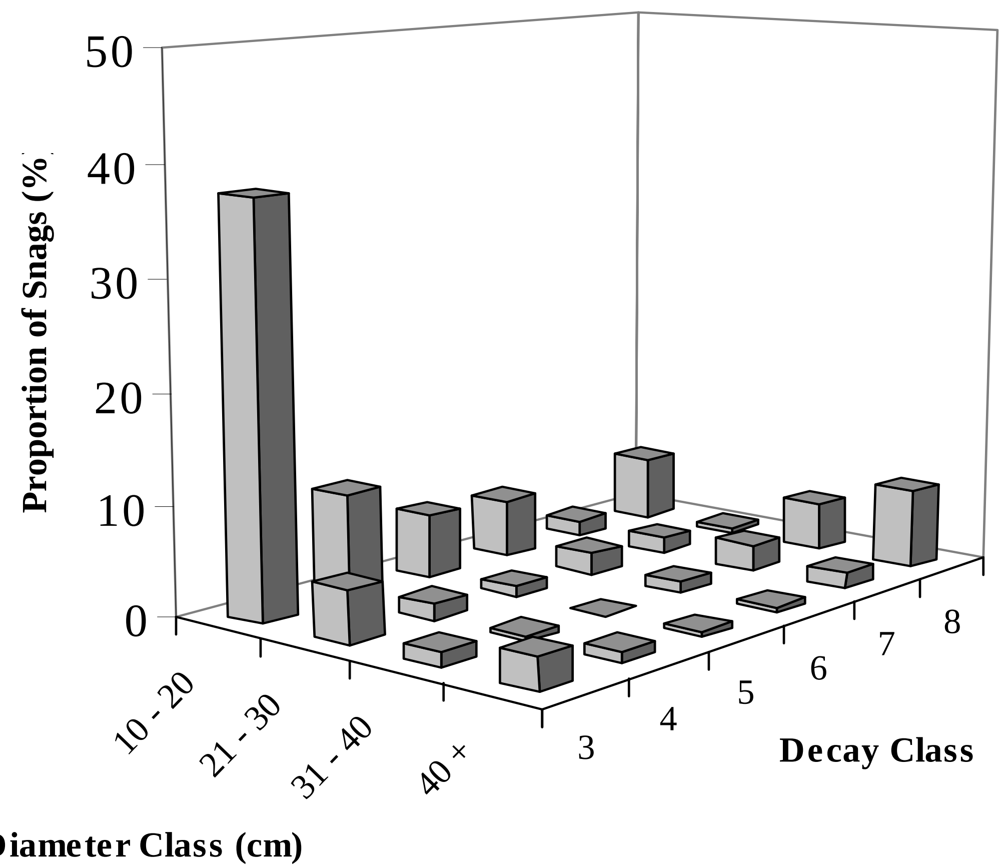


Figure 14. The proportion of all snags encountered in 0.05 ha circular fixed-area plots by diameter class and decay class.

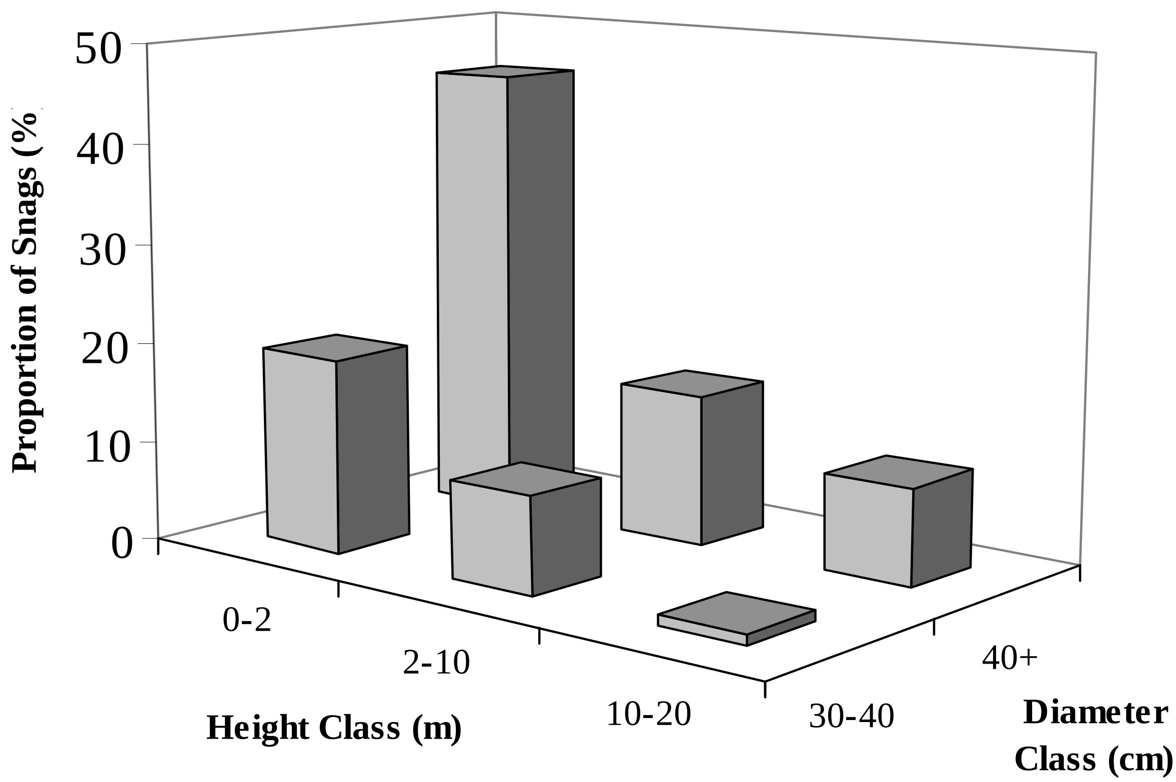


Figure 15. The proportion of all snags encountered in snag transects in each height class and diameter class.

Table 8. Mean thicket area (m^2/ha) and number of thickets in each habitat class

Habitat Class	Thicket area (m^2) Mean	se	Number of thickets Mean	se
Nil	452	173	0.92	0.38
Low	810	234	2.75	0.59
Moderate	485	205	1.17	0.34
High	345	160	0.75	0.30
Statistic	$\chi^2 = 3.87$	$p = 0.28$	$F_{(3,47)} = 4.79$	$p > 0.01$*

* Low > (Nil, Moderate, High) $\alpha = 0.05$ Tukey's HSD

Discussion

The results from our extensive surveys have enhanced our knowledge of the distribution of Flammulated owls in the KFD. We were able to establish the presence of Flammulated owls in areas that were previously not surveyed, or poorly documented (e.g., Deadman River Valley, Barriere, Ashcroft, Cache Creek). Our data indicate that Flammulated owls may not be evenly distributed throughout the Kamloops Forest District. Detection rates in area D were significantly lower than in any of the other areas that were surveyed. It is unclear why this is the case and further investigation would be required to establish causal factors. On the broader scale, the large number of owls that we detected also suggests that this species is relatively common in the KFD. However, due to the nature of the sampling design, we were unable to confirm the absence of Flammulated owls in areas where we did not detect them.

Our owl detection rate (0.99 owls per calling station) falls within the range of detection rates for previous extensive surveys in the Kamloops Forest District. For instance, van Woudenberg et al. (1997) detected 0.11 Flammulated owls per survey location which is approximately 1/9 the rate at which we detected them. Williams and Woodward (1989) detected 1.4 owls per calling station , which is about 1½ times our rate. Howie and Ritcey (1987) detected owls at a rate of 0.85 per calling station on Wheeler Mountain which is close to our overall detection rate.

Our estimate of owl density (1.6 calling males/100 ha) along survey routes is comparable to some areas in the Western United states and much higher than that estimated by Howie and Ritcey (1987) for selected areas in the Kamloops Forest District. Densities for some southern populations ranged from 0.18 calling males/40 ha in Oregon to 2.11 calling males/40 ha in New Mexico (McCallum 1994b).

Our high detection rate may be attributable to our choice of census areas. Censusing was guided by the predictive model that by default biased censusing to habitat that may have been more suitable Flammulated owl habitat than if geographically random locations were selected. In other words, our sampling was generally directed towards suitable habitat: rarely did we sample in the BG or PP biogeoclimatic zones, or higher elevation IDF sub-zones. Any habitat that we sampled that was deemed nil habitat generally fell within the lower elevation IDF sub-zones. As a result, this census can not be considered a true extensive survey because a large proportion of the KFD was excluded from the survey.

We have also been able to demonstrate that some of the habitat attributes occur in relatively low abundance, especially the abundance of live Ponderosa pines (Figure 11) and dead conifer trees >30 cm dbh, particularly Ponderosa pines (Table 4 and 5). This is of importance because of the high use of Ponderosa pine snags as nesting trees by Flammulated owls in the KFD (van Woudenberg 1996).

The analyses that we performed regarding owl/habitat class relationships suggest that the predictive Flammulated owl habitat model tested does not effectively predict relative abundance of Flammulated owls. Results from regression analyses were contrary to our expectations. We hypothesized that calling stations with higher average habitat values would support higher numbers of owls. We were unable to discern any trend in owl numbers and average habitat values regardless of the two scales that we tested (250 and 500 m around survey stations and 250 m radius around owl walk-in sites). In fact, we detected multiple owls in areas of relatively low habitat value (see Figure 6 and 7). Further, correlation analyses yielded similarly ambiguous results: owl numbers were not correlated with the total area of any one single habitat class. We were also unable to determine differences in most of the stand structure and habitat attributes that we assessed between the four habitat classes that we examined. We were only able to discern differences in the percent coverage of grass, and the number of thickets encountered along snag transects between habitat classes. We detected no differences in variables that pertain to forest structure between any of the habitat classes for any of the variables that we measured, despite the fact that we sampled a wide range of habitat classes as delineated by the model.

One of the limitations of the way in which this model was tested assumed that results of census data can act as a measurement of habitat quality. Numerous authors, including van Horne (1983) and van Woudenberg and Christie (1998) assert that estimates of abundance derived from census data can be misleading due to the speculation that a large portion of a population may be non-breeding individuals (non-breeding male Flammulated owls in this case). For instance, Reynolds and Linkhart (1987) determined that calling male Flammulated owls outnumbered nests by a factor of 1.42 within a 1,657 ha study area suggesting a significant proportion of unmated males (approximately 30%). Occupancy can; however, be used as a measure of habitat quality if occupancy data spans a sufficient time frame and if it is also correlated with habitat structure and production of young, survival, tenure and fidelity of owls on territories (Linkhart and Reynolds 1998). A second potential limitation of this study pertains to our survey technique. Our surveys were based on a single visit to each survey station. Using this method we were only able to confirm the presence of calling Flammulated owls and not their absence in the areas we surveyed. We also are unable to say with much certainty whether each calling station where we detected multiple owls reflected higher quality habitat, or if the number of owls that we heard calling at these stations were non-resident owls moving through the study area. As a result, we may have misclassified certain calling stations regarding their potential as Flammulated owl habitat. These are assumptions, however, that we are unable to address at this time.

This predictive model did not adequately delineate differences between different habitat classes for most of the habitat attributes we measured. Why the model was unable to detect differences in vegetation is uncertain. These results are, or should be cause for concern as one of the fundamental aspects of this model should be that it can delineate between habitats that should, by definition of the model, be different. One of the potential problems is data on which the model is based upon. Identification and delineation of uneven-aged stands, such as those in the IDF, is difficult (Reid Collins and Assoc. 1992). In particular, it is widely acknowledged that forest cover data can be unreliable at quantifying and characterizing IDF forests. Problems associated with the characterization of IDF forests are due to difficulties in interpreting aerial photos of these stands. This difficulty is largely due to the extremely heterogeneous nature of these stands that is a result of a long history of forestry activities and natural disturbance events. Even the initial delineation phase (i.e., determination of leading species) has been problematic. Research by J.S. Thrower & Associates has shown a wide range of variability in the classification of leading and secondary species in both the IDFxh1&2 as well as in the IDFdk1&2 (J.S. Thrower & Associates 1997 a and b). Another potential reason why this model is unable to discern differences between habitat classes is the way in which the model was constructed. With this model it is unclear why specific forest cover polygons are aggregated in the same predicted Flammulated owl habitat classes. This problem arises because all variables that lead to adjustments of a polygon are weighted equally in terms of how they affect the overall rating of an individual polygon. In other words, polygons of like habitat classes are grouped together for potentially different reasons, thereby creating large variation within specific habitat classes. The aggregation of polygons for different reasons likely explains why we were unable to distinguish differences between the stand structure of different habitat classes.

Recommendations

This model as it presently stands, and in the means in which it was tested, (call back surveys and fixed-area plot vegetation plots) does not appear to predict the abundance of Flammulated owls, nor is it able to detect differences in stand structure between habitat classes. Potential limitations regarding the use of census data to test this model require some examination. If it is in fact the case that many of the individual birds that we have encountered during our censuses are non-breeding owls, then decisions need to be made regarding the applicability of these data to the testing of the model. Non-breeding males are likely important to the overall "health" of the Flammulated owl population(s) in the KFD and elsewhere as they may represent potential contributions to the breeding population(s) in the future. As such, habitat management should address this portion of the population as well. If management for non-breeding owls were to occur, then it would be important to determine if there are differences between breeding and non-breeding owl habitat. Further questions that also should be explored pertain to the tenure, or time that non-breeding males spend in individual areas in order to better assess how to manage habitat for non-breeding males. Therefore a long-term monitoring project for Flammulated owls in numerous areas within the KFD should be considered. Attempts should be made to secure more detailed data that are similar to those collected in a comparable study in Colorado (see Linkart and Reynolds 1998). Modeling of Flammulated owl habitat would be far more precise with these sorts of data. An additional alternative to a long-term monitoring project would be to further explore the data that we have already collected. Attempts should be made to examine forest cover attributes at known owl locations that have a high degree of accuracy.

Based on our assessment of habitat structure, we believe that this model requires adjustments in the way it classifies habitat. Adjustments of the model can, and should be made on the data on which it was built. Wheeler Mountain reportedly has one of the highest breeding densities of Flammulated owls in North America (D. Christie, Cascadia Natural Resource Management, pers. com.), yet much of the area that the data was based upon falls within moderate to low habitat classes. In addition, the model could be applied to known areas of Flammulated owl breeding activity. The Penticton Forest District has known Flammulated owl nest sites that could serve to further refine and test this (L. Ramsay, CDC Victoria, pers. com.). In addition, some areas in the Williams Lake and Penticton Forest Districts have long term occupancy data that could also be considered as possible areas for model testing this (L. Ramsay, CDC Victoria, and M. Waterhouse MOF Williams Lake pers. com.).

We propose that adjustments to the model should be made in the following areas: re-evaluation of the use of some habitat variables, addition of other variables, and modification to the step down procedure. There are some variables that should be further examined as to whether they should be used in this model, or whether their emphasis should be re-considered. For example forestry activity and activity year may be difficult to justify for inclusion because the history is often incomplete for complex-uneven-aged stands that were selectively harvested (or have been subject to natural disturbances; Bob MacDonald, Growth and Yield / GIS Forester, Kamloops Forest Region pers. com.). In addition, the crown closure of the stand is used to provide an approximation of the stand density. However, in complex stands that have "clumped" stocking and an irregular vertical profile, such as the IDF, measurements of crown closure can be misleading. Estimates of crown closure attempt to measure the vertical projection of the canopy onto the ground. It does not factor in crown width, and it is also not representative of basal area. As a result, similar measurements of crown closures can represent very different stand profiles (Bob MacDonald, pers. com.). Age class may also be a variable that is of limited use. Age class is a variable that is determined with timber and not wildlife habitat objectives in mind. It uses only the estimated ages of the dominant layer in the forest stand and ignores the role of any veteran trees. The presence of a veteran layer in any stand, regardless of stand age, can potentially provide valuable nesting habitat.

Two variables, age range and veteran layer should be considered for inclusion in this model. Age range (the range of all ages in a given stand) may further refine the evaluation of forest cover polygons by providing an assessment of stand age independent of the age class variable. The presence of a veteran layer should also be considered as a variable to delineate Flammulated owl habitat. The occurrence of this habitat layer in a particular polygon could indicate the presence of structural attributes (large live trees and potentially large snags) that are required for Flammulated owl nesting biology, irrespective of stand age.

One of the refinements to the model as it stands today could be an alteration of the step down procedure that it uses. Consideration should be given to modifying steps in the adjustment procedure such that they are related to, or associated with, relative increases or decreases of how each individual variable affects habitat quality. In other words, each adjustment on an individual model variable should not be weighted equally. For example, terrain attributes (slope, aspect, elevation) have a complex relationship in how they affect the stand characteristics and micro-climate. As a result, a favorable aspect and slope may compensate for higher, and potentially less favorable elevation (Bob MacDonald, pers. com.). This suggests that terrain (slope, aspect, elevation) should not be regarded as significant as forest cover (e.g., stand attribute data) in defining potential Flammulated owl habitat. The presence of thinning as a variable that reduces the potential of a polygon to nil should also be reconsidered. At present any polygon that has any forest cover evidence of thinning is automatically assigned as nil habitat due to the fact that thinning may eliminate security cover (thickets). However, thinning per se does not completely eliminate thickets. Rather, specific thinning regimes/prescriptions can maintain thickets that are supposedly required for Flammulated owls. Further, thinning may lead to increases in ground cover vegetation (Agee and Biswell 1970, Dien and Zeveloff 1980, Doerr and Sandburg 1986, Severson and Uresk 1988) that may subsequently increase the availability of foraging habitat. In fact, we along with Howie and Ritcey (1987) found that Flammulated owls were using thinned stands in the Kamloops Forest District. Polygons that have undergone thinning should therefore be evaluated as to their specific prescriptions and adjustments should be made accordingly.

In summary, attempts should be made to adjust the ranking of variables as to their potential to affect overall Flammulated owl habitat quality. In other words, consideration should be given to assigning partial adjustments, based on the probability of how each variable may affect habitat quality. Care needs to be taken to modify the step down procedure such that modifications are made so that the end goal is not purely to make the model fit the distribution of nesting owls.

We also believe that decisions need to be made regarding the applicability of forest cover data to the development of a predictive model for Flammulated owl breeding habitat. The results of our analysis of vegetation data suggest that there is a great deal of variability in the structure of IDF forests in the KFD. The notion of the wide variability of habitat structure within the IDF is widely acknowledged and that classification of these stands is difficult (Reid Collins & Associates 1992, J.S. Thrower and Associates 1997 a and b). It therefore raises the question: should forest cover data be included in the construction of a predictive model regardless of potential problems inherent in the data, or should model construction/refinement be postponed until data that captures more of the inherent variability of the IDF is available (i.e., Vegetation Resources Inventory (VRI))? It is also important to consider whether the forest cover data, or even the VRI data, may exclude, or may not adequately document the abundance of potential limiting factors for Flammulated owls (e.g., large trees that occur at low densities, openings, thickets; snags of adequate size and decay classes; McCallum 1994b, van Woudenberg 1996; Reynolds and Linkart 1987). This is especially pertinent given that the VRI will not include stocking class or age ranges for complex uneven-aged stands. These data will be replaced by an attribute defining the vertical structure of the stand, and the pattern (uniform or clumped) of the trees within the stand (Bob MacDonald, pers. com.).

We believe that there may be an inherent conflict in the use of forest cover data with this model. The data that forest cover information can provide may not be detailed, or reliable enough to base a predictive model upon. However, forest cover information is the means by which numerous management decisions are made upon in the IDF. It is therefore logical to initially build a model based upon these data. This is not an uncommon problem within BC. There are numerous research groups that are wrestling with the use of forest cover data in modeling species/habitat relationships. We strongly suggest that efforts be made to facilitate an exchange of information between these groups in order to further the development of habitat models that are using forest cover data as their basis. One of the main groups that should be contacted is operating out of the Centre of Conservation Biology, Faculty of Forestry, UBC. Dr. F. L. Bunnell (UBC) and Wayne Campbell (MELP, Victoria) are engaged in a project that is modeling similar habitat types in the Williams Lake Forest District (Bunnell pers. com.).

As an alternative to this model, consideration should be given to a model that deviates from, or does not rely on forest cover data. An empirically based model that examines the relationship between the abundance of specific habitat features (large live trees, large snags, thickets, etc) and Flammulated owl density could be more effective at predicting potential Flammulated owl habitat. A model of this sort would adhere more closely to parameters established by Bunnell (1989) in the development and testing of wildlife-habitat models.

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Appendices