Supplement to the Population Assessment of the Northern Spotted Owl in British Columbia 1992 - 2001

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Introduction

In July 2001, a draft report titled “Population Assessment of the Northern Spotted Owl in British Columbia 1992 – 2000” was released to a group of selected individuals and organizations for review and comments. This draft report identified that the Spotted Owl population has declined during the 9-year study and provided possible causes and hypothetical scenarios that may have influenced the observed decline and could affect the future of the Spotted Owl population. Since the release of this draft 2001 report, additional Spotted Owl surveys and data analyses have been conducted that confirm this decline and broaden our understanding of the potential factors affecting the Spotted Owl population. In July of 2002, the “Population Assessment of the Northern Spotted Owl in British Columbia 1992-2001” was finalized.

This “Supplement to the Population Assessment of the Northern Spotted Owl in BC 1992 – 2001” was prepared to address questions and comments received from reviewers (Appendix 1). We provide additional information on the collection, analysis and interpretation of data and information used in the preparation of the Population Assessment Report. As well, this supplemental report provides additional information on the possible factors that may have influenced the observed decline and provides potential remedies that could stop or slow further decline of the population.

Study design and survey methodology

(Comments: 12, 13, 14, 15, 22 and 23)

Between 1992 and 2001, there have been numerous survey objectives, such as: exploring new areas to determine the range, distribution and abundance of Spotted Owls; confirming presence of known Spotted Owls, their reproductive status, nests and roost locations; attaching leg bands and transmitters to monitor movements and habitat use; and assessing potential impacts on Spotted Owls from proposed forestry and other industrial developments. These objectives have not been applied uniformly, but varied from year to year depending on funding and priorities. This variable survey effort and survey objectives has resulted in some data gaps between years at survey areas. There were 3 types of methods used to collect owl data: night surveys, day surveys and radio-telemetry surveys.

Night surveys are the most common survey technique and are used to locate Spotted Owls when they are most active and mobile. In general, most surveys involve “call play-back” stations spaced about every 500 m along a linear transect through the survey area. Each survey area approximates the median annual home range size of 3,200 ha for a pair of Spotted Owls. Owls are enticed by sound lures to defend their territory and announce their presence vocally to the surveyor. Where nest and critical roost sites are known, spot checks (single calling station) at these locations may be performed to confirm presence. If the owl is not detected, linear transects are used to locate the owl. Spot checks also are used in remote areas where a full length transect survey cannot be safely performed. Some survey areas have multiple transects because the entire area could not be surveyed in 1 night.

Day surveys are generally conducted to follow-up on Spotted Owl detections obtained from the previous night survey. They are performed to locate nests, locate roosts, determine reproductive status and attach leg-bands and possibly radio-transmitters. If a nest or critical roost site is

known, we generally perform a day survey at these locations to locate the owl prior to performing an extensive night survey.

Radio-telemetry surveys are used during the night and day to identify movements and habitats used by Spotted Owls that have had transmitters affixed to their tail feathers. Telemetry surveys were used to confirm presence of Spotted Owls in 3 survey areas in 1999 and 2000.

We classified each survey area as either occupied, vacant, not-detected (insufficiently surveyed), or not-surveyed for each survey year. We assumed that all Spotted Owls detected were territorial owls, although some owls detected may have been non-territorial floaters. For our analysis, we used a survey effort threshold of 90% chance of detecting an owl to determine absence of Spotted Owls. This provides a 1 in 10 chance that we failed to detect an owl that was present. This 90% chance is the minimum confidence level accepted by the Resource and Inventory Committee (RIC). We determined that 90% of all initial Spotted Owl detections each year occurred within the first 13 hours of total night search effort at a survey area (Figure 1). Reducing this threshold to determine if a survey area is vacant may increase sample size, but also increases uncertainty on the actual status of the survey area (e.g., a threshold of 80% chance provides a 1 in 5 chance we missed an owl).

The population assessment was first thought of in spring 2000 following compilation of all owl survey data collected at 147 survey areas between 1992 and 1999. A coarse analysis of this data indicated a population decline and a need for further analysis and field work to confirm these findings. A review of all areas surveyed for Spotted Owls between 1992 and 1999 determined that 40 survey areas had sufficient amounts of search effort spread throughout this period to assess occupancy change during the study (Table 1). As well, these 40 survey areas were chosen because territorial Spotted Owls were confirmed in each survey area at least once during this period. This criterion ensured that the local habitats could support owls.
We assumed that survey effort at these 40 survey areas between 1992 and 1999 was not

Figure 1. Chance of detecting Spotted Owls if they are present. Chance of detection is a function of cumulative nighttime search effort needed to initially detect a Spotted Owl each year at the 40 survey areas (1992 - 2000, n = 156).

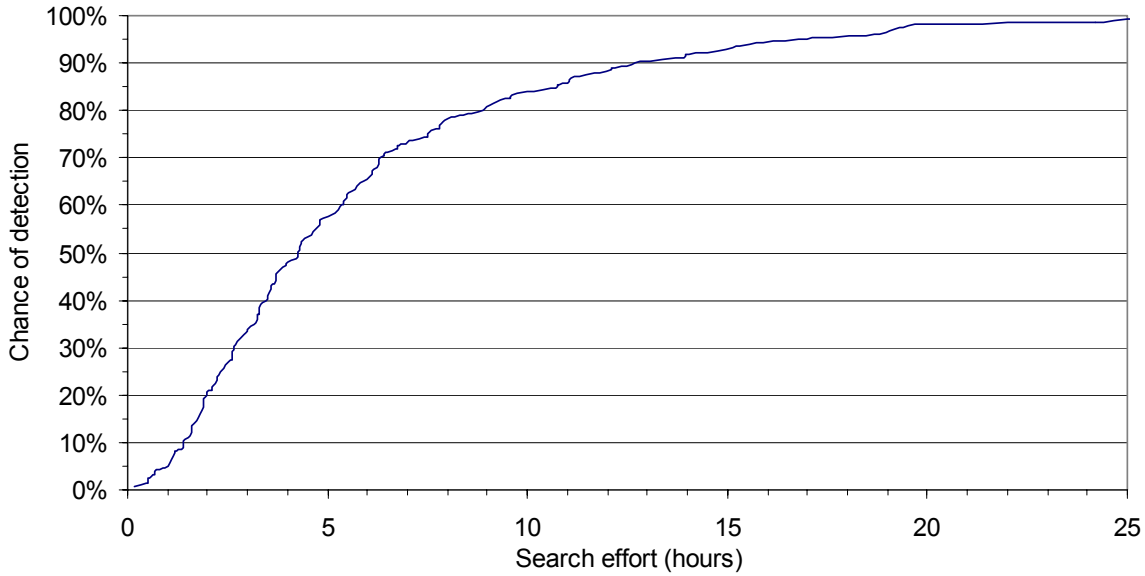


Table 1. Survey results and amount of search effort applied at the 40 survey areas. Survey areas are arranged top to bottom from most occupied to least occupied during the study period.

Survey area	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1				?						
2			?							
3			?							
4			?	?						
5	?	?						?		?
6		26%	?	?						
7	33%	?	?							
8	?	?	33%		?					
9	53%		?	?						
10	?	75%								
11	?						67%	?		?
12		?	?	?		52%		?		
13			?							?
14			?							
15	?							83%		
16			?		61%			65%		
17		27%	?	?		64%		?		?
18	?			46%						
19	?	?	?					33%		
20	?	?	?					37%		?
21			?	35%				87%		
22	?	?						?		
23			?	?		?	78%	?		
24	31%			89%				?		?
25										
26			?		74%	78%		?		
27	?	?					83%	?		?
28	?									89%
29	?						?	?		
34	?	?								
30		21%	?					40%		?
31			?		?			65%		
32	?		?	?	87%		67%	?		
33			?	?	42%	73%		54%		87%
35	?	?	?					39%		88%
36			?	47%	82%	78%	83%	38%		
37			22%	35%	26%	84%		38%		89%
38	48%			85%	83%		72%	?		?
39	?			33%						?
40	?		?	?	?	82%	52%	89%		89%

Occupied

Vacant

? Not -surveyed

% Not-detected - with percent chance of determining status

biased due to the multiple survey objectives and different project managers during this period. In 2000, all 40 survey areas were surveyed extensively (minimum 24 hour unless a Spotted Owl was detected) to determine presence or absence. In 2001, there were sufficient funds to monitor only 30 survey areas which were divided proportionally between the occupied and vacant survey areas observed in 2000.

The population assessment is based on presence/absence of Spotted Owls within the 40 survey areas. The assessment does not consider reproductive status or density of Spotted Owls within each survey area. Most survey areas are adjacent to another survey area, and therefore, there

is a chance of detecting a neighbouring owl. However, during the spring and summer, Spotted Owls tend to use a small portion of their home ranges centered around nesting areas. In the fall and winter, owls extend their activities and use habitats further from natal areas. This centralized behaviour of Spotted Owls during the survey season should lower the risk of detecting an owl from an adjacent survey area. As well, for every neighbouring owl we detect, there is an equal chance that a survey will miss the resident Spotted Owl because it has flown into the neighbouring area.

Population assessment

(Comments: 17, 18, 19, 20, 28, 29, 30, 32, 31 and 33)

We examined several methods to interpret the data and determine possible trends in Spotted Owl numbers. Our initial analysis attempted to use professional judgement to fill in data gaps and estimate population numbers for each year of the study. For example, if a pair of Spotted Owls were detected within a survey area in 1998 and 2000, it is highly likely that owls occupied the survey area in 1999, particularly when adult owls are generally resident and long-lived (survival rates as high as 90%). Conversely, it is highly likely that a survey area is vacant where consecutive years of sampling with high search efforts (but less than the minimum 90% search effort needed to determine vacancy in any given year) failed to detect an owl. The Northern Spotted Owl Survey Protocol in BC states that a minimum of 3 surveys per year performed in 2 consecutive years is sufficient to determine absence of Spotted Owls. However, because occupied and vacant status can change annually, we chose not to use this method due to the assumption and potential bias of this professional judgement.

Estimating the number of occupied survey areas each year

We considered 3 methods to estimate the number of occupied survey areas each year and the annual change in occupancy between consecutive years. The first 2 methods initially determined change in occupancy between years at each specific survey area. The total occupied and vacant status at these survey areas was used to estimate the rate of occupancy change between years by:

$$r_y = 1 + (n_{y+a} - n_y)/ n_y$$

where: r_y is the occupancy change between years y and y+a,
n_y and n_{y+a} are the total number of occupied survey areas in year y and year y+a.

An r_y value equal to 1 represents no net change in occupied survey areas (stable population). An r_y value greater than 1 reflects positive growth and the number of occupied survey areas increased. An r_y value between 1 and zero reflects negative growth and the number of occupied survey areas decreased. The lowest r_y value possible is zero, which reflects extirpation (extinction). To determine the number of occupied and vacant survey areas in 2000, each survey area was visited during the 2000 survey year for either a minimum 24 hours of night search effort (a 99% chance of detecting a Spotted Owl if one was present in the survey area), or until a Spotted Owl was detected. Beginning with the number of occupied survey areas in 2000, the occupancy change between years was used to project backwards and forwards the number of occupied survey areas each year.

Year-to-Year Method

The first method (Year-to-Year), as used in the 2001 draft report, determined the annual change in occupancy using the observed number of occupied survey areas between consecutive years (e.g., 1992 to 1993, 1993 to 1994, …;Table 2). Beginning with the 2000 survey results, we projected the number of occupied survey areas between 1992 and 1999 as:

$$P_y = (n_{2000})/[(r_{1999})(r_{1998})\ldots(r_y)]$$

where: n_{2000} is the number of occupied survey areas in 2000,
P_y is the projected number of occupied survey areas in year y,
r_y is the change in occupancy between years y and y+a.

Similarly, we projected the number of occupied survey areas in the study area for 2001 as:

$$P_{2001} = (n_{2000})*(r_{2000})$$

where: n_{2000} is the number of occupied survey areas in 2000,
P_{2001} is the projected number of occupied survey areas in year 2001,
r_{2001} is the change in occupancy between years 2000 and 2001.

Originally this method was used because it required the fewest assumptions by comparing only changes in occupancy at specific survey areas that had sufficient search effort during each consecutive year to determine occupied or vacant status. This method resulted in a low sample size (165 out of a maximum 360 paired samples) and used only a portion of our data.

Table 2. Year-to-Year method. The estimated number of occupied survey areas for each year. For each year, the change in occupancy between consecutive years was used to estimate the total number of occupied survey areas each year beginning with the 23 known occupied survey areas in 2000.

1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	n	Annual change in occupancy (r_y)	Years of change (y to y+a)
15	14									15	0.93	1992 to 1993
	10	10								10	1.00	1993 to 1994
		10	9							10	0.90	1994 to 1995
			18	16						19	0.89	1995 to 1996
				23	17					27	0.74	1996 to 1997
					18	18				27	1.00	1997 to 1998
						12	13			16	1.08	1998 to 1999
							13	13		16	1.00	1999 to 2000
								18	14	25	0.78	2000 to 2001
										165	Paired samples	
38.5	35.9	35.9	32.3	28.7	21.2	21.2	23.0	23.0	17.9	Estimated occupied survey areas		

Year-to-2000 Method

The second method (Year-to-2000) determined the change in occupancy using the observed number of occupied survey areas between each survey year and year 2000 (e.g., 1992 to 2000, 1993 to 2000…,Table 3). Beginning with the 2000 survey results, we estimated the number of occupied survey areas for each year between 1992 and 1999 as:

$$P_y = (n_{2000})/(r_y)$$

where: n_{2000} is the number of occupied survey areas in 2000,
P_y is the estimated number of occupied survey areas in year y,
r_y is the change in occupancy between years y and 2000.

Similarly, we projected the number of occupied survey areas in 2001 as:

$$P_{2001} = (n_{2000})*(r_{2000})$$

where: n_{2000} is the number of occupied survey areas in 2000,
P_{2001} is the projected number of occupied survey areas in year 2001,
r_{2000} is the rate of occupancy change between years 2000 and 2001.

The Year-to-2000 method is similar to the Year-to-Year method in that it compares only changes in occupancy at specific survey areas that had sufficient search effort during each of the 2 years to determine occupied or vacant status. This method used a greater proportion of our sample (218 out of a maximum 360 paired samples) largely attributed to the extensive survey efforts conducted in 2000. However, this method over-estimated the number of occupied survey areas in 1992 and 1993 by exceeding the maximum (40) possible number of occupied survey areas.

Using the estimated number of occupied survey areas each year, we calculated the annual change in occupancy between consecutive years (Table 4). For 1992 and 1993, we limited the number of occupied survey areas to a maximum 40 occupied survey areas.

Table 3. Year-to-2000 method. The estimated number of occupied survey areas for each year based on rates of occupancy change between each year and year 2000. For each year, the total change in occupancy was then applied to the 23 occupied survey areas in 2000 to estimate the number of occupied survey areas.

1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	n	Total change in occupancy (r_y)	Years of change (y to y+a)
19								10		19	0.53	1992 to 2000
	25							13		26	0.52	1993 to 2000
		15						9		15	0.60	1994 to 2000
			22					15		23	0.68	1995 to 2000
				26				20		30	0.77	1996 to 2000
					19			21		32	1.11	1997 to 2000
						21		20		32	0.95	1998 to 2000
							13	13		16	1.00	1999 to 2000
								18	14	25	0.78	2000 to 2001
										218	Paired samples	
43.7	44.2	38.3	33.7	29.9	20.8	24.2	23.0	23.0	17.9	Estimated occupied survey areas		

Table 4. Year-to-2000 method showing the estimated annual change in occupancy between consecutive years. The estimated number of occupied survey areas was constrained to a maximum of 40.

1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Annual change in occupancy (r_y)	Year (y)
40.0	40.0									1.00	1992
	40.0	38.3								0.96	1993
		38.3	33.7							0.88	1994
			33.7	29.9						0.89	1995
				29.9	20.8					0.70	1996
					20.8	24.2				1.16	1997
						24.2	23.0			0.95	1998
							23.0	23.0		1.00	1999
								23.0	17.9	0.78	2000

Proportional Method

The third method (Proportional) used each survey year independently and determined the proportion of occupied survey areas each year in relation to the total number of survey areas that were adequately sampled based on the total search effort each year at all survey areas. To account for search efforts in not-detected survey areas, we divided the summed chance of detecting a Spotted Owl at all not-detected survey areas each year by the 90% chance needed to assess vacancy. The result provides an estimate of the number of "equivalent vacant survey areas", i.e., the number of additional survey areas that would be classified as vacant based on the minimum survey effort requirement of a 90% chance of detecting a Spotted Owl needed to assign a vacant status to a survey area. The total number of survey areas that were adequately sampled was determined by:

Number of survey areas adequately sampled	=	Number of occupied survey areas	+	Number of vacant survey area	+	Number of "equivalent vacant" survey areas

For each survey year, the proportion of occupied survey areas was multiplied by maximum population sample size of 40 to estimate the number of occupied survey areas at the 40 survey areas (Table 5). Using the estimated number of occupied survey areas each year, we calculated the annual change in occupancy between consecutive years (Table 6). This method used all sampling effort performed at each survey area (up to 90% effort per survey area) each year which increased the sample size (295 out of maximum 400 samples). The Proportional Method does not depend on the results from the 2000 survey year.

Table 5. Proportional method. The estimated number of occupied survey areas for each year is based on the proportion of observed occupied survey areas and the total number of adequately sampled survey areas each year.

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Observed occupied survey areas	19	25	15	22	26	19	21	13	23	14
Total survey areas adequately sampled	20.8	28	15.6	27.1	35.1	37.7	37.6	23.4	40	29.9
Proportion of occupied survey areas	0.91	0.89	0.96	0.81	0.74	0.50	0.56	0.56	0.58	0.47
Estimated occupied survey areas	36.5	35.8	38.4	32.5	29.7	20.2	22.4	22.2	23.0	18.7

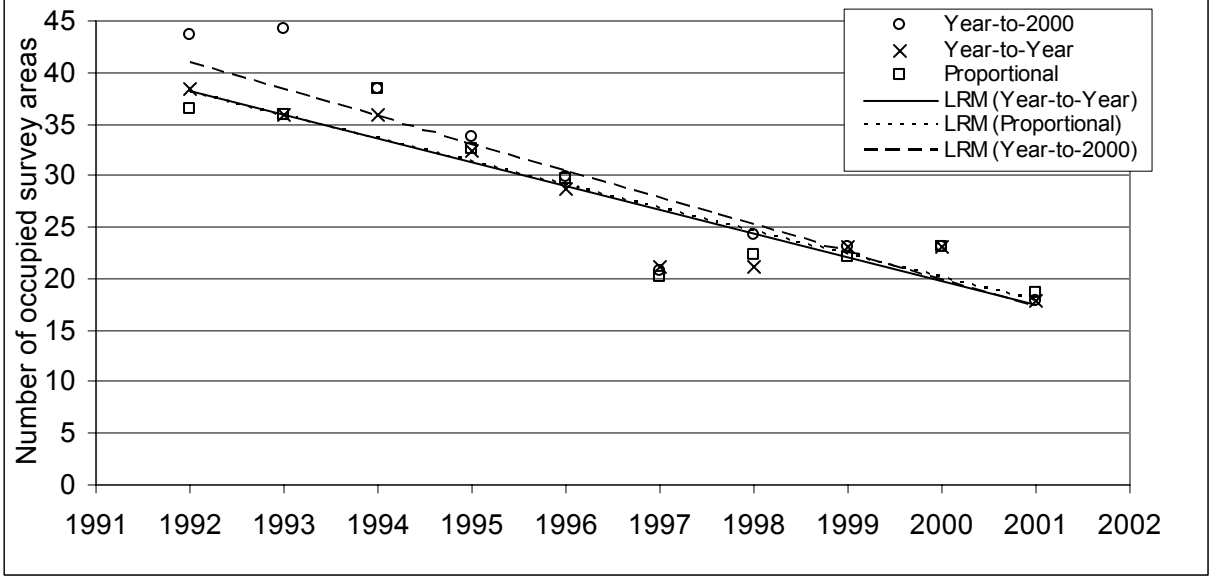
Estimating the trend of the Spotted Owl population:

We used Linear Regression and Linear Multiplicative models to estimate trends in the number of occupied survey areas each year between 1992 and 2001. Linear regressions reflect the best-fit line through the data set. Figure 2 displays linear regressions for the estimated number of occupied survey areas for each method. For the Year-to-2000 regression, the number of occupied survey areas in 1992 and 1993 were limited to a maximum 40 occupied survey areas. Linear regressions are uni-directional. However, population growth is seldom uni-directional, but fluctuates annually in response to favourable (positive growth) and unfavourable (negative growth) conditions. These fluctuations or rates of population growth are generally defined on an annual basis, particularly for species that reproduce only once a year.

Table 6. Proportional method. The estimated annual change in occupancy between consecutive years.

1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Annual change in occupancy (r_y)	Year (y)
36.5	35.8									0.98	1992-1993
	35.8	38.4								1.07	1993
		38.4	32.5							0.85	1994
			32.5	29.7						0.91	1995
				29.7	20.2					0.68	1996
					20.2	22.4				1.11	1997
						22.4	22.2			0.99	1998
							22.2	23.0		1.04	1999
								23.0	18.7	0.81	2000

Figure 2. Comparision of Linear Regression Model (LRM) and associated rates of annual change for the Year-to-Year (-8.4% annual decline), Year-to-2000 (-9.2% annual decline) and Proportional (-8.1% annual decline) methods.



The Linear Multiplicative model accounts for positive and negative population growth by using the annual change in occupancy to determine population trends. The Linear Multiplicative model is described as:

$$N_y = N_i \beta^{(y-i)}$$

where: N_y is the population size in year y,
N_i is the population size in the initial year,
β is the estimated annual change of occupancy.

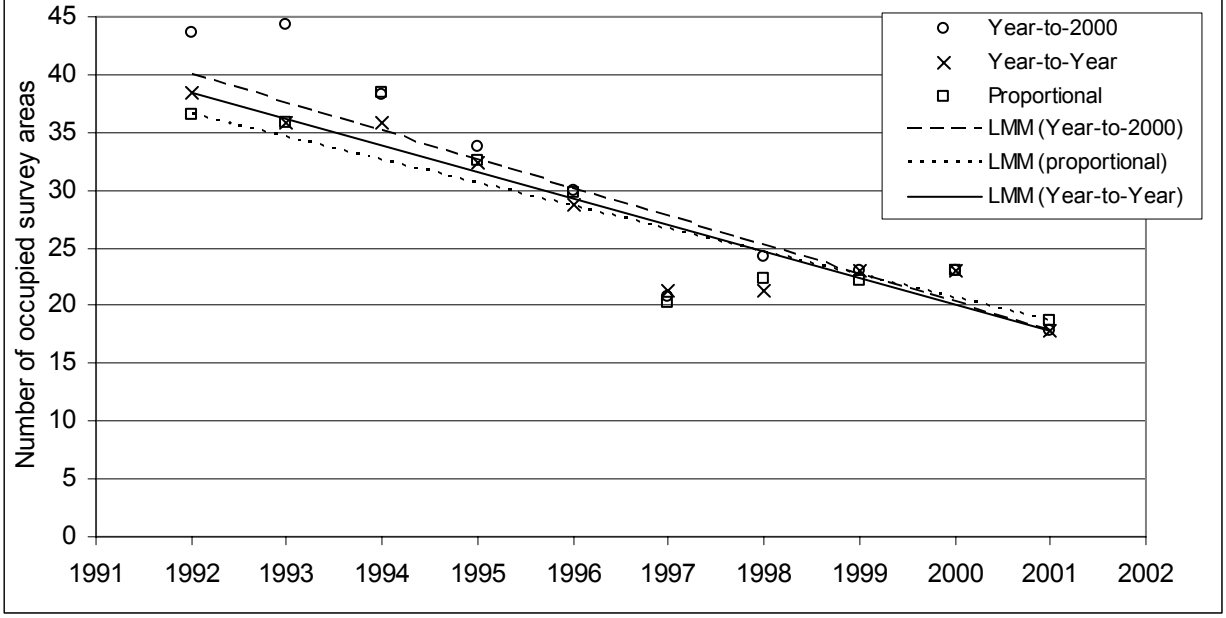
The change in occupancy between consecutive years can be used to calculate β by:

$$\beta = (r_{1992} r_{1993} r_{1994} \ldots r_{2000})^{1/(2001-1992)}$$

where: r_y is the change in occupancy between years y and y+1,
β is the estimated annual change of occupancy.

Figure 3 displays the Linear Multiplicative model for the estimated number of occupied survey areas for each method. Similar to the Linear Regression model, the number of occupied survey areas in 1992 and 1993 was limited to a maximum 40 occupied survey areas for the Year-to-2000 method.

Figure 3. Comparision of Linear Multiplicative Model (LMM) and associated rates of annual change for the Year-to-Year (-8.1% annual decline), Year-to-2000 (-8.6% annual decline) and Proportional (-7.2% annual decline) methods.



Methods and Trends

Results of the 3 methods to estimate the number of occupied survey areas each year were similar. However, the Year-to-2000 method predicted 1992 and 1993 estimates that were greater than the maximum (40) possible number of survey areas. Differences in the estimates between the Linear Regression and Linear Multiplicative models are not substantial and are consistent with a linear decline in occupied survey areas. These slight differences in methods and trends should be expected because the results are based on the same data set. Regardless of method and trend, the results indicate that the population of Spotted Owls has decreased over the past 10 years. All 3 methods and the 2 trend models support the conclusion that the number of occupied survey areas has sharply declined by 49% to 58% between 1992 and 2001, depending on which of the 6 combinations of methods and trends were used (Table 7).

Table 7. Total and average annual rates of occupancy change determined by the Linear Multiplicative and Linear Regression models using the 3 methods to estimate occupied survey areas each year between 1992 and 2001.

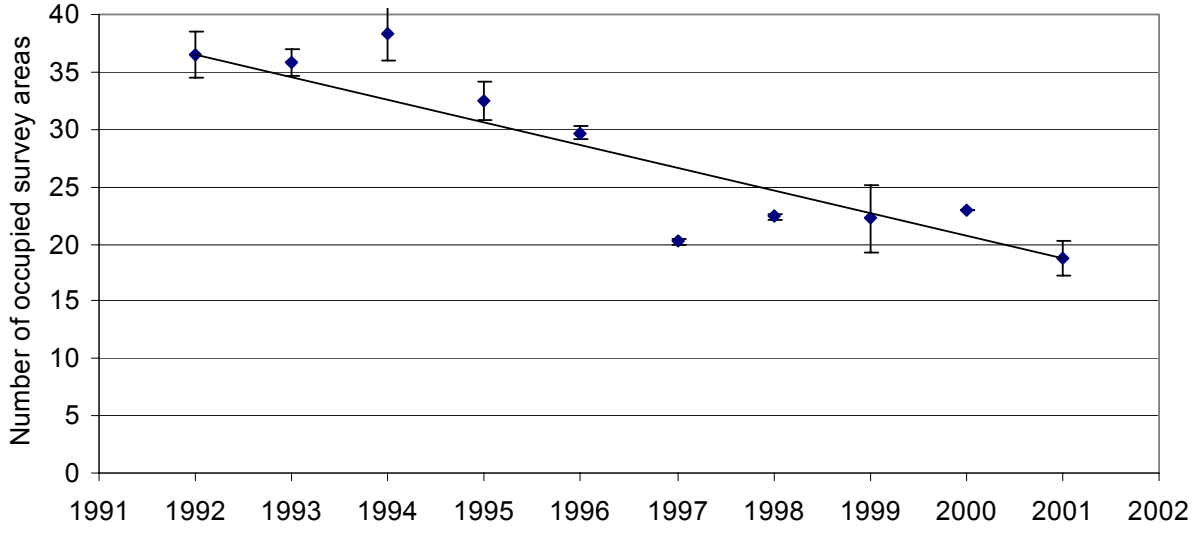
Trend model	Year-to-Year		Year-to-2000		Proportional	
	Total change	Annual change	Total change	Annual change	Total change	Annual change
Linear Regression	54% decline	8.4% decline	58% decline	9.2% decline	53% decline	8.1% decline
Linear Multiplicative	53% decline	8.1% decline	55% decline	8.6% decline	49% decline	7.2% decline

We chose the Proportional method for the 1992–2001 Population Assessment because, other than the preceding year, each year's estimate of occupied survey areas was determined independently from the results from other survey years and all search effort performed during each year was used in the analysis. This method also allowed for the calculation of 90% Confidence Intervals (C.I.) on the results for each year. For the trend analysis, we chose the Linear Multiplicative model because this method is recommended by Resource Inventory Committee and is tied most directly to the raw data by using the annual changes in occupancy. It also provided the lowest rate of decline, and hence, most conservative estimate.

We calculated the 90% C.I. for the annual change in occupancy between 1992 and 2001 by calculating the maximum and minimum slopes of the 95% C.I. for the estimated number of occupied survey areas in 1992 and 2001. The 95% C.I. was used because both years' estimates have error that when analyzed together, the error estimates are multiplied (95% C.I. x 95% C.I. = 90% C.I.).

For the 1992-2001 Population Assessment, we conclude that the number of occupied survey areas declined between 1992 and 2001 by 49% (range 40% to 57% for 90% C.I.) at an average annual rate of -7.2% +/- 1.7% (90% C.I., Figure 4).

Figure 4. Estimated number of occupied survey areas among the 40 survey areas from 1992 to 2001 (with 90% C.I.). The Linear Multiplicative model suggests the number of occupied survey areas declined by about 49% at an average annual rate of -7.2%.



Potential biases

(Comments: 25, 26 and 27)

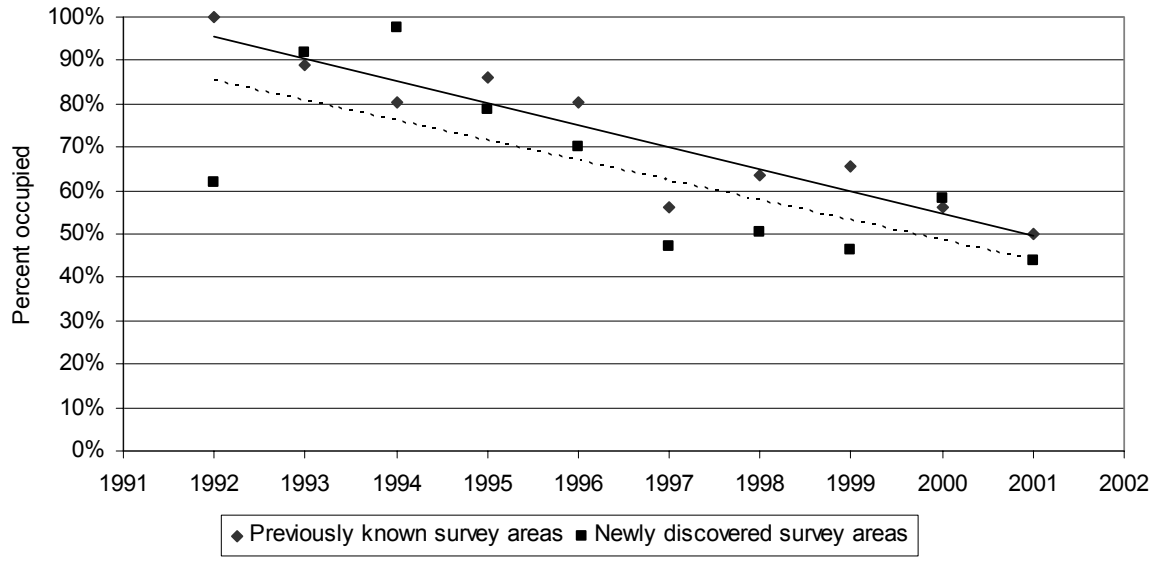
In the 2001 draft report, we discuss several potential biases that may cause an over-estimate or under-estimate in the number of occupied survey areas each year as well as the rate of population decline. Two of these potential biases, discussed below, involve the selection of survey areas used in the assessment.

Did the 16 previously known occupied survey areas influence the observed trend?

Spotted Owls were known to occupy 16 of the 40 survey areas used in the Population Assessment prior to 1992, hence, there is a potential bias towards high numbers of occupied survey areas at the beginning of the 10-year study period. This potential bias would be caused because all 16 survey areas were occupied in the initial year (1992) of the Population Assessment and because Spotted Owls are long-lived territorial birds that generally remain resident within the same geographic area throughout their lives. Conversely, there is a potential bias to under-estimate the number of occupied survey areas if these 16 survey areas became vacant sooner due to age-specific relationships (older birds) than newly discovered occupied survey areas that may be occupied by younger owls.

If these biases occurred, we expected to detect differences in survey area occupancy (percent occupied) each year, and population change between the 16 survey areas occupied prior to 1992 and the 24 survey areas discovered after 1992. We conducted linear regressions on the observed occupancy of survey areas during the 10-year study period at the 16 previously occupied survey areas and at the 24 newly discovered survey areas (Figure 5). The percentage

Figure 5. Percent occupied and relative trends of Spotted Owl numbers for 16 previously known survey areas (solid line) and 24 newly discovered survey areas (dashed line).



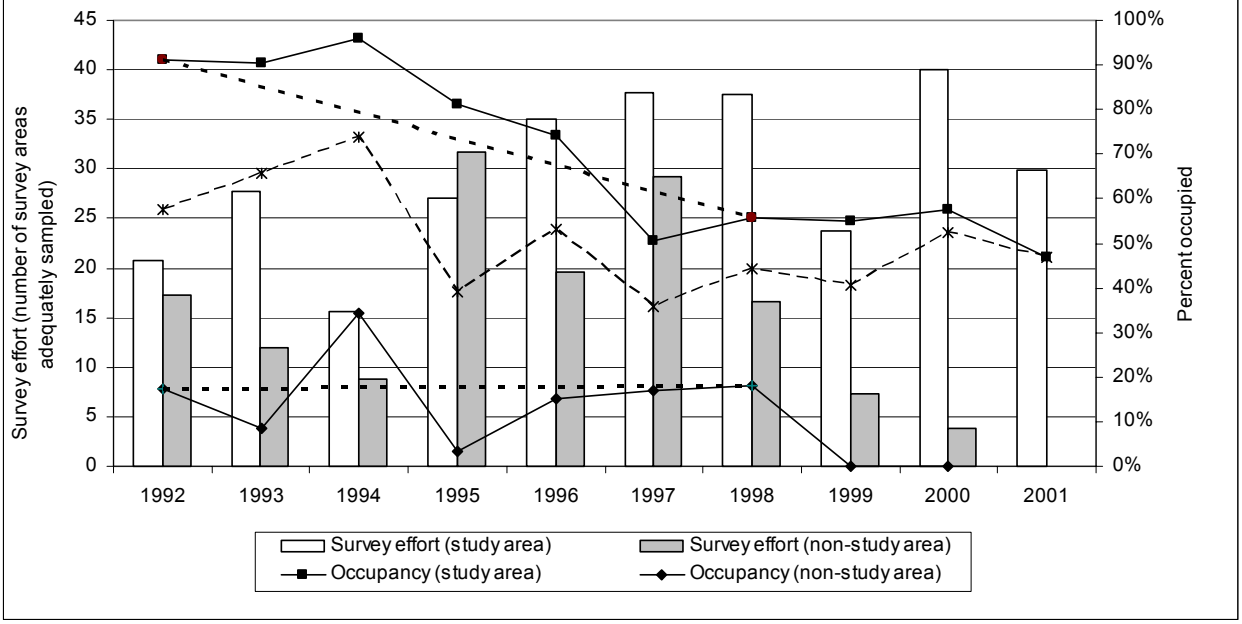
data were arcsine square root transformed and then we used a General Linear Model (SPSS 2001) to compare the slopes of the 2 regressions. We found no significant difference between the slopes of the 2 regressions (ANOVA, F=0.48, d.f.=1, P=0.50). Therefore, we conclude that the 16 previously known occupied survey areas did not influence the number of occupied survey areas or the estimated decline in population any greater than the 24 newly discovered survey areas. Hence, we combined both data sets for the Population Assessment.

How well do the 40 survey areas represent the entire Spotted Owl population in BC?

The number of potential Spotted Owl territories is finite and depends on the territorial behaviour and amount of habitat available to the species. In the southwestern portion of BC where we conducted our study, we estimate about 200 potential 3,200-ha survey areas exist that contain a minimum 50% suitable Spotted Owl habitat. This estimate omits the Squamish and Whistler corridor because Spotted Owls have not been detected in this area since 1979 despite considerable search effort in the 1990's. Between 1992 and 2001, 124 survey areas of the 200 potential survey areas were visited with varying levels of search effort. We observed Spotted Owls at 56 survey areas. Of the 124 survey areas visited, 40 survey areas (20% of the 200 potential survey areas) were used in the Population Assessment.

Sixteen (56 survey areas – 40 survey areas) occupied survey areas did not meet the minimum criteria for inclusion in the study area. We could not assign territorial status to 3 of these occupied survey areas discovered in 1994 despite extensive survey effort performed at these areas in subsequent years. These owls, observed only in 1994, are thought to have been non-territorial floaters. Spotted Owls were confirmed as territorial status at 6 survey areas and owls were detected at least once at 7 other survey areas. However, no further survey effort was performed at these survey areas in subsequent years following the initial owl detection.

Figure 6. Survey effort and occupancy of Spotted Owls in the study area (n=40) and non-study area (n=84). Dashed line is the combined occupancy for both areas. Dotted line is the trend in owl numbers from 1992 to 1998 for the study and non-study areas.



A comparison of occupancy (percent occupied) between the study area (40 survey areas) and non-study area (84 survey areas) during 1992 and 2001 demonstrates a clear difference between the 2 data sets (Figure 6). This suggests that the results from the study area are biased and over-estimates the occupancy if applied to all 200 potential survey areas. One option to reduce this bias is to combine the two data sets and calculate the combined occupancy for each year. However this introduces other biases. First, the combined occupancy is inversely related to the amount of effort performed at the non-study areas. As the amount of survey effort at non-study areas increases, the occupancy decreases, and vice versa. Second, the combined occupancy between 1997 and 2001 suggests that owl numbers increased during this period despite the results from the study area and non-study area data sets both indicate stable or declining occupancies. This bias is caused by the declining effort at non-study areas during this period which resulted in the combined occupancy increasing to resemble the occupancy of the study area. These 2 observed biases suggest a sampling bias towards the 40 survey areas, and therefore, we chose to keep the 2 data sets separate for the Population Assessment.

If Spotted Owls change their territories frequently and/or if territories are not occupied quickly after the resident owls die or move to other areas, then we may expect a bias towards over-estimating the trend (steeper decline) at the 40 survey areas than the “true” population trend. This is due to the 40 survey areas returning to a state of equilibrium with the “true” population trend. If this bias was occurring, we expected the occupancy of owls in the non-study areas to increase as the occupancy of owls within the study area decreases. A comparison of the 1992 to 1998 results indicates that the occupancy in the non-study area did not increase, but remained relatively stable, while the study area decreased (Figure 6). This comparison omitted data from 1999 to 2001 due to the low sample size in the non-study during this period. This suggests that Spotted Owls are not replacing themselves outside of the study area (in the non-study area) at the same relative rate that the owls are declining within the study area. Therefore, we conclude that the results from the 40 survey areas is a reliable representation of the status of the entire “true” Spotted Owl population in BC.

Suitable habitat within the Chilliwack and Squamish Forest Districts.

(Comments: 7, 8, 10, 36 and 37)

The percent suitable habitat within the study area and SRMZs in the 2001 draft report was based on information from the Spotted Owl Resource Management Plan (RMP). We used the percent suitable habitat within each Long-term Activity Centre or survey area. Suitable habitat was defined as forested polygons below 1,370 m in elevation and older than 100 years (age classes 6, 7, 8 and 9). However, the percent suitable habitat in the 2 forest districts was from a different habitat analysis that included forest polygons below 1,370 m in elevation and older than 100 years, but excluded all forest polygons with overstory trees shorter than 19.4 m tall (height classes 1 and 2). In both analyses, the amount of suitable habitat was estimated where data gaps occurred in our habitat analysis of SRMZ and the 2 forests districts. Given the two habitat analyses and habitat data gaps, we labelled the report “draft” until these discrepancies could be remedied.

In 2002, we re-analyzed the most recent forest cover data for both forest districts using forest polygon age, height and elevation to determine capable and suitable habitats. Data gaps in forests cover were reduced but still exist for the Seymour watershed and Golden Ears Provincial Park, both of which fall within the boundaries of SRMZs 9 and 7, respectively. These areas represent 17% of the forested area within all SRMZs. For the habitat analysis, we assumed that

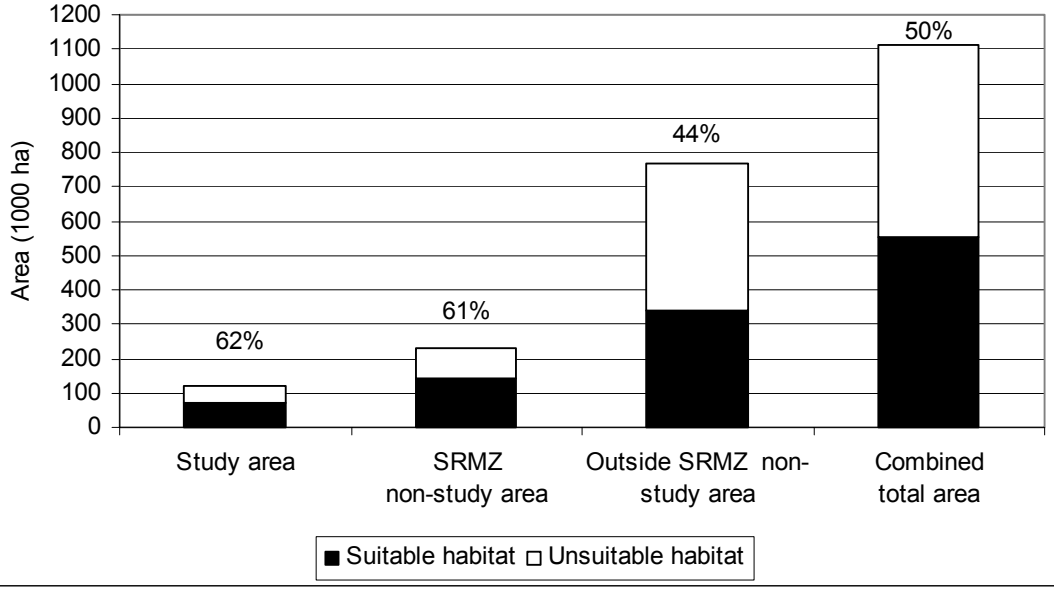
67% suitable habitat was distributed uniformly in these habitat gaps.

For the 1992 – 2001 Population Assessment, the amount of habitat was determined within the study area, SRMZs (non-study area) and outside SRMZs (non-study area) based on the total gross forested area (Figure 7). We did not differentiate between the 2 forest districts simply because Spotted Owls do not differentiate between these 2 areas. The Squamish Forest District is about ½ the size of the Chilliwack Forest District. However, there is a higher percentage of suitable habitat in the Squamish Forest District (58%) than in the Chilliwack Forest District (47%). Excluding the study area and SRMZs, the percentage of suitable habitat is 55% and 40% for the Squamish and Chilliwack Forest Districts, respectively.

We estimate that SRMZs are capable of eventually supporting 101 Long-term Activity Centres, which, on average, currently contain 62% (+/- 15% SD, n = 101) suitable habitat (Figure 8). Forty-four of these Long-term Activity Centres currently contain less than 67% suitable habitat. Resource Management Plans estimate it will take up to 60 years for these 44 Long-term Activity Centres to attain the minimum 67% suitable habitat requirement. Clear-cut harvest with some structural retention (termed Heavy Volume Removal) in suitable habitat is allowed in 14 Long-term Activity Centres which contain greater than 67% suitable habitat. Eight of these 14 Long-term Activity Centres fall within the 40 survey areas used in the Population Assessment.

The suitable habitat model is a coarse filter approach that identifies some stands as suitable when they are not. Suitable habitat should not be defined by forest age, height and elevation alone, but classified based on the stand level structural characteristics. Unfortunately, this detail is limited to only a few stands, and therefore, we relied on forest cover data. It is also unknown how much of the suitable habitat identified from maps is actually suitable and could be used by Spotted Owls. A large portion of the suitable habitat identified represents small patches of mature and old forest surrounded by extensive areas of unsuitable young forest. It is unlikely that these suitable patches will be used by Spotted Owls to establish territories until a larger

Figure 7. Estimated amount and percentage of potential suitable habitat within the study area, SRMZ non-study area, outside SRMZ non-study area, and combined total habitat in the 2 forest districts (data source: MSRM 2002).

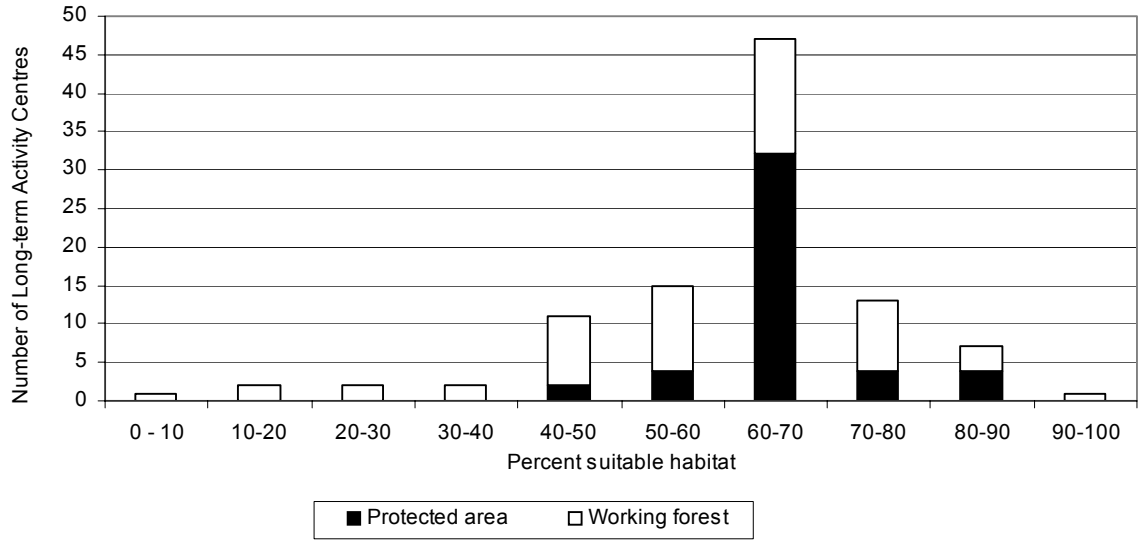


proportion of the surrounding unsuitable habitat becomes suitable. This has likely resulted in an over-estimate of the current amount and distribution of suitable habitat.

MWLAP, subject to resource allocations in 2002, is currently working on a landscape habitat model to predict owl territory capability based on percentage of suitable habitat available within the landscape. This will assess fragmentation of habitats and distances between potential owl territories to help estimate how much suitable habitat is "useable" by Spotted Owls. This landscape habitat model will also assess the level of fragmentation within owl territories and survey areas. However, a direct comparison on the level of fragmentation between occupied and vacant survey areas would be difficult due to the small population size and because the species' distribution throughout the range may be influenced by other factors external to the amount of habitat and fragmentation within survey areas. As well, a comparison of the percentage of suitable habitat within occupied (mean = 62% +/- 13% SD) and vacant (mean = 62% +/- 11% SD) survey areas was not significantly different (t-test, t = 0.1, df = 35, P = 0.92).

The suitable habitat model used in the Population Assessment does not consider the contribution of forests younger than 100 years. MWLAP's preliminary results from a study of habitat-use by Spotted Owls do not support a preference by the owl for younger forests over older forests. The study did demonstrate that some young forests (age class 5 and 4) were used, but upon stand inspection these particular young forest stands exhibited characteristics similar to older forests. Young forests can be used for owl movement and dispersal, but the minimum stand criteria are unknown. Some reports suggest that owls will move through young forests, but still seek old and mature forests for foraging and roosting. A concern is whether or not the owls are flying within or above the young forest canopy. If an owl must fly above the canopy because the young forest is too dense or short, then the owl is exposed to increased predation. Another concern is whether dispersing owls can find sufficient old and mature forest in which to forage, as otherwise they may not obtain sufficient food during emigration and succumb to starvation.

Figure 8. Frequency distribution of percent suitable habitat in Long-term Activity Centres. Protected areas represent Long-term Activity Centres that are 100% within areas not subject to timber harvest.



Territory occupancy: historic and present

(Comments: 4, 9 and 24)

Various studies in the United States have used simulation models to predict territory occupancy based on the size of suitable habitat patches (i.e., number of potential territories) and the distance between adjacent patches that owls must move through to disperse and successfully establish a new territory. The results vary depending on the parameters used in the model. However, the general trend is that the larger the patch size and/or the closer the patches are together, the higher the percentage occupancy and the greater the chance of stabilizing the population.

Given the relatively small size of SRMZs (average 5.4 Long-term Activity Centres; range 2 to 13) and distance between SRMZs (average 15 km apart) there is a possibility that not all Long-term Activity Centres would be occupied in any given year. This is particularly true over the short-term given the required 60-year period to recruit the minimum 67% suitable habitat target in 44 Long-term Activity Centres. Therefore, it is expected that the current occupancy (percent occupied) in SRMZs is lower now than in the future when amounts of suitable habitat increase in SRMZs. A key conservation question is, “what level of occupancy is considered a stable and secure population?”. If the population stabilizes at the current occupancy level, then the hypothetical scenario identified in the Population Assessment report that the Spotted Owl population will stabilize in response to stabilizing amounts of suitable habitat may be true. Even so, this low occupancy (small population size) provides a high risk of extirpation due to it’s vulnerability to stochastic environmental events.

The occupancy observed in BC may be confounded by the “packing” hypothesis that predicts owls displaced by habitat loss elsewhere will move into the more stable habitats found in SRMZs and Matrix Activity Centres. If true, this would result in an aggregation of Spotted Owls in SRMZs and Matrix Activity Centres and an over-estimation of the occupancy of Spotted Owls throughout the range of the species. Such a bias would lead to observing a more abundant, stable population when it is actually declining.

Historically (pre-European settlement), habitat patch sizes were large and distances between habitat patches were likely negligible. Although natural disturbances, human disturbances and land features may have created geographic or habitat barriers for owl movements, for the most part, habitat patches were likely large and close to other patches. Occupancy was likely high in this historical landscape.

Historic (pre-European settlement) population estimates

(Comments: 4 and 5)

The historic pre-European owl population estimate from the Population Assessment report is based on the assumption that 60% - 67% of the capable forested area (including the Lower Mainland area) was forests older than 100 years. This assumption is from the Forest Practices Code Biodiversity Guidebook (page 92, based on mean disturbance return interval for CWH and IDF Biogeoclimatic zones). The density of Spotted Owls depends on the percentage of habitat available in the landscape. These historical habitat conditions mirror the habitat objectives of the Spotted Owl Management Plan. Based on these similarities, we applied the median annual home range size estimates of Spotted Owls to the historically capable forested area (Table 8).

Table 8. Estimated number of potential Spotted Owl territories based on the historic capable forested land area within the Lower Mainland and Chilliwack and Squamish Forest Districts.

Geographic Region	Capable forested area	Estimated owl territories
Chilliwack (includes TFL 26, parks and GVRD)	767,411 ha	320
Squamish (includes TFL38 and parks)	418,045 ha	174
Lower Mainland (estimated)	150,000 ha	62
	1,335,456 ha	556

This calculation assumes a median annual home range of 3,200 ha and a home range overlap of 25% between adjacent resident owls. Assuming that up to 90% of the 556 potential territories were occupied by a pair of owls at any one time, this analysis suggests that up to 500 breeding pairs of Spotted Owls may have occurred historically in the Lower Mainland and the Chilliwack and Squamish Forests Districts. The contribution of forests within the Sunshine Coast, Lillooet and Merritt Forest Districts were not considered in the historic population estimate. Doing so, this would have increased the historic population estimate.

There is an issue regarding the historic contribution of forests in the Interior Douglas-fir Biogeoclimatic zone for Spotted Owls in the Chilliwack and Squamish Forest Districts. The Natural Disturbance Type for the IDF is ecosystems with frequent stand-maintaining fires. Arguments have been made that current forest conditions in the IDF zone are not naturally occurring, but are a result of fire suppression. Therefore, because Spotted Owls use some of these current forest conditions, the owl's occurrence in these areas must have begun only after implementation of fire suppression policy. However, there is no evidence to suggest that the owl did not occupy suitable habitat in this area historically.

On the contrary, the IDF zone in the Chilliwack and Squamish Forest Districts is largely comprised of the wettest subzone in this Biogeoclimatic zone (IDFww) which suggests that this subzone likely burned less often than dryer subzones. There are numerous refugia (areas that infrequently burn) of old and mature forests in the IDFww, due to the numerous creeks and mountainous terrain, as well as, the abundance of forests with northerly aspects that tend to burn less frequently than forests with southerly aspects. Furthermore, the IDF zone is a narrow band of habitat found along the valley bottom at lower elevations. The Coastal Western Hemlock (CWH) zone, the zone in which the majority of all owl habitat occurs, is found at mid-slope directly above the IDF zone. The Natural Disturbance Type for the CWH in these areas is ecosystems with infrequent stand-initiating events. Therefore, these forests likely burned less frequently. There is no reason to believe that Spotted Owls did not reside, at minimum, within these the CWH forests.

Fire suppression may have increased the amount of suitable habitat in the IDF zone, which may have increased the number of Spotted Owls in the area. However, this potential benefit may be offset by the urbanization and timber harvesting that has occurred in the IDF zone since European settlement. Regardless of this uncertainty, the contribution of the IDF zone is small relative to the CWH zone within the Chilliwack and Squamish Forests Districts, and would not substantially alter the calculated size of the historic population.

Current population estimates

We estimated the current Spotted Owl population size in British Columbia as follows. Starting with Dunbar *et al.* (1991) estimated number of Spotted Owls in BC of less than 100 breeding pairs in 1991, we applied our observed 1992 to 2001 population decline of 49% which suggests that the current 2001 Spotted Owl population estimate may be less than 50 breeding pairs.

To support or refute this estimate, we performed another analysis using the data from our study. In the southwestern portion of BC where we conducted our study, we estimate about 200 potential 3,200 ha survey areas exist that contain a minimum 50% suitable Spotted Owl habitat. This estimate omits the Squamish and Whistler corridor because Spotted Owls have not been detected in this area since 1979 despite considerable search effort in the 1990's. Between 1992 and 2001, we surveyed for Spotted Owls at 124 of these 200 potential survey areas; 40 survey areas within the study area and 84 survey areas at non-study areas. To calculate the population size, we multiplied the sample size for both study and non-study areas with their respective occupancies to estimate the total number of occupied survey areas (Figure 8). Because search effort was low between 1999 and 2001, we used the occupancies for 1998. Furthermore, because the search effort was highly variable at the 84 non-study survey areas, we reduced this sample size from 84 survey areas down to 60 survey areas to reduce the potential bias of underestimating the population size. Therefore, our estimate of owl population size is conservatively based on 100 survey areas (40 study and 60 non-study survey areas). This estimate was then doubled to account for the 200 potential survey areas. This method estimated a population of 66 occupied survey areas in 1998. To obtain an estimate for 2001, we multiplied the 1998 population estimate by the 16% decline observed between 1998 and 2001 at the 40 survey areas. Based on this analysis, we estimate the 2001 Spotted Owl population at 55 occupied survey areas in British Columbia.

There is a discrepancy in definitions between the use of "breeding pairs" by Dunbar *et al.* (1991) and "occupied survey areas" used in the Population Assessment. In the past, it was assumed that a response by a Spotted Owl reflected a territorial owl with a mate. However, survey efforts between 1992 and 2001 were unable to detect a mate or an individual of the opposite sex in the same year within 13 (33%) of the 40 survey areas. This suggests that a response by a Spotted Owl may not necessarily reflect a breeding pair of owls. If the definition of "breeding pairs" by Dunbar et al. (1991) actually represents occupied territories (survey areas), then we conclude that the results of the 2 population estimate methods are similar (50 to 55 occupied survey areas).

There are several correction factors that should be considered when estimating the current Spotted Owl population. Both methods do not account for the number of Spotted Owls found in the Lillooet, Merritt and Sunshine Coast Forest Districts. Spotted Owls have been found in the Lillooet Forest District and preliminary estimates suggest that perhaps 10 occupied survey areas occur there. Limited survey effort has been performed in the other 2 districts and therefore, no estimates have been made on the number of Spotted Owls within these districts. However, we suspect that the number of owls in these 2 districts will be low. Therefore, we conclude that the current number of occupied survey areas in BC is estimated at fewer than 65 occupied survey areas (territories).

From a conservation perspective, we are more concerned with the number of pairs of Spotted Owls (potential breeding population) in the population. If we assume that 33% of all occupied survey areas are inhabited by single owls (as suggested by survey data collected from 1992 –

2001), then we conservatively estimate that fewer than 45 breeding pairs of Spotted Owls occur in BC. However, this estimate is based on survey areas where mates could not be detected in any year during the 10-year study period. Although mates were detected at least once at 67% of occupied survey areas, our data do not support that these survey areas were occupied each year by owl pairs during the study. Therefore, we suspect that the number of breeding pairs is lower than our estimated 45 breeding pairs of Spotted Owls.

Spatially-explicit simulation model

(Comments: 1, 3 and 11)

Models are tools that allow for comparisons between management scenarios, but, models may not predict accurately population responses to each scenario. This is due to the sensitivity of parameters used in the model. Changing the value of some parameters can quickly change the population's response from immediate extirpation to immediate increase in size. Furthermore, there is an increasing chance of a wrong prediction with increasing numbers of parameters used. However, the comparison of populations for different management scenarios allows for general trends/indicators of the population's potential response to these management actions.

A spatially-explicit model was developed by Don Demarchi and Dr. Carl Walters (University of British Columbia) to predict the outcome of the Spotted Owl population to various management scenarios. MWLAP was involved in the model development. The model employs a two-tiered approach. First, based on the management scenario and timber harvest rate, the model, as used by MWLAP, predicts habitat change (harvest and re-growth) spatially at a 100-ha scale and temporally over 100 years. Then, an individual-based model, that simulates the movements and fates of individual owls depending on the habitat they encounter, uses each habitat change scenario to predict the population outcome over 100 years.

In 1996, the simulation model was used by MWLAP to assess 4 of the 6 management options presented by the Spotted Owl Recovery Team (see Appendix 2). A recent review of this preliminary report identified that the rates of population change were recorded incorrectly, albeit minor errors, and are corrected in Table 9. The simulation model predicted that Option H, which maintains 67% suitable habitat within SRMZs (Spotted Owl Management Plan), would result in an owl population decline of about 25% over the next 20 years (short-term) at an average rate of -1.5% per year. After which, the owl population stabilizes at this lower level for about 50 years

Table 9. Corrected rates of population change under 4 management options assessed by WLAP using the spatially-explicit simulation model (see Appendix 2).

Management Option	0 to 20 years		20 to 70 years		70 to 100 years	
	Total change	Annual rate	Total change	Annual rate	Total change	Annual rate
Option C	25% decline	-1.5%	105.6% increase	1.5%	48.7% increase	1.4%
Option H (SOMP)	25% decline	-1.5%	27.8% increase	0.5%	56.5% increase	1.6%
Option N	36% decline	-2.3%	no change	0.0%	50.0% increase	1.5%
Interfor's Option	37% decline	-2.4%	35% decline	-0.9%	9.1% increase	0.31%

(0.5% annual growth), and, then increases more rapidly in 70 years (1.6% annual growth) from the initial year of the simulation. The greater rate of population increase 70 years from 1996 coincides with all SRMZs attaining the 67% suitable habitat target. A short-term decline is predicted under all 4 options analyzed, including the Recovery Team's Option C which stopped all clear-cutting in SRMZs.

The results presented by MWLAP most closely reflect what is expected by a declining population in response to recovery actions. This includes a decline followed by population stabilization in response to stabilizing habitat levels and a gradual increase in population size in response to increasing habitat availability. Two key findings are drawn from the results of the model. First, the Spotted Owl population size may increase sooner than 70 years (as predicted for the Spotted Owl Management Plan - Option H) in response to increasing the amount of habitat protected above the 67% habitat target within SRMZs (Option C). Similarly, the results suggest that the owl population size may increase sooner by reducing the time required to attain the 67% habitat target in SRMZs by accelerating the recruitment of suitable habitat through forest stand treatments (thinning). Second, reducing the Annual Allowable Cut, and subsequently maintaining higher retention levels of owl habitat in the landscape, increases the chance of stabilizing and increasing the owl population size. Combining this cut reduction with aggregating the higher habitat retention levels in SRMZs greatly increases this chance of population recovery compared to simply reducing the cut level.

The results of the simulation model provided MWLAP with assurances that the Spotted Owl Management Plan would provide a reasonable chance that the owl population would stabilize. The results also provided MWLAP with an index by which predicted (simulation model) and observed (population assessment) population responses can be compared. The observed population trend from 1992-2001 does not support the results of the simulation model, and indicates the population is declining at over 4.8 times faster than the rate predicted rate by the simulation model. The chance of stabilizing the population is considerably less than previously expected.

Species at the periphery of their range

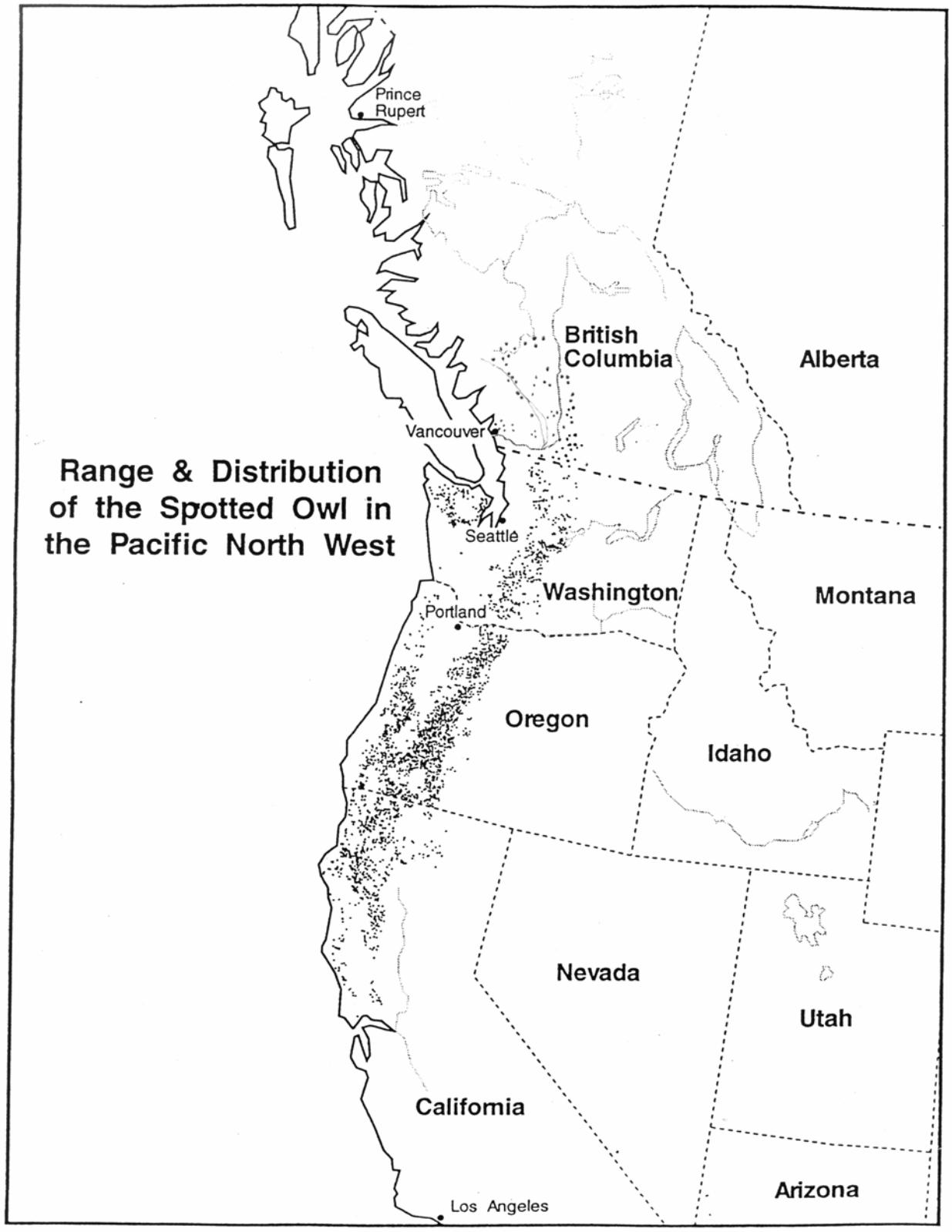
(Comments: 6 and 43)

Spotted Owls in BC occur at the northern periphery of the species range in North America (Figure 9). The Canadian Spotted Owl Recovery Team asserts that peripheral populations are important to a species' survival for 3 reasons. First, the risk of extinction of a species is reduced by maintaining individuals over the widest possible distribution and habitat types. Second, peripheral populations are often sites of the most rapid genetic adaptations within a species. Third, peripheral populations are likely best adapted to the unique climate/habitat conditions that prevail in these areas, and therefore, the species would be better able to persist if similar conditions became prevalent in other portions of its range.

Environmental conditions

At the periphery of a population, there are several population responses that could be observed depending on the life history of the species. Species with high annual reproductive rates and high juvenile survival rates, may expand into, rapidly exploit and occupy habitats that become temporarily suitable due to favourable environmental conditions. However, once the

Figure 9. Range and distribution of Northern Spotted Owls in North America.



environmental conditions become unfavourable, the population may experience rapid mortality and decline until the environmental conditions become favourable again. Conversely, species with low reproductive rates and low juvenile survival rates (such as Spotted Owls), may, slowly over many years, exploit and occupy habitats that become temporarily suitable. Once the environmental conditions become unfavourable, the population may experience rapid mortality and decline until the environmental conditions become favourable again. Due to the slow rate of population growth, if unfavourable conditions are frequent then these species likely will be unable to expand into, exploit and occupy these temporary suitable habitats.

The observed rapid decline of the Spotted Owl population over the last decade may be attributed to unfavourable environmental conditions, particularly with the observed 32% decline between 1996 and 1997. However, the population was also observed to decline by about 23% between 1994 and 1996 and by 19% between 2000 and 2001. This suggests either the environmental conditions have been frequently unfavourable over the last decade or other factors are also contributing to the observed decline. Figures 10 and 11 display the temperature and precipitation departures from normal between the winter 1995/96 and summer 2001. The 1996 to 1997 decline in Spotted Owl number may have been attributed to unfavourable environmental conditions with a colder fall (2 degrees below normal) and wetter fall and spring (60% above normal precipitation). However, the decline observed in 2000 to 2001 does not appear to be a result of unfavourable environmental conditions because temperatures were normal and precipitation 25% and 45% below normal in the fall and winter, respectively, but 20% above normal in spring. Unfortunately, the data were only available for 1996 to 2001, limited to averages for specific seasonal periods, and did not identify severe weather events.

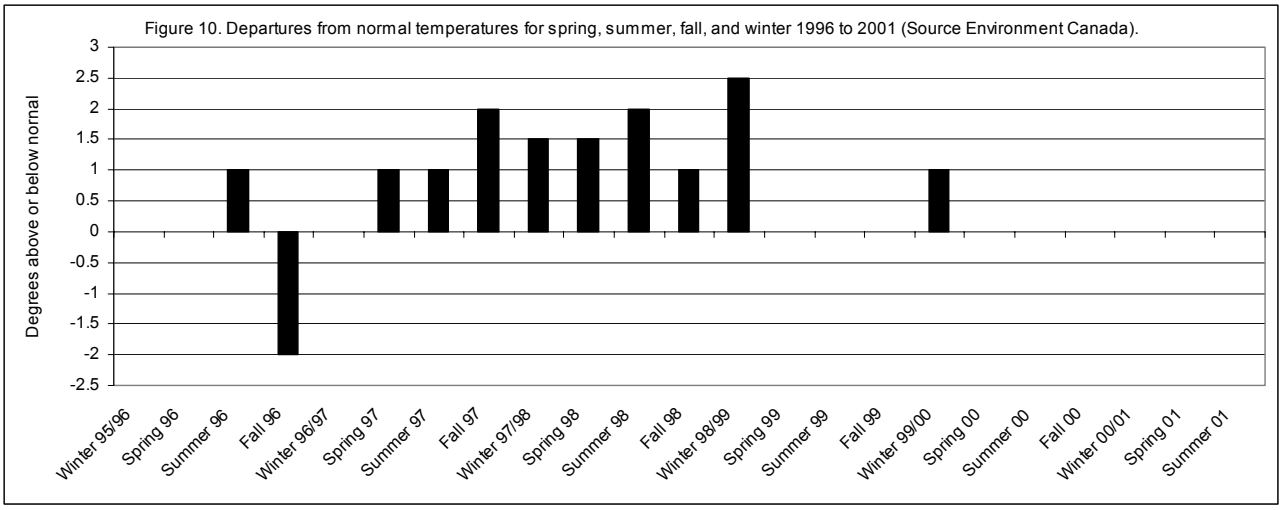
The long known presence of Spotted Owls in BC and the observed separate winter ranges of some Spotted Owls suggest that they are adapted to environmental conditions at the northern periphery of its range. The rapid decline in Spotted Owl numbers does not appear to be solely attributed to unfavourable environmental conditions.

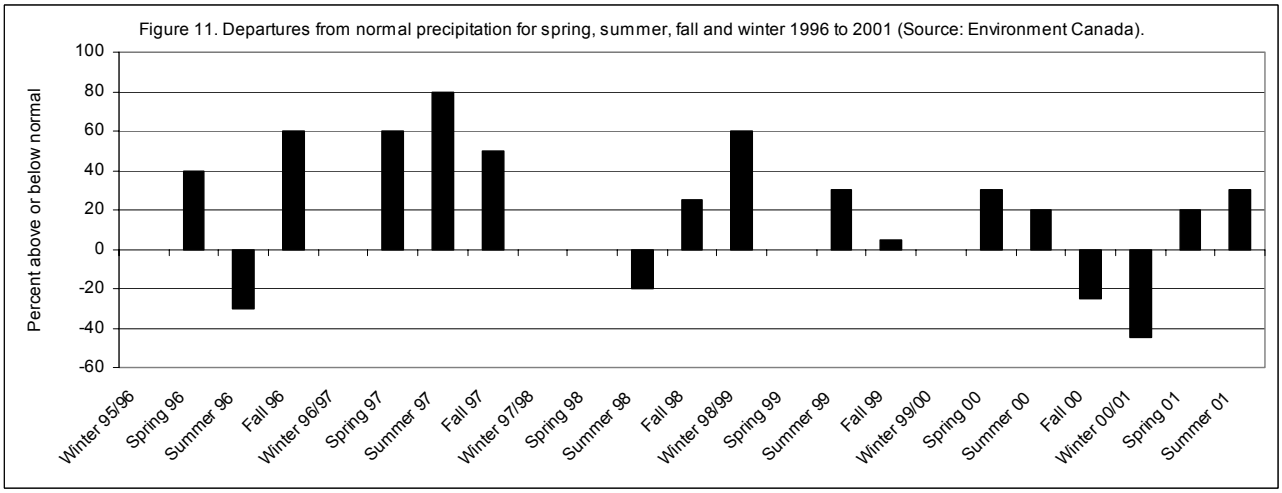
Spotted Owl density

Under ideal habitat conditions, the density of Spotted Owls in the northern periphery of its range in North America is less than the density of owls found further south. This occurs because home range sizes used by Spotted Owls increase with latitude. The larger home range size may be the owl's response to decreased habitat quality and a need to exploit more habitat to obtain sufficient prey throughout the year. The resulting lower density, and hence smaller population size, could have a greater influence on the observed rates of population change than elsewhere in the species' range. For example, the loss of one individual from a population of 100 is a 1% decline, while the loss of 1 individual from a population of 10 is a 10% decline. Regardless of reasons for the low density of Spotted Owls in BC, from a conservation perspective, there is a greater risk of imminent extirpation for the smaller population.

Population connectivity to the United States

The Spotted Owl population in BC is continuous with the owl population in the United States. However, the contribution of Spotted Owls immigrating from the US, and thus sustaining the BC population, may be limited. Based on banded and radio-marked owls, median (50%) natal dispersal distances of Spotted Owls were about 14 km for males and 24 km for females. The





maximum dispersal distance recorded is 125 km from the natal area (Eric Forsman, pers. comm. 2002). Therefore, the further the US populations are from BC, the lesser the influence these owls likely have on the observed population trend in BC. As well, the benefit of this immigration must be weighed with the loss of BC owls emigrating to the US. If there is an equal density of Spotted Owls on both sides of the border, then the rate of immigration and emigration may be equal with no net benefit to BC. Furthermore, if Spotted Owls in BC were sustained by immigration, then we should not have observed a decline, particularly adjacent to the International Border.

Habitat protection and timber harvesting between 1992 and 2001

(Comments: 34, 35, 44 and 45)

Timber harvesting within the 40 survey areas was limited between 1992 and 2001. Twelve (30%) survey areas received protection prior to 1992 due to overlaps with protected areas, old-growth study areas and the Greater Vancouver Water District. Nine of these were originally old-growth study areas established in 1989 and were incorporated into SRMZs; 3 of these became new protected areas in 1997.

In 1993, an Interim Conservation Strategy (ICS) was established to maintain options for Spotted Owl conservation until a recovery option has been chosen by government, and to minimize the impacts on 1993 and 1994 planned harvest levels, as much as possible. The strategy maintained up to 67% suitable habitat within 3,200-ha activity centres around known owl locations. If planned cut blocks would negatively impact critical owl habitat or if less than 67% habitat occurred within the activity centre, mitigative strategies were developed. These strategies included short-term deferrals of cut blocks, modifications to approved cut blocks and/or a “log around” strategy that identified alternate cut blocks outside of these Spotted Owl locations. The Interim Conservation Strategy resulted in the protection of an additional 9 (23%) survey areas in 1993, and provided provisions to expand this strategy if new Spotted Owl locations were discovered. Inventories between 1993 and June 1995 resulted in the discovery and application of the Interim Conservation Strategy to an additional 15 (38%) of the 40 survey areas.

In 1995, the provincial government announced its preferred option for Spotted Owl management and directed government staff to develop the Spotted Owl Management Plan. Similar to the habitat protection measures of the ICS, this decision resulted in the short-term protection of SRMZs and all Spotted Owls found prior to June 1995. In addition, Spotted Owls discovered at 3 other survey areas after June 1995 were afforded temporary protection pending the completion of Landscape Unit planning process. As a result, 39 of the 40 survey areas received short-term protection until the Spotted Owl Management Plan was approved in 1997.

After 1997, the 29 (73%) survey areas in SRMZs were extended protection until the Spotted Owl Resource Management Plans were completed in 1999 to direct all future timber harvest activities in SRMZs. These 29 survey areas in SRMZs are managed to maintain a minimum 67% suitable habitat within each Long-term Activity Centre. Eight survey areas in SRMZs have greater than 67% suitable habitat, and therefore, have opportunities for clear-cut harvest (Heavy Volume Removal). By 2001, 6 of these 8 survey areas had some harvesting. In addition to clear-cut harvest, partial harvests, that remove up to 33% of the timber volume, is allowed within the retained 67% suitable habitat (excludes protected areas) to create, enhance and maintain suitable habitat conditions. By 2001, only a small amount of partial harvests in survey areas have occurred.

By 2001, 4 of 7 Matrix Activity Centres (owls found outside SRMZs prior to June 1995) and 1 of the 3 additional survey areas protected until the completion of the Landscape Unit planning process had some clear-cut harvest activities.

In summary, 39 of 40 survey areas received substantial habitat protection during the study, with 28 (70%) survey areas remaining largely protected during the most of the study. Most timber harvesting activities occurred post 1997 following the observed large decline in numbers of owls.

Between 1992 and 2001, several timber supply reviews were performed with new Annual Allowable Cuts (AAC) determined by the Chief Forester for both Fraser (Chilliwack Forest District) and Soo (Squamish Forest District) Timber Supply Areas. In 1995, the Chief Forester's AAC determination for the Fraser TSA recognized that "Areas affected by Spotted Owl habitat and the PAS (Protected Areas Strategy) alone occupy approximately 22% of the long-term timber harvesting land base of the TSA", and that "…Spotted Owl management will undoubtedly have a significant impact on timber supply...". However, until the formal land-use decision is made, the Chief Forester "made no adjustment at this time to the AAC in relation to the timber supply impacts caused by Spotted Owl management.". The Chief Forester recommended the implementation of an interim AAC reduction until the land-use decisions are made. This recommendation was not implemented. In 1996, the Chief Forester's AAC determination for the Soo TSA stated he could not consider Spotted Owls until the Provincial Government approved the Spotted Owl Management Plan. "Spotted Owls and the PAS alone occupy approximately 30 percent of the long-term timber harvesting land base of the TSA". The Chief Forester accounted for Spotted Owl habitat protection measures in April 1999 and October 2000 for the Fraser and Soo TSAs, respectively.

As a result of the minimal timber harvest activity within the 40 survey areas and the mitigation strategies applied to minimize direct impacts on critical owl habitats, we do not suspect a direct correlation between the observed population decline and the harvest activities within survey areas. However, the increase in timber harvesting and habitat loss since 1997 in 11 survey areas may result in further declines in owl numbers.

The mitigation strategy to "log around" these owl areas to maintain forestry jobs and timber volume requirements may be correlated to the population decline. The "log around" approach concentrated timber harvesting and increased the rate of habitat loss in areas outside of SRMZs and Matrix Activity Centres. Any Spotted Owl living in these areas may have experienced higher levels of habitat loss than normal which may have resulted in increased mortality, displacement or decreased reproductive success. As well, habitat outside of owl areas is needed for dispersal. The increased habitat loss, as a result of the "log around", may have lowered the likelihood of dispersal success. It is unlikely that the "log around" alone caused the population decline, but it is highly likely that it made habitat conditions outside of owl areas worse than had the AAC been reduced to accommodate Spotted Owls.

Competitors and predators

(Comments: 38, 39 and 40)

Barred Owl

The influence of Barred Owls on Spotted Owls, and vice versa, is poorly understood and likely to be the subject of increased attention throughout the Pacific Northwest. There is no doubt that Barred Owls have influenced Spotted Owl numbers. The United States is currently experiencing rapid Barred Owl population growth and range expansion. In many cases, US researchers have observed Spotted Owls being displaced by Barred Owls, and some have reported direct mortality of Spotted Owls by Barred Owls. This displacement suggests that Spotted Owls will eventually be out-competed by Barred Owls. To further complicate the issue, cross breeding has occurred between the two species, however this is not uncommon among bird species.

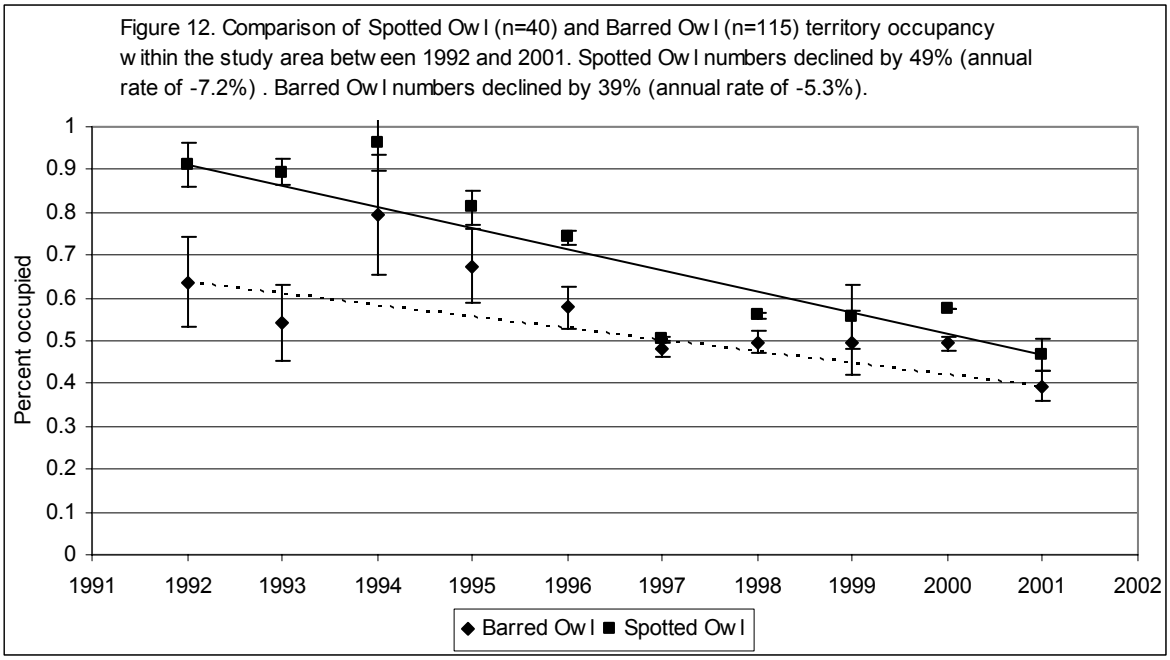
A research study near Mount Baker in Washington State reported divergent life histories and habitat requirements between the two species. For example, Barred Owls tend to use more uniform stands and tend to take prey found on the forest floor while Spotted Owls use more structurally diverse stands and tend to take more arboreal prey. These differences between the species suggest that both species can co-exist in the same geographic area, although exploiting different forest stand types. In the absence of one of these species, it is reasonable to expect that the other species would better exploit a broader range of forests stand types and prey. This may explain the displacement in the US of some Spotted Owls by Barred Owls as both species exploit and extend into different forest stand types.

In BC, Barred Owls are more abundant than Spotted Owls and occur throughout the Spotted Owl's range. Most Barred Owls detected during Spotted Owl surveys tend to occur along the valley bottom near riparian habitats; Spotted Owls tend to occur at the mid to upper elevation where the majority of old forest exists. A preliminary draft analysis of Barred Owl territory occupancy within the 40 survey areas observed a decline in Barred Owl numbers similar to the Spotted Owl (Figure 12). Several scenarios can be hypothesized to interpret the similar population decline.

First scenario: The results suggest that Barred Owls are not displacing Spotted Owls, but Barred Owls are affected similarly by factors causing the Spotted Owl decline (such as habitat availability, environmental conditions, prey availability and predators). If the influences of these factors remain unaltered, the both species will become eliminated from these 40 survey areas. Because Spotted Owls do not appear to be moving to new areas, this continued decline may result in the species' extirpation.

Second scenario: The large number and widely distributed Barred Owl population suggests that this species possesses viable populations and is not in danger of becoming extirpated. Barred Owls are similar to Spotted Owls, and therefore, they could be considered an indicator species to assess the state of the Spotted Owl population. If the Barred Owl population is viable, then

Figure 12. Comparison of Spotted Owl (n=40) and Barred Owl (n=115) territory occupancy within the study area between 1992 and 2001. Spotted Owl numbers declined by 49% (annual rate of -7.2%) . Barred Owl numbers declined by 39% (annual rate of -5.3%).



the observed decline in Barred Owl numbers may be a natural occurring fluctuation in numbers, and we would expect the population to begin to increase in the future. Because Spotted Owls demonstrated a similar decline, perhaps, the Spotted Owl numbers are also naturally fluctuating and will eventually increase in numbers. If true, these natural fluctuations still pose a significant risk of extirpating the Spotted Owl because its small population size may be incapable of producing enough young to offset the decline.

Third scenario: The results demonstrate competition between the 2 species of owls. The decline in numbers is in response to both species competing for the same resources. Once these resources are exhausted, both species will be affected and decline in numbers in the geographic area where they competed. However, because Barred Owls are more abundant and wide spread, as these resources are replaced, the remaining species (Barred Owl) will re-occupy the geographic area. However, if Barred Owls also declined at non-Spotted Owl areas, then the Spotted Owl decline may not be attributed to competition.

The Barred Owl occupancy assessment is preliminary and requires further analysis, including an assessment of Barred Owls at the 84 non-study survey areas, and further discussion on these 3 scenarios. Subject to 2002 resource allocations, MWLAP anticipates this further analyses and completion of this report by March 2003.

Predators

Predators could influence the number of Spotted Owls. For these predators to be the main cause for the decline requires an increase in the number of predators over what would be considered normal predator numbers (i.e., the rate of mortality caused by predators must be higher than normal otherwise the species would have been extirpated long ago). However, Spotted Owls would likely only be incidental prey for these predators. It is possible that the presence of new predators into a Spotted Owl's territory may result in the displacement of the owl. The degree to which a Spotted Owl would be displaced is unknown, and it is unlikely that this would exclude the Spotted Owl from all of its 3,200-ha territory. Spotted Owls may use alternate nest sites in differing years possibly as a mechanism of predator avoidance. We have observed several Northern Goshawks mobbing Spotted Owls, as well as, Great Horned Owls residing in the same landscape as Spotted Owls. We did not observe mortality, injury or displacement of Spotted Owls that we could attribute to predators.

Comparison with the United States

(Comments: 41 and 42)

A -3.9% +/- 3.6% (95% C.I.) annual decline between 1985 and 1998 was observed in the US. This was based on 15 demographic studies using mark and recapture that determined recruitment and mortality rates. This assessment covered about 23% of the range of the Spotted Owl in the US and occurred on federal, Native American Tribal, and private lands. The US considers this rate of decline a positive response over previous trend estimates that suggest the population was declining at an estimated average rate of -4.5% per year. The US attributes this slowing of the rate decline, in part, to habitat protection measures implemented in the early 1990's to conserve the species, as well as reconsideration of juvenile immigration.

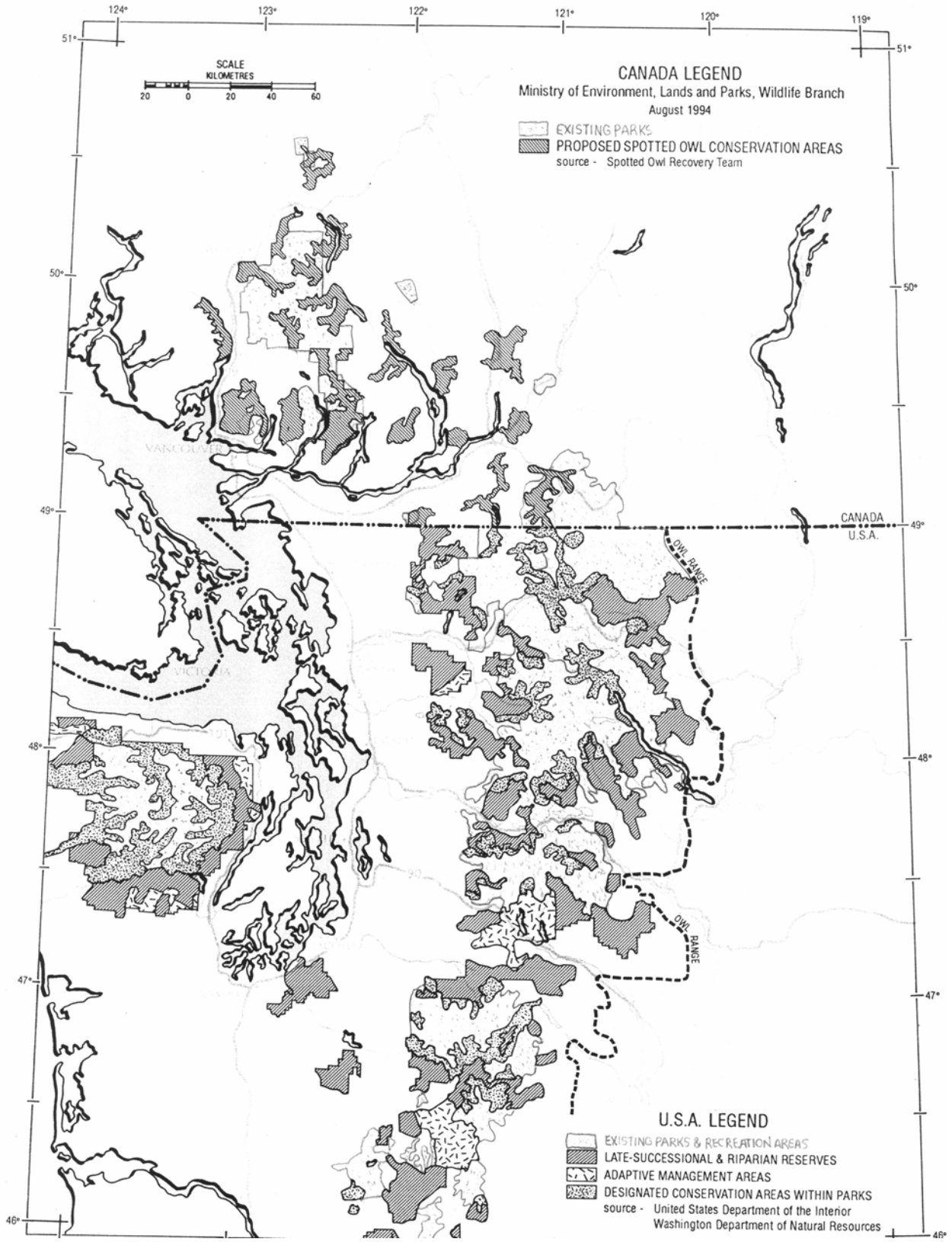
The U.S. Endangered Species Act provides a means to conserve the ecosystems upon which endangered species and threatened species depend. The Act lists several activities that are prohibited, including significant habitat modifications or degradations where it actually kills or injures wildlife by significantly impairing essential behavioural patterns, including breeding, feeding or shelter.

In 1993, President Clinton convened the President's Northwest Forest Conference to resolve the conflicting ecological, social, and economic issues surrounding forest management on federal lands. In April 1994, Alternative 9 was selected as the preferred option to conserve Spotted Owls on federal lands. Alternative 9 was assessed as providing an 83% chance of recovery. The premise of this alternative is that federal lands would bear most of the burden for recovery of the Spotted Owl. State and Private lands also require approved conservation plans for Spotted Owls under section 4(d) of the Endangered Species Act prior to further removal of any Spotted Owl habitat. These conservation plans must provide a means whereby the species no longer requires designation under the Endangered Species Act.

In Washington State, federal lands provide approximately 2,420,736 ha (34%) of the total habitat capable of supporting Spotted Owls (including parks and reserves). Alternative 9 provides habitat protection to 77% (1,863,967 ha) of these federal lands. This includes 740,156 ha of Late Successional Reserves (LSR) that only allow silvicultural treatments that create owl habitat in stands younger than 80 years old. An additional 7% (163,904 ha) of federal lands has been identified as Adaptive Management Area to test silviculture and harvesting techniques that maintain Spotted Owls and socio-economic opportunities. Only 16% (383,170 ha) of federal lands will be made available for timber harvesting over the long-term.

In BC, the proportion of SRMZs (363,000 ha) in the Chilliwack and Squamish Forest Districts is similar to the proportion of federal lands protected for Spotted Owls in Washington State (Figure 13). However, within these areas managed for Spotted Owls, Washington State eventually maintains up to 100% suitable habitat, where as, SRMZs eventually maintain a minimum 67% suitable habitat (owl areas found exclusively within protected areas in BC will maintain up to 100% suitable habitat). Untested silvicultural and harvesting techniques are limited to Adaptive Management Areas in Washington State, whereas in BC these experiments will be applied throughout SRMZs. Alternative 9 established conservation areas that, in general, are capable of supporting 15 or more breeding pairs of Spotted Owls; SRMZs average only 5.4 breeding pairs (range 2 to 13 breeding pairs). To BC's benefit, SRMZs are not limited by private landowners and therefore provide a uniform distribution of SRMZs throughout the Chilliwack and Squamish Forest Districts, whereas, the federal lands in Washington State are limited in distribution largely to the Cascade and Olympic Mountain Ranges. However, in Washington State, additional habitat protection is provided outside of federal lands in State and private lands for breeding owls and connectivity between federal lands. In BC, the Spotted Owl Management Plan does not specifically manage habitat outside of SRMZs except for 7 matrix activity centres that will be phased-out over the next 50 years, or sooner. In summary, the management strategy in Washington State provides a higher level of protection, greater connectivity, and a higher likelihood of recovery (83%) for Spotted Owls than the BC Spotted Owl Management Plan (60% chance of stabilizing the owl population).

Figure 13. Comparison of managed Spotted Owl areas in Washington and British Columbia.



Recovery actions

The Spotted Owl population in B.C. has declined but the causes of the decline are unknown. Identifying the cause(s) will require additional research with considerable funding, resources and time to collect and analyze data, and to develop and implement solutions. However, it is not necessary to know the exact cause of the Spotted Owl decline before additional recovery actions are implemented.

One of the conservation principles of the Spotted Owl Management Plan is that increasing the population size increases the stability and resilience of the population to stochastic events that cause population declines and extirpations. The current owl population size is very small and is extremely vulnerable to these random events. Failure to act quickly and counter this decline will likely result in the extirpation of the Spotted Owl from BC. Immediate recovery action is needed to protect Spotted Owls and increase their population size to more stable levels. Delays in recovery actions will make Spotted Owl recovery more difficult, more costly, and less attainable.

There are 3 key recovery actions identified to increase the Spotted Owl population size. These include increased habitat protection, habitat recovery within Spotted Owl areas, and Spotted Owl population recovery.

Increase habitat protection

Increasing the amount of habitat protected increases the number of potential owl territories that can be established which provides opportunities to maintain a larger population size. There are 2 issues regarding additional habitat protection. First, there is a large portion of the Spotted Owl range in BC that is not adequately managed to sustain the species in this portion over the long-term. Maintaining a well distributed, connected population over all habitat types occupied by the species provides the greatest chance of reducing the risk of extirpation. For example, researchers in Washington State have observed geographic variations in breeding success whereby owls on the west side of the Cascade Mountains had high reproductive success while owls on the east side had low reproductive success, and vice versa, in specific years. Providing sufficient amounts of habitat in all habitat types occupied by Spotted Owls throughout its entire range in BC will reduce the chance of extirpation. Second, increasing the amount of habitat protected within the portion of the species range that falls under the Spotted Owl Management Plan will reduce the chance of extirpation. This is particularly true if the additional habitat protected ensures larger habitat patch sizes and improves the connectivity between adjacent owl territories.

Habitat recovery within Spotted Owl areas

Research in the United States has demonstrated that increasing the amount and quality of habitat available within the territory of a Spotted Owl increases adult survivorship and reproductive success. There are 2 issues regarding habitat recovery within Spotted Owl areas. First, the results of the modelling by MWLAP suggests that the current SRMZ may be sufficient to maintain a stable population once all Long-term Activity Centres achieves the 67% suitable habitat target in 60 years. Forty-four Long-term Activity Centres are currently below the 67% habitat target. This 60-year period may be reduced through forest stand treatments (i.e., thinning) that creates and enhances the quantity and quality of habitat available to Spotted Owls.

However, forest stand treatments that only maintain habitat quality in existing superior suitable habitat (forest stands older than 140 years) will not increase the habitat quantity and improve habitat quality, and pose a risk of degrading the superior quality of the habitat being treated. Because the Spotted Owl may become extirpated within the next 10 years, priority should be given to forest stands (i.e., forests aged between 80 to 140 years) that following treatment quickly become useable and more beneficial to Spotted Owls. These priority treatments should be situated to increase habitat patch sizes and improve connectivity to other habitat patches. Forest stand treatments should also prioritize Long-term Activity Centres that are grossly below the 67% habitat target to increase suitable habitat to levels that are useable by Spotted Owls.

Second, the target of 67% suitable habitat within each Long-term Activity Centre may be insufficient to sustain Spotted Owls. Increasing this habitat target will provide a greater chance of sustaining owls within each Long-term Activity Centre and reduce the chance of extirpation. However, achieving a higher target of habitat within Long-term Activity Centres faces similar problems as attaining the 67% habitat target, and could take longer than 60 years to attain. Increasing the habitat target would immediately protect additional suitable habitat in at least 14 Long-term Activity Centres that currently contain greater than 67% habitat.

Spotted Owl population recovery

The population assessment suggests that over 50% of the Long-term Activity Centres within SRMZs are currently vacant, despite the presence of considerable habitat. Although the slower rate of decline observed since 1997 may be attributed to the habitat protection measures in SRMZs, the introduction of these SRMZs may have been too late to stabilize the population. Fortunately, vacant habitats exist for the Spotted Owl population to immediately increase and occupy within SRMZs. However, the current population may be too small and unable to stabilize or increase its size (mortality of adults exceeds the recruitment of juveniles to the population).

To prevent extirpation, the population needs to be assessed for its reproductive potential and its capability to stabilize. If the population is confirmed to be too small and individuals too isolated to stabilize itself, hands-on recovery actions may be necessary to offset the continued population decline. There are 2 issues regarding Spotted Owl population recovery.

First, if the population is deemed incapable of stabilizing and increasing in numbers, then there is a need to increase the reproductive potential of the population. Because sufficient habitat exists in the wild for owls to reproduce (e.g., SRMZs), it likely is not necessary to establish a breeding facility, particularly if this approach results in possible behavioural modifications to the species. However, recovery actions should consider moving confirmed single Spotted Owls into habitats occupied by another single Spotted Owl of the opposite sex in an attempt to establish a reproductive pair. Preferably these translocated owls should be placed in to Long-term Activity Centres in SRMZs where sufficient habitat exists.

Second, increasing the breeding population alone may not be sufficient to stabilize the population. Although adult Spotted Owls are long-lived, juvenile owls have high mortality rates. Juvenile owls leave the care of their parents in September and disperse from their natal area to search for new territories and mates. These inexperienced owls are highly susceptible to mortality due to predators and starvation because of their poor hunting skills and limited prey availability during the late fall, winter and early spring. Recovery actions should consider increasing juvenile survivorship. One option may be to supplement the food intake of juveniles

while they are with their parents and into the fall. Another option may be to capture juveniles owls before they disperse and maintain them in a holding facility until the early spring when they are released into vacant habitats or habitats occupied by a single owl of the opposite sex.

There are risks that must be assessed prior to translocating Spotted Owls. Most significantly is: “what is the potential impact of removing one or more owls from the local population?” The removal of an individual from a local population that is stable may make the population unstable and cause it to decline, and possibly become locally extirpated. The priority should be directed to translocating single isolated Spotted Owls. Furthermore, any interventions must be well designed and monitored to measure success and refine techniques.

Appendix 1:

Detailed review comments on the draft document entitled "Population Assessment of the Northern Spotted Owl in British Columbia 1992-2000"

1. Abstract, what rate of decline is more than 5 times i.e. the average annual, total or both ? What was the predicted rate specifically ?

2. In the first paragraph of the introduction, the paper should cite primary literature to support old growth dependence, rather than the SORT.

3. The "short-term" and "long-term" need to be explicitly defined in the introduction as they were used in the original model. Reference is made to suggest that the management plan may be inadequate in the short-term, yet later references indicate this was not the expectation as the plan was intended to stabilize populations in the long-term.

4. It is suggested that historic levels of owls could have been as high as 500 breeding pairs. Citations in support of this would be beneficial as this assumes total capable forest was once saturated and it assumes that capable habitat can be defined which is somewhat contrary to the assumptions used in the multplicative model.

   It should also be noted that the assumption is that the forests of today are similar to "pre-logging" forests. There is ample evidence to suggest that this is not the case and the "historic" capability of much of the districts may have been significantly less than it is today. If SRMZ 18 is used as an example, even today with active fire suppression activities approximately 34 % of SMRZ 18 is young forest (age class 3 to 6). These are natural forests that developed due to natural disturbances. It is likely that the area of young forests in the "pre-logging" era would have been significantly higher than present day, which would suggest that historic populations could have been low.

5. The calculation of historic spotted owl numbers should include the entire Fraser Valley, not just current forest area, and recognize the major cause of habitat loss was settlement and agriculture, not logging.

6. What is the implication of periphery of range ? (reference is required).
7. At the top of Page 3, the first full sentence is misleading. In the RMP's each of the SRMZ's has been separated into several activity centres. There are very few activity centres in the SRMZs which are below 67%. It would be more appropriate to have each of the survey areass and activity centres show as to how much habitat is there.
8. On Page 3 the report notes that "on average"; SRMZs currently comprise 57% suitable habitat, however, based on the data contained in the RMPs within the Squamish Forest District, the SRMZ average is 74% suitable habitat.

   In addition to the "suitable" habitat, another 12 % of the SRMZ are younger forests (age class 3 to 5). The majority of these younger forests developed due to natural disturbances. Thus approximately 87% of the SRMZs (applies to SRMZ 14, 15, 17, 18 and 21) within the Squamish Forest District are 'naturally' occurring forests.

9. It would be useful if there was reference to the number of random suitable areas surveyed but not found to have spotted owls at any time between 1992-2000. This would then provide a base index for how much suitable habitat is used compared to that available. If all suitable habitat was not used then the expectation should be that at any one time a proportion of habitat set-aside would not be utilized.

10. What is the unresolved data problem which effects the current estimate of suitable owl habitat as noted in the cover letter ? Are the 18% and 42% numbers correct for amount of total suitable habitat ?

11. More information (appendix) could be provided on the referenced spatially-explicit model associated with the Spotted Owl Management Plan (Blackburn 1996) and it's assumptions since this is an unpublished document and there are a number of comparisons made to this model.

12. Is each survey area equivalent to a territory ? How does one know that there is not more than one breeding pair per study area ?

13. Page 4, the first two paragraphs are confusing. It appears that 25 areas not known to have owls prior to 1992 were chosen by both amounts of suitable habitat and also by occurrence of a territorial owl ? Were the 25 areas randomly chosen from all those available ?

14. At the bottom of Page 4, how long were the transects? For example, did they traverse the length of the entire study area (more or less)?

15. It would be useful to have a copy of the survey protocol attached in an appendix. Were there any deviations from the protocol during the surveys?

16. In Figure 3, the word "cumulative" is misspelled.

17. On page 7, the assumptions of the multiplicative model should be more clearly stated to better explain why this model was chosen compared to the original model or other models. For example, what are the benefits of examining average annual rate of occupancy change instead of using regression to model change in annual occupied frequency? Why not use both?

18. On Page 7, after the linear-multiplicative model is introduced, some reason should be given why occupancy change (β) was estimated in this fashion, rather than say, least squares or maximum likelihood.

19. The geometric mean equation at the top of Page 8 has a few peculiarities that need to be addressed. Specifically, what happens if one (or more) of the r_y's is zero? Also, if the Exponent is the reciprocal of an even number, and the argument in the base is negative, there is no real-valued solution. For example, when the values for r_y from Table 2 are plugged into this equation, the estimate is zero, not -6.85%.

20. For the second equation on Page 8, "N_{2000}" should be written as "n_{2000}" to be consistent with the notation on Page 7. Also, the negative signs are incorrect and should be positive. In other words, the equation should look like: "$P_y = (n_{2000})/[(1+r_{1999})(1+r_{1998})\cdots(1+r_y)]$".

21. In the first paragraph of the results regarding the potential 360 records, it should be made clear that there was a major lack of complete sampling until 1995 and again in 1999.

22. In Table 1, indicate which 15 areas were known to have spotted owls prior to selection. In the years when field data could not be collected from all study areas, how did the authors chose which sites would be eliminated in that year and which sites would be retained for study ? It is important to state this because non-random selection would lead to biased results.

23. Was there a particular reason surveys were not conducted or were incomplete in some areas or was this random year to year ?

24. In any one year are all areas expected to be used ?

25. On page 10, the explanation of the potential bias associated with the 15 areas is difficult to understand and should be clarified. The issue appears to be that those 15 areas could only lose birds, not gain birds. Consequently, they could only produce a stable or negative trend in the first few years, whereas the other sites could be negative, positive or stable. This creates a potential bias towards finding a population decline.

    Regardless, this bias would be most pronounced in the first few years, not over the entire decade (i.e. once one of these sites becomes vacant, it now can contribute to a positive trend). In fact in Figure 4, in the first 3 years the known sites are declining while the habitat sites are increasing in occupancy which suggests there was a bias in the first few years. If this is true, this gives further weight to the idea that the population was relatively stable during the first few years and the major decline was concentrated in the 1995-1997 period.

26. In the main paragraph on page 11, MANOVA is used to compare the slopes of the two regressions. This is odd because MANOVA would only be required if the slopes and intercepts were being compared simultaneously. The more appropriate test is to use the ‘extra sums of squares principle’.

27. In Figure 4, the y-axis should be labeled “Percentage Occupancy”. The methods for calculating occupancy frequencies need to be provided.

28. For the numbers in Table 2, it appears that those areas having a ‘not detected’ status (in Table 1) were not used at all. Perhaps this should be mentioned? How sensitive is the current estimate of occupancy change to the incorporation of the 'not detected' areas? For example, if areas were handled as vacant when the probability of being vacant exceeds some threshold (e.g. 80%, 75%, etc.), does the estimate differ greatly. A sensitivity analysis of this type might shed some light on the stability of the final number.

29. The analyses and conclusions in this paper are hampered by the large amount of missing or incomplete data, especially during the early years (1992-1995), and in 1999. Unfortunately, the analysis appears to be quite sensitive to slight changes in missing or incomplete data.

    For example, just changing one “?” in Table 1 to an occupied or vacant classification is often enough to change the annual rate from stable to increasing or decreasing e.g. 1) if

it is assumed that all areas that had a >50% chance of being vacant were in fact vacant, and then 2) calculate the percent of areas that were occupied (occupied/vacant or >50% chance of being vacant) each year and 3) also look at the year-to-year paired comparisons using the same assumption that areas with >50% chance of being vacant were vacant. There are numerous other assumptions that could be used for other analyses.

Based on the above assumptions, the conclusion that there was a significant decline in the number of occupied sites during the 1990's appears to be correct and is reflected in all 3 analyses. However, the pattern of decline depends on the analysis used. The above approaches suggest that there may have been a stable number from 1992-1994, a fairly precipitous decline from 1995-1997, but that the number was stable or slightly increasing since then. The analysis in the paper also indicates the most dramatic decline occurred in 1996. It would be interesting to try and explore why the major decline may have occurred during this period. Was there accelerated logging of these sites at this time? Was that a year of severe weather? The possible stability since 1997 may indicate that the spotted owl plan has been effective in stablizing the population. This example demonstrates that no particular approach is better than the one used in the draft report, but it indicates that the conclusions are very sensitive to the assumptions made about the missing or incomplete data.

30. It is recommended that the authors explore several different ways of analysing the data. Given the sensitivity of the analysis to missing data, any conclusions would be stronger if they were supported by more than one line of analysis.

31. In the middle paragraph of Page 12, standard errors should be determined for the estimate of the rate of occupancy change. This would allow more defensible statements about the rate of population decline, rather than using $\pm$1%, which has no apparent basis. Without a standard error for the estimate of occupancy change, it is difficult to assess its reliability. This would also allow one to assess the precision of the predicted population decline. For example, 44% +/- 5% would be cause for concern but 44% +/- 40% would imply that further study is required. Also note that in the last sentence, "6.85%" within the parenthesis should be "-6.85%".

32. If the main concern is the average annual rate of decline, is it meaningful to back calculate the predicted number of territories in 1992 and then to reuse this to report overall decline?

33. On Page 12, the estimated 44% population decline is based on predicted values and should be treated cautiously. It should be mentioned that a different model could lead to different predicted values and hence a different estimated decline rate. There are now formal ways to examine estimates from a variety of models to get more robust estimates.

34. On page 14, the predicted sharp decline is attributed, in part, to the AAC for the forest districts and it is stated that AAC's were not reduced in response to spotted owl habitat protection measures until April 1999 and October 2000. This is "technically" true however the AAC has been significantly reduced twice since 1992 i.e. it should be noted that for the Soo TSA, there was a decrease of 17.7% in the AAC in 1992 and further decrease of 12.8% in 1996. In addition, there was an AAC undercut of 4.7% in the Soo TSA during the period 1992 – 1999 cut control.

In the Chilliwack District there was an increase of 9.2% in the AAC for TFL 26 in 1996. There was a decrease of 12.2% in the Fraser TSA in 1995 and a further decrease of 18.1% in 1999. There was an AAC undercut of 26.5% in TFL 26 and an undercut of 8.7% in the Fraser TSA during the period 1992 to 1999.

Harvesting on Timber License areas has also steadily declined from in excess of 410, 000m³/year in 1992 to less than 124,000 in 2000. Moreover, the only reason the AAC did not decrease further in TSR 2, completed in 1998 for the Soo TSA, was due to the inclusion of a significant amount of helicopter wood. This wood was previously considered inoperable and helped reduce the impacts from the owl protection measures.

35. Notwithstanding the above, it is accepted that in TSR 2 for the Soo TSA the potential impacts of the owls were not adequately accounted for. The primary reason for this was the fact that harvesting activities within the SRMZ had been deferred since about 1995 and thus there was little or no experience in attempting to apply the management strategies.

36. The draft report also implies habitat fragmentation is a major contribution to the owl's decline, partly by preventing dispersal of new owls into vacant areas. It is not known if research exists to assess the "degree of fragmentation" and the degree of connectivity across the landscape or if it is only an assumption that connectivity does not exist. If the areas outside the SRMZ have similar extensive areas of "naturally" occurring young forests as described above then while these forests are not considered "suitable" habitat are they adequate for dispersal purposes? In addition to natural fragmentation (i.e. extensive area of non-productive forests, old burns, large rivers and lakes), the forest districts have major highways, transmission and railway lines traversing much of the valley bottoms. When combined with extensive areas of private land there are limited options to have or maintain cross-elevation linkage

37. Vacant survey areas are presumably equivalent to occupied survey areas in total amount of habitat, but are they the same as habitat quality if fragmentation is important?

38. Page 17. The report suggests that the populations of barred owls are also declining. Barred owls are more of an "edge" species that tolerates open areas. Given what appears to be opposite habitat requirements, it seems somewhat contradictory for both species to be declining if habitat loss is the primary reason for the spotted owl decline. Literature suggests that it is doubtful that both species, similar in habitat and food habits, could coexist in the same areas for long.

39. Can vacant areas be examined separately for occurrence of Barred owls if these were also picked up during surveys?

40. Page 16. The draft report appears to discount the potential impact of predators such as goshawks and great horned owls. Relatively frequent observations of goshawks within areas proposed for harvesting suggest the population may be significant. During a recent field trip in the Squamish district a goshawk attack on a young spotted owl was observed.

41. Was the pattern of decline in US similar to BC (Figure 5)?

42. If more habitats are protected in the US for SPOW, is this per individual or total?

43. The northern Coast Range has a decline in the number of owl pairs. As the B.C. population is at the periphery of the owls range would response be potentially amplified due to cumulative effects such as immigration?

44. The critical point for the Discussion is what was the harvest history in the SRMZ areas from 1990 to 2000. If they were being harvested up until 1997, then one cannot attribute the population decline to a failure of the Spotted Owl Management Plan, which has only been in place since 1997. There is some suggestion that the population may have stablized since that time.

    If those areas were deferred from harvest throughout the 1990's, it cannot be concluded that the population declined despite protection from logging, but one can't conclusively say there has been a continuous decline each year. If the decline occurred primarily in one year, it may indicate some stochastic environmental factor was the cause.

    Since 1992 harvest activities have been limited within the SRMZ's in the Squamish and Chilliwack districts. Most of the harvesting occurred during the period from 1992 to 1994 prior to any consideration of owls. Between 1995 to 2000, little harvesting occurred while the RMPs were being developed. Therefore the authors should provide additional information on the history of the SRMZ's. Were they deferred from logging between 1990 and 1997, or was there harvesting occurring in them? This is important for interpreting the results of this paper.

45. The authors state that the population is stable between 1997-2000 which coincides with the reported official status of the management plan and adjustments to the AAC. Therefore can the sharp decrease be attributed to the management plan? It appears that there may be three different issues somewhat confused: 1) the sharp decline in 1996/1997 and its cause and contribution to the overall decline; 2) the general overall decline as predicted by the original model; 3) the authors preferred option for intervening in the decline through the forestry sector, although other factors may be contributing to or accelerating the decline e.g. environmental factors.

46. Overall, the authors should be more cautious in their interpretation of this data and stress the need for ongoing monitoring that avoids these data gaps that make interpretation difficult.

47. The report specifically makes no mention of new spotted owl detections in areas such as the Lillooet Forest District. It is our understanding that the current LRMP process is considering some owl management options.

Appendix 2:

BC Environment: Preliminary Results of the Spotted Owl Simulation Model – An Assessment of Spotted Owl Management Options

Prepared by Ian Blackburn 1996

Introduction:

The following provides a summary of preliminary results and discussion regarding the current work performed by BC Environment, Lower Mainland Region, on the Spotted Owl Simulation Model developed by Carl Walters and Don Demarchi. Although these results are preliminary and further refinements to the model are required, the model indicates that the management option selected by government will have significant implications on the recovery of the Spotted Owl in BC.

The model simulated four options that were developed by the Spotted Owl Recovery Team for Spotted Owl management in the Chilliwack and Squamish Forest Districts. These options include:

Interfor's Option:	*No additional protection for Spotted Owls aside from protected areas and the Forest Practices Code.*
Option N:	*Range Reduction - Maintain 100% suitable owl habitat within Special Resource Management Zones (SRMZs) within the Sasquatch Range, and no additional protection for Spotted Owls outside of this range aside from protected areas and the Forest Practices Code.*
Option H:	*Maintain 67% suitable habitat (forests > 120 years old) in SRMZs.*
Option C:	*Maintain 100% suitable habitat in SRMZs.*

For each option, the model was changed to reflect the management configuration and rate of harvest. Timber supply levels for each option reflect those determined by the Ministry of Forests, Vancouver Forest Region, and include predicted impacts for the Forest Practices Code.

Results:

The model provides a tool to measure the relative differences among various management scenarios. These results do not reflect actual population sizes or rates of change, but allows for comparison between the different management options considered.

The first 20 years:
For all four options, the model predicts that the current owl population size in the two Forest Districts will decline by about 30% at a rate of 1.5% per year over the next 20 years (figure 1).

The period from 21 to 70 years:
Within this period, the model begins to demonstrate significant differences among the four management options, and provides a focus point for where the management option selected by government will set the course for the status and viability of the owl population over the next 100 years.

Option C, which maintains 100% suitable owl habitat in SRMZs, immediately demonstrates Spotted Owl recovery efforts with a significant increase in population size at a rate of 2.1% per year.

Option H, which maintains 67% suitable owl habitat (forests >120 years old), also demonstrates a gradual increase in population size at a rate of 0.5% per year.

Option N, which reduces the managed range, continues to demonstrate a population decline over the next 10 years at a rate of 1.9% per year before gradually returning back at a rate of 0.6% per year to the same population levels as those at the beginning of this period. No population increase is observed during this 50 year period.

Interfor's Option continues to demonstrate a population decline over the next 25 years at a rate of 1.9% per year before stabilizing at this low level. No population increase is observed during this 50 year period.

The period from 71 to 100 years:
Within this period, the model demonstrates Spotted Owl recovery efforts with significant population size increases at rates of 1.8%, 1.9%, and 1.7% per year for Options C, H, and N respectively. Interfor's Option, however, maintains the owl population at its current low level without any increase in owl population size.

Discussions:

The model demonstrates population trends that would be predicted in a recovery plan. This trend would include a continued population decline that gradually stabilizes as a result of habitat protection efforts for the species. This trend would then be followed by a gradual increase in population levels in response to an increase or recovery of suitable habitats.

The model's results of these four options are a concern to wildlife biologists, as:

The existing small Spotted Owl population in BC will further decline over the next 20 years placing the species at an increased risk of extirpation. The greater the population declines, the greater the chance of extirpation. This temporary decline is expected as existing suitable owl habitat found outside of SRMZs will be harvested during this period, and subsequently, will reduce or eliminate the number of owl activity centres in these areas. Increasing the number of matrix activity centres, or suitable habitat protected during this period could off-set this population decline, and decrease the risk of extirpation to the species.

Any owl population response to our management efforts will not be seen until after 20 years from now (up to 70 years for Option N), at which point, it may be too late to make changes to our management plan if it is shown to be inadequate for the species. As well, the increased duration the owl population size declines or remains at low levels, the greater the chance that the species will become extirpated. Reducing or preventing this duration of low population levels can be achieved by increasing the level of protection for the owl (i.e. Option C or H).

Likelihood of Recovery

The preliminary results of the model suggests that several options currently being considered by the government (Option N and Interfor's Option) pose very high risks to the owl population's persistence in BC, and will likely extirpate the species or maintain the species as Endangered in the province for the next 100 years. Under these two options, the model predicts that population levels at 100 years from now will be well below current 1996 levels.

The preliminary results for Option H suggest that this option likely possesses the minimum criteria to stabilize and possibly recover the species in the province. This is demonstrated by its immediate, gradual increase in population size following the 20 years of population decline. The model predicts that population levels at 100 years will be slightly greater than current 1996 levels, and suggests that the status of the population at this time would be somewhere between Endangered and Threatened.

The preliminary results of Option C suggests that this option, in comparison with the other three options, provides the best chance to maintain and recover the Spotted Owl population in the province. The model predicts that population levels at 100 years will be almost double current 1996 levels, and suggests that the status of the population at this time would be somewhere Threatened and Vulnerable.

The following table compares the preliminary results of the model at 100 years with those predicted for the same options by the Biological Assessment Team in the Spotted Owl Recovery Team's report. The comparison indicates that the model predicted higher likelihood of owl recovery for Option C and Interfor's Option, the same likelihood of recovery for Option H, and a lower likelihood of recovery for Option N.

Management Option	*Biological Assessment Team*	*Model's Assessment*
Option C	*86%*	*96%*
Option H	*61%*	*61%*
Option N	*47%*	*40%*
Interfor's Option	*11%*	*18%*

Range Reduction versus Timber Harvesting Options

The preliminary results of the model allows for direct comparison between options that reduce the managed range of the species and those that allow for increased timber harvesting in SRMZs. Reducing the managed range or decreasing the level of habitat protection within SRMZs increase the risk of owl extirpation. In comparison with Option C, the model suggests that decreasing the level of habitat protected in SRMZs located throughout the range of the species (Option H) is significantly better than protecting all habitats in SRMZs located within approximately 50% of the species' range (Option N). Other combinations of habitat protection level and managed range may provide different results. To provide comparable results to Option H, Option N would require an increase in size of the managed range (i.e. greater than the Sasquatch range).

Spotted Owl Population Response in Relation to Timber Supply Impacts

The four options each have their own timber supply impacts. To test whether the observed population size response is a direct relation to the reduction in Allowable Annual Cut, Interfor's Option was simulated using the AAC reduction for Option C. Although the preliminary results suggest that the AAC level plays an important factor in owl recovery, differences between Option C and Interfor's Option are still observed (figure 2). The observed difference suggests that large aggregations of nesting Spotted Owls in SRMZs provides a greater chance of recovery than maintaining single isolated nesting owls. This result supports the application of SRMZs to conserve the Spotted Owl population in the province.

Conclusion:

Several conclusions can be made from these preliminary results:

Without changing the current management options, the Spotted Owl population in the province is expected to decline over the next 20 years as existing suitable owl habitat found outside of SRMZs will be harvested during this period, and subsequently, will reduce or eliminate the number of owl activity centres in these areas.

The long delay in detecting a response to a selected management option may be too late to make changes to the management plan if it is shown to be inadequate for the species. Therefore selecting a management option that provides a better chance of recovering the Spotted Owl provides a lower risk for management plan failure.

Option C, in comparison with the other three options, provides the best opportunity to recover the Spotted Owl population in the province.

Option H, in comparison with the other three options, provides the minimum criteria to stabilize and possible improve the status of the species in the province.

Option N (Range Reduction) and Interfor's Option both pose high risks to the owl population, and likely will not improve the status of the species.

Decreasing the level of habitat protected (67% level) in SRMZs located throughout the entire range of the species is significantly better than protecting all habitats in SRMZs located within approximately 50% of the species' range.

Decreasing the timber supply AAC level increases the likelihood of Spotted Owl recovery.

Large aggregations of nesting Spotted Owls in SRMZs provides a greater chance of recovering the Spotted Owl population than maintaining single isolated nesting owls.

Figure 1. Preliminary Assessment of Spotted Owl Management Options

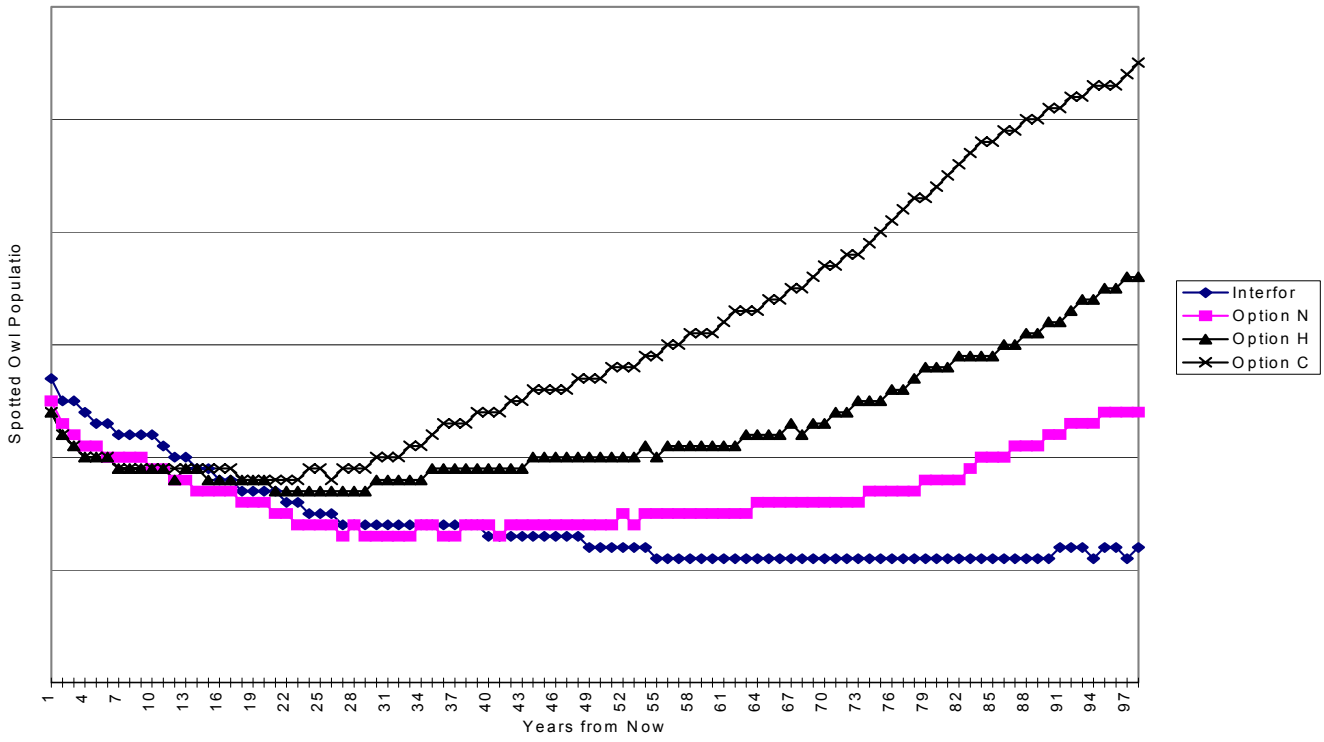


Figure 2. Comparison of SORT Option C and Interfor Option, both with the same AAC reduction for SORT option C.