MANAGEMENT OPTIONS FOR THE NORTHERN SPOTTED OWL IN BRITISH COLUMBIA

Canadian Spotted Owl Recovery Team

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FINAL DRAFT

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DISCLAIMER

This management options report has been prepared by the Canadian Spotted Owl Recovery Team, in consultation with others, to provide the British Columbia cabinet with an array of options to manage the Northern Spotted Owl in Canada. This document provides cabinet with management options that range from maximum to minimum protection for the owl. The six management options presented do not all represent options that will recover the species nor are all options fully endorsed by the participating agencies and organizations.

The Provincial Government acknowledges that several First Nations have a unique interest in the management of wildlife resources in the geographic area covered by this report. Nothing in this report should be construed as being prejudicial to any current or future negotiations of land claims and/or interim measures between the British Columbia government and such First Nations.

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No project like this come to completion without exacting a toll on the participants' personal support groups of families and friends. We appreciate the indulgence of those closest to us, who have put up with our frequent physical and mental absences during the preparation of this report.

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I. INTRODUCTION

A. Status of the Northern Spotted Owl

The northern spotted owl (*Strix occidentalis caurina*) is found exclusively within the temperate coniferous forests of western North America. The range of the species occurs from British Columbia south to California. The entire Canadian distribution of the owl is confined within the southwest mainland of British Columbia where it is considered a rare, but local resident species (Campbell *et al.* 1990). Although the present range approximates the limits of its historic range in North America, the species' distribution and abundance have changed greatly (USDI 1992).

The spotted owl is an uncommon secretive bird that is closely associated with late successional and old-growth forests (Forsman *et al.* 1984, Terres 1987, Bent 1938, Campbell and Campbell 1984, Dunbar *et al* 1991, Blackburn 1991). Unfortunately, much of these habitats have been logged in Canada and the United States. Furthermore, much of the remaining late successional and old-growth habitat is poorly distributed and highly fragmented. The owl's habitat requirement has placed the species squarely in the forefront of controversy over the use of these remaining forests by society (Dixon and Juelson 1987, Salwasser 1987, Simberloff 1987).

Based on a status report by Campbell and Campbell (1984), the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the spotted owl as Endangered in Canada in 1986. This means the spotted owl is "threatened with imminent extirpation throughout all or a significant portion of its Canadian range". This designation was based on the small number (n=28) of historic spotted owl records in southwestern British Columbia; the owl's close association with late successional and old-growth forests for foraging, roosting and nesting; and on the large reduction of these forests caused by agricultural development, urban development and timber harvesting (Campbell and Campbell 1984). Although the species probably was never abundant in the British Columbia, the recent reduction of these forests likely has led to a decline in the number of owls in Canada. Besides its national designation as Endangered, the spotted owl is on the Wildlife Branch's Red List as a species being considered for legal designation as Endangered under the British Columbia Wildlife Act.

In the United States, the northern spotted owl was designated as Endangered in Washington and Threatened in Oregon State in 1988. The U.S. federal government conducted status reviews of the northern spotted owl in 1981, 1987, 1989, and 1990 to determine if the species warranted listing under the U.S. Endangered

Species Act. The first two reviews concluded that it did not meet the listing requirements of the Act, but "If current trends in old-growth timber harvest continue, the northern spotted owl could become endangered in a relatively short time". However, after appeals launched by conservation groups, the Seattle Federal Court determined that decisions not to list were not based on biology, and ordered the U.S. Fish and Wildlife Service to re-address their earlier decisions. In June 1990, after the completion of the fourth status review, the northern spotted owl was listed as Threatened throughout its range under the U.S. Endangered Species Act. This means that the northern spotted owl is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range". Under the U.S. Endangered Species Act, the Secretary of the Interior is obligated to determine and designate critical habitat, and to develop and implement a recovery plan for the conservation and survival of the species.

B. Recovery Initiatives

United States[1]

The issue of what is an appropriate level of conservation for the northern spotted owls in the United States has been a source of considerable debate over the past 20 years (see Thomas *et al.* 1993, pp 32-47). Legal challenges have ensued, ranging from the listing of the owl under the U.S. Endangered Species Act, to the management of the owl's habitat needs. Various scientific committees have been struck to address these issues, with the result that volumes of information has been collected and presented in the form of committee reports. The following summary will concentrate on the most significant developments, particularly those of the past few years.

At about the same time the owl was federally listed as Threatened, a landmark report was developed by an Interagency Scientific Committee (ISC). The ISC report (Thomas *et al.* 1990) described in detail the biology and a conservation strategy for the species. This strategy has since become the cornerstone of subsequent recovery plans and forest ecosystem management plans. Approximately one year after the northern spotted owl was federally listed, Judge Dwyer of Seattle issued an injunction in 1991 against further federal timbers sales in spotted owl habitat pending adoption of a spotted owl habitat management plan. This legal action set into motion a number of processes designed to allow a lifting of the injunction. First, a spotted owl recovery team was established in 1991, and a draft recovery plan (USDI 1992) was released for public and agency review in

[1] Prepared by Bill Harper

1992. Consistent with the ISC report, the draft plan recommended the establishment of 196 Designated Conservation Areas (DCAs) to provide approximately 3.0 million hectares of federal forest land as the primary habitat for the spotted owl population. Economic impacts of implementing the plan were estimated to include employment reductions of 18,900 direct and 13,200 indirect jobs, and a value of foregone timber harvest of $470 million per year.

Another result of the legal action was the U.S. Forest Service reported on the environmental consequences of 5 different management alternatives in a Final Environment Impact Statement (USDA 1992). The U.S. Forest Service proposed alternative was in accordance with the ISC report. Following release of this report, a Scientific Analysis Team (SAT) was formed by the Chief of the Forest Service. The SAT report (Thomas *et al.* 1993) addressed the effect of exempting 13 BLM timber sales from the requirements of the Endangered Species Act, the effect of new information on the Final Environmental Impact Statement, and the risks and related mitigation measures to other species associated with late successional and old-growth forests. Thomas *et al.* (1993) identified 667 species that have a high likelihood of being associated with these forests (555 terrestrial species and 112 at risk fish stocks or species). The SAT report was the beginning of a movement away from the single-species approach to more ecosystem-oriented approach.

After a daylong Forest Conference in April 1993, President Clinton created 3 interagency working groups to produce a plan in 60 days to break the gridlock over federal forest management. The Forest Ecosystem Management Assessment Team (FEMAT), the Labour and Community Assessment Team, and the Agency Coordination Team were assembled to prepare and assess alternative strategies that applied an ecosystem approach to forest management in the Pacific Northwest. A Draft Supplemental Environmental Impact Statement (USDA and USDI 1993) presented the options developed by the three interagency working groups. Part of this document included the report from FEMAT "Forest Ecosystem Management: an Ecological, Economic, and Social Assessment" (FEMAT 1993). The FEMAT report was produced by working groups totalling 97 scientists and technicians, with over 600 scientists, technicians, and support personnel contributing to the overall effort. The environmental and economic consequences of 10 options were presented. All the options were identified as being apt to be displace between 21,200 and 32,000 natural resource based jobs.

President Clinton chose Option 9 in July 1993. This decision affected over 9.8 million hectares of federal land and established various reserves on over 3.7 million hectares where timber harvesting would be severely restricted (Table 1). Timber sales on federal lands under this option will be reduced by approximately 75% of the peak levels of the mid-1980s.

Table 1. U.S. Federal lands affected by Option 9 (FEMAT 1993).

Land Allocation	**Millions of Hectares**
Existing Parks, Recreation, and Wilderness Areas	2.82
Other areas not contributing to timber base	0.67
Late-Successional Reserves	2.85
Riparian Reserve	0.90
Matrix	1.98
Adaptive Management Areas	0.60
Total	**9.82**

About 36% of the land designated under Option 9 does not currently support timber harvesting. This 3.49 million hectares is in established protected areas such as National Parks, Wild and Scenic Rivers, National Recreational Areas, National Monuments, Wilderness Areas, or lands already removed from the suitable timber base through existing agency direction and land management plans.

About 38% of the land designated under Option 9 did contribute to the federal timber base, but are now identified as either Late-Successional Reserves or Riparian Reserves. Timber harvesting within these areas will be either not allowed at all, or will be very limited. The 2.85 million hectares in Late-Successional Reserves are designed to meet the needs of the spotted owl, with additional habitat added where necessary to contribute to the habitat needs of other species. Riparian Reserves are designed to address the requirements for fish, other aquatic and riparian species, and water quality.

About 26% of the land designated under Option 9 is where most timber harvesting will occur. In general, 15% of trees in the Matrix will be maintained after harvesting with half in small intact patches of late-successional forest. Adaptive Management Areas will attempt to integrate the desired ecologic, economic, and other social benefits. Their objective is to improve the knowledge of ecosystem management by pursuing a variety of approaches to achieve the conservation objectives of Option 9. There is more reliance on the ingenuity and experience of resource managers and communities, rather than the more prescriptive approaches applied to other designated areas.

Canada

In 1985, the British Columbia Wildlife Branch first initiated inventory surveys to determine the status and distribution of spotted owls in the province. By 1989, results from these surveys provided the Wildlife Branch with sufficient information to identify 10 "Spotted Owl Habitat Areas" (SOHAs) in accordance with a similar SOHA network in the United States. SOHAs were designed to contain the minimum amount of habitat required to maintain a successful reproductive owl pair (Thomas *et al.* 1990). These 10 SOHAs were submitted to the British Columbia Ministry of Forests for deletion from the Annual Allowable Cut (AAC) in the Fraser Timber Supply Area (no deletions from the AAC have occurred as a result of this submission).

In the spring of 1990, 6 of these SOHAs were submitted to the B.C. Forest Service's Old-Growth Strategy Project to be represented within their old-growth forest strategy. By the fall of the same year, 4 of these SOHAs were given 2-year deferrals from timber harvests under the conditions that 1) further research be conducted in these areas, and 2) a plan for spotted owl management and habitat protection be prepared by the fall of 1992 (CATSC 1990). In 1992, these four SOHAs were incorporated into a new land use planning initiative called the Protected Areas Strategy (PAS). At present, these four SOHAs receive short-term protection through PAS Interim Management Guidelines.

The national Committee for Recovery of Nationally Endangered Wildlife (RENEW) is represented by all provinces and territories, the federal government, and 3 nationally based non-government organizations. RENEW is responsible for overseeing and coordinating recovery efforts for nationally endangered and threatened species. At the request of RENEW, the Canadian Spotted Owl Recovery Team (SORT) was established in 1990 by the British Columbia Director of Wildlife to develop a recovery plan for the spotted owl in Canada (see Appendix A1).

SORT is an eight-member technical committee consisting of professional biologists and foresters representing the British Columbia Wildlife Branch, British Columbia Forest Service, Canadian Wildlife Service, University of British Columbia, British Columbia Council of Forest Industries, British Columbia Truck Loggers Association, and the Northwest Wildlife Preservation Society. The mandate of SORT is to examine the current status of spotted owls in Canada and to develop a national recovery plan for the species. Under the guidelines of RENEW, the national recovery plan will outline a course of action which will stabilize the current owl population and eventually lead to an improvement in its status. The recovery plan will guide all efforts in the research and management of spotted owls in British Columbia.

Since a recovery plan will involve some level of protection of forest habitats capable of maintaining a viable spotted owl population, concerns were raised regarding the potential economic and social effects to local communities and the forest industry. Therefore, at the request of the British Columbia Director of Wildlife, SORT was asked to provide a report that outlined an array of management options, with their associated risks to the owl, that could be used to address the potential economic effects associated with owl conservation (see Appendix A2). These management options were to span the scale from maximum to minimum protection for the owl. Six management options were developed to represent the five status categories of COSEWIC (Appendix A3). This Management Options Report accompanied by an associated Socio-economic Analysis Report will be submitted to cabinet for selection of a preferred management option.

A Spotted Owl Interim Conservation Strategy (SOICS) was developed in May 1993 between the Ministry of Forests and the Ministry of Environment, Lands and Parks to address the immediate conflicts between spotted owl needs and timber harvesting plans. The objectives of this short-term strategy were to maintain the recovery potential for spotted owls until cabinet selects its preferred management option, and to minimize the impacts on 1993 and 1994 planned harvest levels, as much as possible. The SOICS involved maintaining a 3,200 ha area, with a minimum target of 2,100 ha (66%) retention of suitable owl habitat, around each known active owl site.

C. Approach

This section provided a review of the current status and threats facing the spotted owl population throughout its range in North America. For the development and presentation of the six management options, this document reviews the current biology of the northern spotted owl, outlines the development process for a series of management options, provides an independent biological assessment of the recovery potential of six management option presented and suggests possible implementation strategies.

Section II reviews the current biology of the northern spotted owl. The section describes the distribution and abundance of the species in the province, provides an overview of their habitat requirements and food habits, and discusses factors influencing their abundance and population viability. Although a concerted effort has been made in British Columbia in recent years to determine the species' abundance and distribution, almost no research studies have been undertaken in the province to provide insight into the specific life requirements. Consequently, much information in this section has been extrapolated from studies conducted in

United States, particularly from the State of Washington.

Section III describes the development of a range of management options, culminating in the presentation of six options that span the scale from maximum to minimum protection for the owl. Management options were developed by combining three independent parameters; these were 1) range of the species to be managed, 2) configuration of Designated Management Areas, and 3) timber management. The final six options were selected to represent the COSEWIC status designation categories of Extirpated, Endangered, Threatened, Vulnerable and De-listed (no designation required). Criteria were established by SORT to provide measurable targets to assess whether conservation efforts achieve these COSEWIC status categories.

Section IV provides an evaluation of the six options. The primary objective of the assessment was to estimate the likelihood that a specific option would result in a particular COSEWIC status category or categories. The assessments of the six options ranged from providing a very high likelihood of down-listing the spotted owl population in British Columbia, to providing virtually no likelihood of improving the status.

Section V discusses other related land management issues that have implications for the conservation of spotted owls in British Columbia. These related land use initiatives include the Protected Area Strategy, B.C. Forest Practices Code and draft Coastal Biodiversity Guidelines. This section also suggests an implementation strategy for the management of spotted owl in the province.

II. BIOLOGY OF THE NORTHERN SPOTTED OWL

A. Introduction

The Northern spotted owl is a chocolate brown, medium-sized owl with round to elliptical white spots on the body feathers and white horizontal bars on the chest and tail. Other distinguishing features are its dark eyes surrounded by tawny facial disks. Males and females are not easily distinguishable by plumage characteristics, however, the sex of the owls can be recognized readily by voice and size (Forsman *et al.* 1984). Spotted owls, and most owls in general, show reversed sexual dimorphism with females larger than males (Blakesley *et al.* 1990).

Research on spotted owl in British Columbia is limited. Most studies involved inventories to determine the range, distribution and abundance of spotted owls. Research conducted on the species to-date has been concentrated in the United States. In the preparation of this document, pertinent information from the US was largely extrapolated and applied to the owl population in the province. In general, individuals that are widely separated across the species' range may exhibit different behaviors and characteristics than individuals located closer to one another. For example, spotted owls in British Columbia will exhibit similar habitat requirements with owls in the United States located closest to the International Border than those found further south. To account for these possible differences, most information applied to spotted owls in the province were extrapolated from Washington State.

B. Taxonomy

Spotted owls are members of the largest owl family, Strigidae, within the order Strigiformes. In North America there are three species of *Strix*: the spotted owl, the barred owl (*Strix varia*) and the great gray owl (*Strix nebulosa*). The American Ornithologists' Union Committee recognizes three subspecies of spotted owls in North America (Thomas *et al.* 1990). The Northern subspecies (*Strix occidentalis caurina*) is considered genetically distinct from the Mexican subspecies (*Strix occidentalis lucida*) and morphologically distinct from the California subspecies (*Strix occidentalis occidentalis*) (Barrowclough and Gutierrez 1990). The Northern spotted owl is the only subspecies to occur in Oregon, Washington and British Columbia.

C. Range and Distribution

In North America, Northern spotted owls are found from northern California, north to southwestern British Columbia (Figure 1). In the United States, they range from the coast of the Pacific Ocean eastward to the edge of the Palouse prairie in Washington and the great Basin shrub steppe in Oregon and California. In British Columbia, the owl has been detected east to the Cascade Mountain range. The owl is found from sea level to as high as 2,300 metres in the southern portion of its range to approximately 1,370 metres in elevation in the northern portion of its range. Densities of owls vary across this broad range according to habitat type, quality and quantity (Thomas *et al.* 1990).

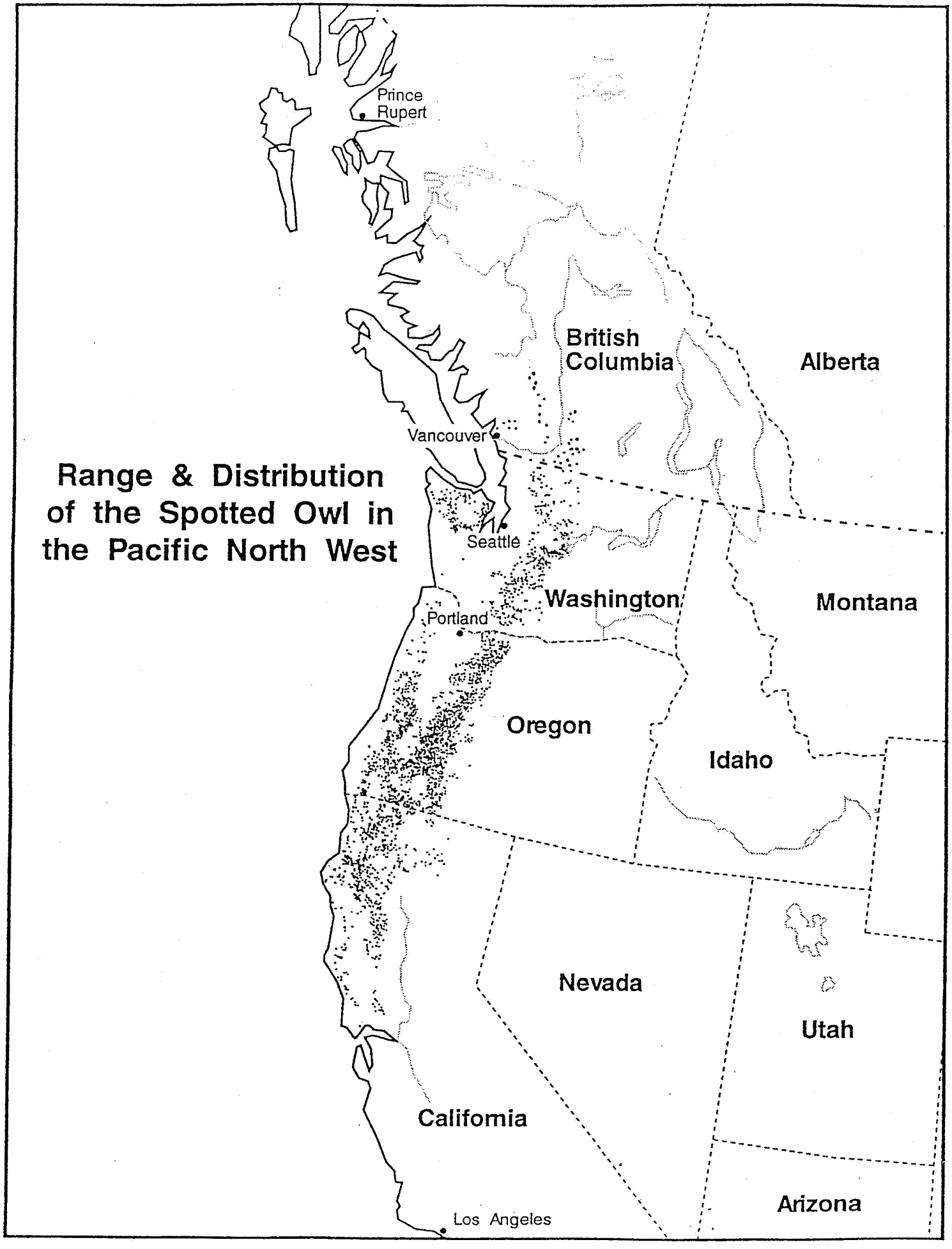
Historic Range

Prior to 1985, only 28 spotted owl observations were recorded in Canada with all records located within the southwestern mainland of British Columbia (Campbell and Campbell 1984, Campbell *et al.* 1990). From these few records, the unconfirmed historic spotted owl range (Figure 2) occurred north to Bute Inlet and Whistler (Alta Lake), east to Spuzzum, and south to the International Border (Bent 1938, Campbell and Campbell 1984, Howie 1980).

The confirmation of the historic range is difficult since the distribution of historic records may be biased by their small number and patchy distribution. For example, most specimens were collected opportunistically in populated and accessible areas. Few specimens were collected in inaccessible areas and no studies were conducted to determine the range of the owl.

The northwestern limit of the historic range is uncertain. Spotted owl records from Powell River and Bute Inlet were based solely on owls heard (Laing 1942). Several publications excluded these owl records from their spotted owl range maps because specimens were not collected (Campbell *et al.* 1990, Guiguet 1960, Munro and Cowan 1947). Several points are relevant regarding these two records: 1) identifying owls by sound is the standard methodology for detecting spotted owls (USDI 1991); 2) given the extensive network of contiguous, old-growth forests in the southwestern mainland of British Columbia prior to settlement, there is no obvious reason for the absence of spotted owls in these two areas; 3) it is almost certain that Laing did not mistake a Northern barred owl (*Strix varia varia*) for a spotted owl, since, the first barred owl record in British Columbia occurred in 1943 at the northeastern corner of the province (Liard River; Munro and Cowan 1947); and 4) Laing was clearly convinced of the identification. Although these points suggest that spotted owls may have occurred as far west as Bute Inlet, the recovery team could not reach a consensus regarding the authenticity of these

Figure 1. Distribution of the Northern Spotted Owl in North America



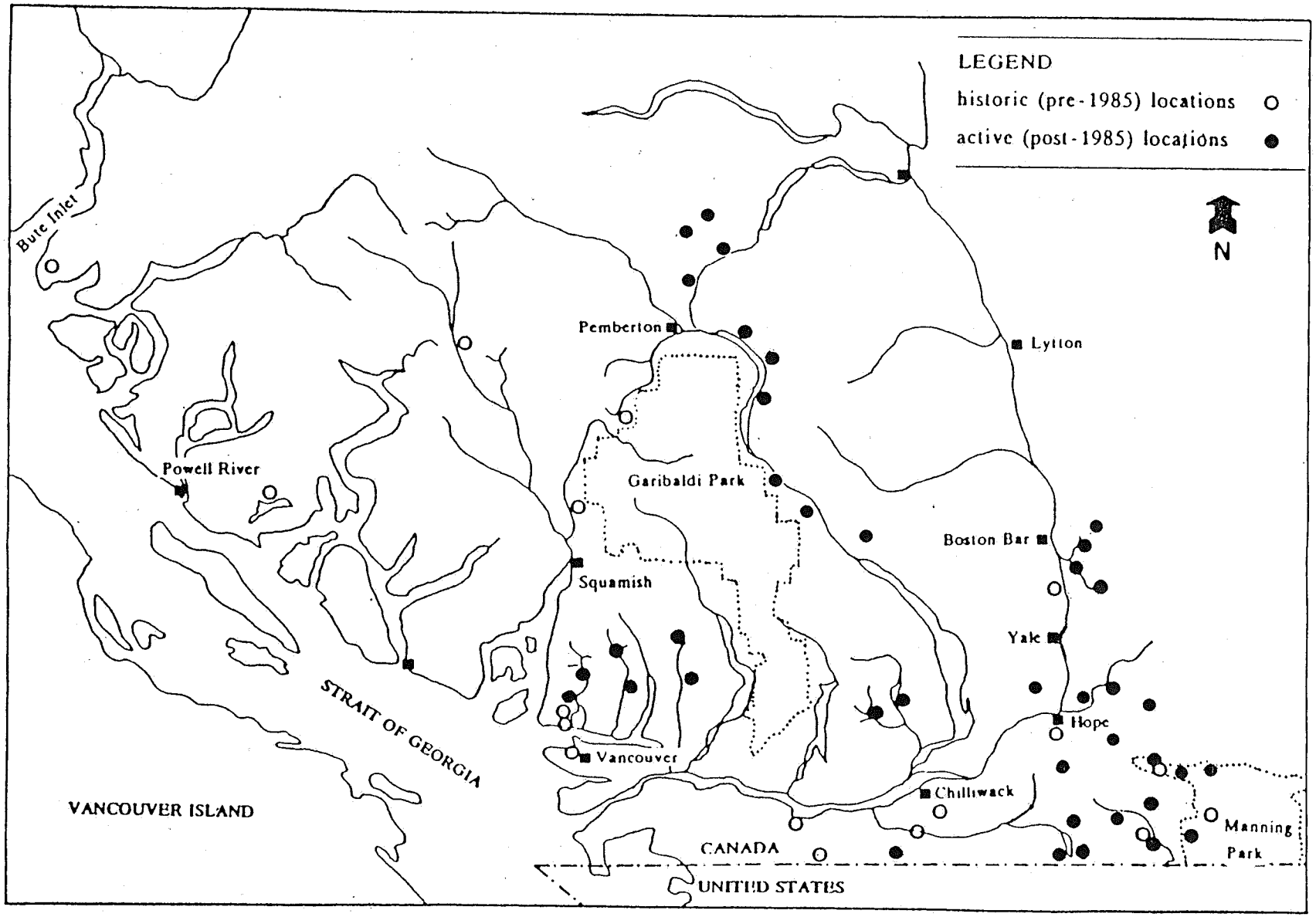


Figure 2. Distribution of Spotted Owls in British Columbia

records.

Based on specimens collected, the confirmed historic range extended west to Squamish River, north to Whistler (Alta Lake), east to Spuzzum and south to the International Border.

Current Known Range

Since 1985, owl surveys have been conducted to determine the current range, distribution and status of the owl in British Columbia (Forsman and Dunbar 1985; Forsman and Booth 1986; Booth 1987; Hetherington *et al.* 1987; Banci 1989; Blackburn 1990, 1991; Blackburn *et al.* in prep.). Over the various years, these surveys have been limited in geographic coverage, in timing and in intensity. These factors have made delineating the range and distribution of the spotted owl difficult.

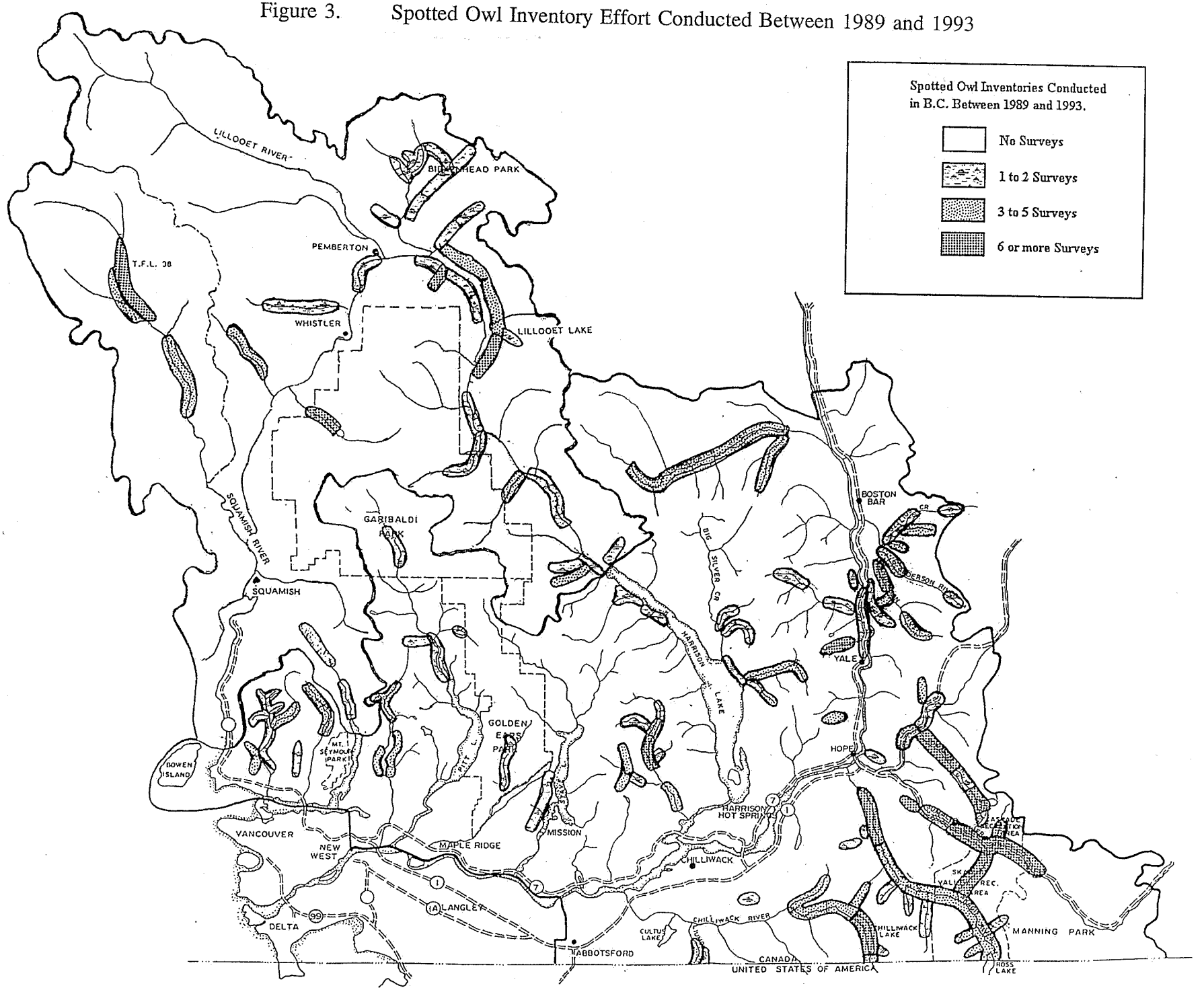
To confidently determine the presence or absence of spotted owls within a given area, a minimum 6 surveys should be conducted over a two year period (USDI 1991). In British Columbia, 892.7 linear kilometres of habitat has been surveyed between 1989 and 1993 (Blackburn *et al.* in prep.) (Figure 3). Most surveys were concentrated in forests stands containing late successional and old-growth forest stands of various quality and quantity. However, approximately 15% of the total survey efforts were concentrated in younger forest stands (trees aged less than 140 years). Of the total surveyed, 328.0 km (36.7%) of habitat have been sufficiently inventoried[2], 209.7 km (23.5%) have been inventoried 3 to 5 times, and 354.9 km (39.8%) have been inventoried 1 to 2 times.

Between 1985 and 1993, a minimum 39 active sites have been detected in the province. An active owl site refers to an area where there has been a recent (within 5 years) detection of a single owl or pair of spotted owls. Twenty-nine of these active sites have been confirmed as resident owl. Confirmation of a resident owl site involves either 1) the presence of an owl within the same general area on 3 or more occasions within a breeding season, 2) the location of an owl nest or 3) by multiple owl responses over several years from the same general area. The 10 unconfirmed active sites were detected in 1993 and require confirmation during the 1994 field season. From these data, the Current Known Range[3] of the spotted

[2] Sufficiently surveyed includes areas surveyed six or more times and areas that are known to be inhabited by spotted owls, but have not been surveyed six times.

[3] Current Known Range is defined as the area encompassing known active spotted owl sites.

Figure 3. Spotted Owl Inventory Effort Conducted Between 1989 and 1993



owl in the province extends west to Capilano River, north to Birkenhead Lake, east to Anderson River and south to the International Border (Figure 2).

The "true" range of the species in the province is difficult to determine given the current inventory data. Three different areas outside the range remain to be inventoried. First, unconfirmed historic records suggest that spotted owls may occur as far northwest as Bute Inlet (Laing 1942). To date, no surveys have been conducted in this area to confirm the presence or absence of spotted owls. Second, no surveys have been conducted in areas further north of the northernmost owl sites (Birkenhead Provincial Park and Boston Bar) to determine how much further north the species may occur. Third, recent surveys have detected spotted owls utilizing forests within the Interior Douglas-fir Biogeoclimatic Zone. Inventories on the eastern slopes of the Cascade Mountain Range in Washington also have detected owls utilizing these habitats. No spotted owl inventories have been conducted in similar ecological zones in British Columbia north of these sites in the United States.

Although confirmed historic records exist for the Squamish and Whistler areas, recent surveys have failed to detect the presence of spotted owls in these areas (Hetherington *et al.* 1987, Blackburn 1991, Blackburn *et al.* in prep.). The combining effects of urbanization of the Lower Mainland and Squamish, high elevation parkland located in Garibaldi Park, and the limited amounts of remaining low elevation old-growth forest may have segregated the Fraser Valley from areas northwest of Squamish by limiting the amount of suitable habitat available and the number of dispersal corridors (Blackburn 1991, Blackburn *et al.* in prep.). Although these recent surveys do not conclude the absence of spotted owls, these factors may have decreased the numbers and viability of the species in these areas.

Distribution

Despite the possible absence of spotted owls from the Squamish and Whistler areas, the range of the owl probably has not been severely altered from historic times. However, the owl's distribution within its range probably has had significant changes. For example, much of the lower Fraser River Valley, once occupied by spotted owls, has been altered to urban and agricultural uses. Spotted owls are generally found from sea level to approximately 1,370 metres in elevation and occur within the Coastal Western Hemlock (CWH) and Interior Douglas-fir (IDF) Biogeoclimatic Zones.

In the CWH zone, spotted owls generally inhabit the mid to high elevational habitats that consist of large, less fragmented stands of old-growth forests (Blackburn 1991, Blackburn *et al.* in prep.). However, this geographic distribution

probably is related to the owl's habitat requirement. Most habitats at the lower elevation have been previously harvested and currently consist of younger forest, while habitats at higher elevations have been untouched from harvesting due to the steep terrain and limited access. Blackburn (1991) was unable to detect spotted owls in forest stands less than 140 years old. As these younger forests develop older forest characteristics, it is suspected that spotted owls will occupy these stands.

In the IDF zone, spotted owls generally are found at various elevations in areas that contain large stands of old-growth forests (Blackburn *et al.* in prep.). However, detections of spotted owls in younger forests is not uncommon. Generally, these younger forests exhibit structural components created by disturbances (eg. fire, wind, selective logging) that are typical of old-growth forests.

D. Abundance

Spotted owls have demonstrated a close association with late successional and old-growth coniferous forests in the Pacific Northwest and British Columbia (Thomas *et al.* 1990, Dunbar *et al.* 1991, Blackburn 1991). Given the extensive network of old-growth forest throughout southwestern BC prior to the 1900s, it is reasonable to assume historic populations were much greater than present. Although hard evidence of a reduced spotted owl population in the province is unavailable, the owl population is thought to have declined since the turn of the century as a result of the loss of owl habitat (Dunbar *et al.* 1991, Campbell and Campbell 1984). No estimates for the historic population size of the northern spotted owl exist, but owls are believed to have inhabited most old-growth forests throughout the Pacific Northwest (Thomas *et al.* 1990).

With increasing survey and monitoring of populations, the number of known owls has increased since the first estimates of total abundance in North America were made (USDI 1992). These higher owl abundances reflect greater knowledge and effort expanded by biologists to count owls. These larger estimates should not be interpreted as evidence that the owl population is increasing as the total abundance of owls appears to be declining gradually over time (Forsman *et al.* 1984, Thomas *et al.* 1990, USDI 1992). Furthermore, spotted owl surveys do not provide an absolute abundance of the owl population, but yield an index of its relative abundance (Forsman *et al.* 1984). For example, inaccessible owls and "floater" owls (adult owls without a territory to defend) are difficult to census.

Recent inventory surveys (post-1985) conducted in the southwestern mainland of British Columbia suggest that spotted owls are rare in the remaining old-growth

forests (Dunbar *et al.* 1991, Blackburn *et al.* in prep.). A minimum of 69 adult owls have been recorded at 39 different sites. Of the 29 confirmed sites, 23 have been identified as resident owl pairs. This number is a smaller estimate of the true population size as it does not include juveniles, undetected resident owls and floater populations. An accurate number of spotted owls occurring in the province is unknown. Based on the availability of suitable owl habitat within the range of spotted owls in the province, there are probably less than 100 resident pairs occurring in Canada.

In British Columbia, the overall spotted owl response rate was 6.0 owl sites/100kms of habitat surveyed between 1989 and 1993 (Blackburn *et al.* in prep). This response rate is biased as it does not reflect surveys of contiguous old-growth forests, but includes forest stand conditions of various ages, quality, quantity and fragmentation. Furthermore, this estimate includes surveyed areas that did not meet the minimum number of surveys required to confidently detect spotted owls.

Although the low response rate is indicative of a species at the edge of their distribution, other factors clearly have influenced this rate. The extensive loss and fragmentation of low to mid elevation old forests caused by recent timber harvests has severely reduced the amount of suitable habitat available to the owl.

E. Habitat Requirements

Studies to determine the habitat requirements of spotted owls in British Columbia are limited. Banci (1989) and Blackburn (1990) investigated habitat characteristics at known owl sites. However, the value of information collected may be a poor index of habitat requirements because these studies sampled only selective plots in the vicinity of owls; no samples of nesting or roosting habitats were collected. Other studies of habitat requirements were based on the presence or absence of owls in stands of various forest age-classes and/or varying amounts of habitat in the landscape (eg. Blackburn 1991). However, these studies may only provide simple observations of owls in a habitat without understanding the context of the observation (Peek 1986).

Conversely, numerous studies have been conducted on the habitat requirements of spotted owls in Washington State (summarized in Hanson *et al.* 1993). Results from these studies may provide some insight into habitat requirements of spotted owls in British Columbia. Information collected from the Western Washington Cascades and Eastern Washington Cascade Physiographic Provinces demonstrated that spotted owls have slightly different habitat requirements. These two physiographic provinces are strongly correlated with habitats in the Coastal

Western Hemlock (CWH) and the Interior Douglas-fir (IDF) Biogeoclimatic Zones, respectively. However, caution should be applied as the boundaries between the two physiographic provinces are unclear (D. Demarchi, pers. comm.). Much of the information pertaining to the habitat requirements for spotted owls in British Columbia were extrapolated from these two physiographic provinces.

Habitat Quality

The quality of habitats utilized by the owl is variable and can be graded from excellent to poor (Thomas *et al.* 1990). For example, habitats considered excellent support higher densities of owls and prey than habitats that represent lesser quality.

Evaluating habitat quality is based on habitat "use" versus availability of different habitats. Methods to determine habitat "use" include: 1) Habitat use: relative abundance of spotted owls in various habitat types, 2) Habitat selection: radio-telemetry to indicate preference or avoidance of various habitat types and 3) correlation of ecological features with specific habitat utilization (eg. nest or roost selection). Presence of owls is not in itself an adequate measure of habitat quality, because not all birds may nest, reproduce or survive with equal success. Relative abundance provides a better index of habitat quality, because presumably where owls are abundant there must be relatively "good" habitat conditions in terms of providing prey, nest sites, roost sites or other essentials.

As described by Thomas *et al.* (1990), habitats selected in excess of availability by the majority of owls were considered as superior habitat. Superior habitats support greater abundances of prey, nesting sites, roosting structures and other critical elements of the owl's life-history. Habitats considered marginal were seldom used in excess of availability, were used in proportion to availability by many individuals, and were used less than expected by many others. Marginal habitats at the upper end of the scale may be adequate for all life-history needs of a species, but marginal habitats at the lower end may be unsuitable for most or all of its life-history needs. This does not mean that marginal habitats are unimportant to a given species. They may be vital for maintaining a reservoir of individuals (floaters). Marginal habitats also may contain scarce elements critical to the species, but used infrequently enough that measures of habitat "use" provide poor indices of their importance. Furthermore, in areas where the amount of suitable habitat is slightly less than a species typically requires, the availability of additional marginal habitats may tip the balance in favor of successful occupancy or even occasional breeding. Habitats avoided by the owl are considered unsuitable habitats.

Habitat Selection

Spotted owls utilize a wide variety of habitat types and forest stand conditions throughout its range in North America (USDI 1992). In general, superior suitable habitats associated with spotted owls exhibit an uneven-aged, multi-layered, multi-specied canopies that contains numerous large trees with broken tops, deformed limbs and large cavities; numerous large snags; large accumulations of logs and downed woody debris; and canopies that are open enough to allow owls to fly within and beneath it (summarized in Thomas *et al.* 1990, USDI 1992). With the exception of some habitat types utilized in California and on the eastern slopes of the Cascade Mountain Range, these habitat characteristics are predominately found naturally within late successional and old-growth forests (summarized in Thomas *et al.* 1990, USDI 1992, Hanson *et al.* 1993).

Although selection for old-growth forests by spotted owls is relatively consistent throughout its range, owls have been observed utilizing younger forests in various regions (eg. Eastern Washington Cascade Physiographic Province). In general, these younger forests exhibit structural components typical of old-growth forests that were created from earlier disturbances (eg. fire, wind, selective logging) that left behind large trees, snags and downed logs. In British Columbia, this habitat selection appears to be exclusive to some owl sites located in the IDF zone (Blackburn *et al.* in prep.). Within the CWH zone, no spotted owls were detected utilizing forests dominated with trees less than 120 years old (Blackburn 1991). Similar results have been observed in northern Washington in the Western Cascade Physiographic Province (D. Hays pers. comm.). These results do not necessarily suggest that spotted owls avoid young forests, but the numbers and densities of owls in these habitat types are very low.

Habitat selection by spotted owls in northern California is somewhat different. As well as using old-growth forests, spotted owls utilize considerably younger forests than those found in other regions of the owl's range (Thomas *et al.* 1990). The Coastal Redwood Zone of northwestern California can attain suitable owl habitat conditions in 50 to 60 years on some sites after harvest and superior conditions in 80 to 100 years. This ability is attributed to the redwoods' (*Sequoia*) rapid growth rate, early intrusion of other tree species into the understory, relatively high rainfall and frequent fog, long growing season, and an abundance of prey. Given the unique conditions found in the Coastal Redwood Zone, it would be unwise to apply these results to other parts of the spotted owl range.

The observed regional variation in habitat selection by owls does not indicate that they will respond positively to any human-induced habitat changes in one part of their range that lead to habitat conditions similar to those used in other parts of their range (USDI 1992). For example, in British Columbia, creating "new" habitat

conditions in the wet CWH zone to resemble conditions found in the dry IDF zone does not indicate that spotted owls will utilize these "new" conditions.

Many hypotheses have been postulated to explain spotted owl habitat selection. Examples include: 1) nesting structures are more abundant in old-growth forests than younger forests (Forsman *et al.* 1984), 2) dark, dense forests are needed to satisfy thermoregulatory requirements (Barrows and Barrows 1978), 3) prey abundances are greater in old-growth forests (Thomas *et al.*1990, Hanson *et al.* 1993), 4) owls forage more efficiently in old-growth forests because of its openness of the individual canopy layers and the range of foraging perches from near-ground level to the upper canopy (Thomas *et al.* 1990, Hanson *et al.* 1993), 5) old-growth forest may provide better protection against predators (Thomas *et al.* 1990, Johnson 1993), and 6) an evolutionary association with late successional and old-growth forests has caused behavioral and physiological specialization which precludes spotted owls from utilizing other habitats (Gutiérrez 1985). These hypotheses are not mutually exclusive, and each may be partially responsible for the owl's observed habitat selection.

Suitable Owl Habitat

Suitable owl habitat is defined as habitat essential to meet the life requisites of the owl (eg. nesting, roosting, foraging and dispersal). Hanson *et al.* (1993) described suitable owl habitat as Types A, B and C for the Western and Eastern Cascade Physiographic Provinces (Appendix B). In this document, the habitat definitions described by Hanson *et al.* (1993) will be applied to similar habitat conditions in British Columbia. The observed forest habitats used by spotted owls and the ecological functions they serve in the owl's life-history are displayed in Table 2. In considering these descriptions, caution should be used as research is ongoing and descriptions of suitable habitat may change as more data are gathered. Furthermore, the descriptions of suitable owl habitat in Washington may be slightly different from those in British Columbia.

"Old Forest[4]" habitats within the Western and Eastern Washington Cascade Physiographic Province include Type A and B suitable habitat definitions (Appendix B). Old Forest habitat consists of old-growth and mature forest that provide all the characteristics required for nesting, roosting, foraging and dispersal. Old Forest habitats are superior and function as high quality habitats by supporting greater abundances of prey, nesting sites and roosting structures. Habitat "use" vs

[4] In this document, further use of the term "Old Forest" will refer to old-growth (Type A) and mature (Type B) forests as defined in Appendix B.

Table 2. Observed habitat types used by spotted owls and the functions they serve for western and eastern Washington (Hanson *et al.* 1993).

Western Washington

Habitat Type	Habitat Designation	Nesting	Roosting	Foraging	Dispersal
Old Forest	A	X	X	X	X
Sub-mature	B & C		X	X	X
Young Forest Marginal	C		X	X	X
Dispersal[1]	None				X
Non-habitat	None				

Eastern Washington

Habitat Type	Habitat Designation	Nesting	Roosting	Foraging	Dispersal
Old Forest	A	X	X	X	X
Sub-mature	B & C	X	X	X	X
Young Forest Marginal	C		X	X	X
Dispersal[1]	None				X
Non-habitat	None				

[1] Dispersal habitat includes Old Forest, Sub-mature, Young Forest Marginal and other younger forest conditions that provide the characteristics spotted owl need for successful dispersal.

availability studies in this habitat type indicated a strong selection by spotted owls.

"Sub-mature" habitats within the Western Cascade Physiographic Province consists of non-Old Forest habitat that provides all of the characteristics spotted owls need for roosting, foraging and dispersal. Although spotted owls may nest in this habitat type, it usually does not serve this function. Sub-mature habitat is distinguished by the presence of characteristics that provide roosting opportunities and are associated with healthy prey populations, although prey may not be as abundant as in Old Forest. This habitat type corresponds to the "high end" of the current Type C and some stands currently described as Type B suitable owl habitat. Habitat "use" vs availability studies in this habitat type did not indicate a selection by spotted owls.

In the Eastern Cascade Physiographic Province, Sub-mature habitat functions and looks somewhat different than the western physiographic province. This habitat type includes a wide variety of even-aged and multi-aged stands with a history of disturbance from fire, disease, insect or selective timber harvesting. Sub-mature habitats provide all of the characteristics spotted owls need for nesting, roosting, foraging and dispersal. Distinguishing features of this habitat type are stand characteristics associated with high canopy closure, moderately-large diameter trees and snags, multi-layered canopies and the presence of fir trees. This habitat type generally corresponds to Type B and some habitats at the "upper end" of Type C suitable owl habitat. Habitat "use" vs availability studies in this habitat type indicated a selection by spotted owls.

"Young Forest Marginal" habitat consists of younger forests that provide some of the characteristics spotted owl need for roosting, foraging and dispersal. This habitat type is distinguished by the presence of some of the characteristics that provide roosting opportunities and/or are associated with healthy prey populations, although prey may not be as abundant as in Old Forest and Sub-mature habitats. Young Forest Marginal habitat corresponds to the low to mid-range of the Type C suitable owl habitat. Selection for this habitat type generally has not been shown in "use" vs availability studies.

"Dispersal" habitat includes Old Forest, Sub-mature, Young Forest Marginal and other young forest conditions that provide the characteristics spotted owls need for successful dispersal. These habitats provide conditions for dispersing individuals to capture prey in an environment that is relative safe from predators. Research suggests that dispersal is random and these habitats provide temporary refuges until individuals have established their own territories (Thomas *et al.* 1990, USDI 1992). Landscape configuration patterns and minimum stand sizes and characteristics associated with higher rates of successful dispersal is poorly defined, and therefore, Hanson *et al.* (1993) did not develop explicit descriptions

of dispersal habitat.

"Non-habitat" consists of forests that do not at least provide the characteristics needed for spotted owl dispersal.

Food Habits

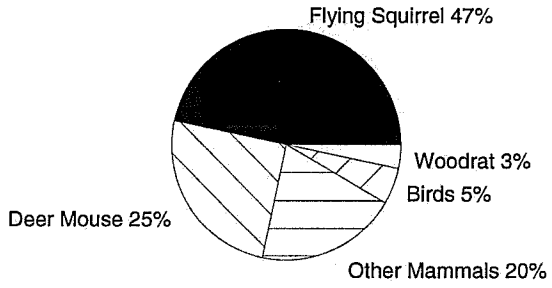
Although spotted owls utilize a wide variety of prey species (eg. mammals, birds and insects), small mammals predominate their diet, particularly those which are nocturnal and arboreal or semi-arboreal (Thomas *et al.* 1990, USDI 1991, Carey 1992). Two to three mammal species, particularly Northern flying squirrel (*Glaucomys sabrinus*), Dusky-footed (*Neotoma fuscipes*) and Bushy-tailed woodrats (*N. cinerea*), often contribute 70 to 90% of prey biomass consumed by owls (Solis 1983, Forsman *et al.* 1990). One of these species usually dominates the diet in an area, and this regional variation is related to habitat and the distributional limits of the prey species (Forsman *et al.* 1984, Thomas *et al.* 1990)

In general, spotted owls prey largely upon flying squirrels from British Columbia to central Oregon (Thomas *et al.* 1990). In southwestern Oregon and northwestern California, there is an increasing shift towards woodrats and voles, particularly the red tree vole (*Arborimus longicaudus*) (Thomas *et al.* 1990). This trend may be attributed to flying squirrels generally being more abundant and wide spread in the mesic (wet) forests of the western hemlock/Douglas-fir zones in the north and woodrats more abundant in drier mixed-conifer/mixed evergreen forests in the south (Thomas *et al.* 1990).

In British Columbia, analyses of 60 prey items indicate that spotted owls predominately predated on flying squirrels (47%) and deer mice (25%) (*Peromyscus spp.*) (Figure 4). Comparing the prey analyses to Washington, the flying squirrel component is considerably higher in British Columbia. Most data from British Columbia were collected from known nest sites. The high component of flying squirrels in the diet may reflect prey requirements for successful reproduction. Barrows (1985, 1987), Laymon (1988), and Thrailkill and Bias (1989) reported that large prey items were associated with spotted owl reproductive success. Unfortunately, the small sample sizes of these studies precluded any inferences to whether this result reflected a strong ecological or evolutionary relationship, or that large prey are transported at higher rates to nest sites than smaller prey (Thomas *et al.* 1990). The lower flying squirrel data from Washington may reflect data collected during poor reproductive years and from non-reproductive owls (D. Hays, pers. comm.). Furthermore, the results from Washington may reflect fluctuations in prey population sizes and/or seasonal shifts in dietary composition (Thomas *et al.* 1990).

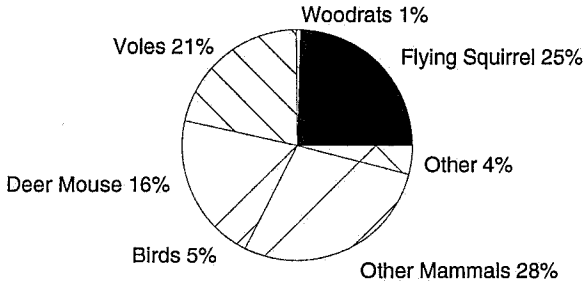
Figure 4. Food habits of spotted owls in British Columbia and Washington.

British Columbia



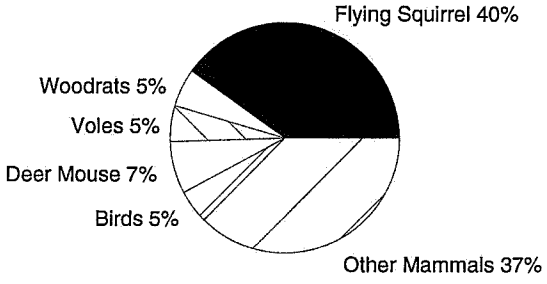
n=60; From Lenihan (unpubl. data) and Smith (1969).

Washington
Western Cascades



n=822; From Hays (unpubl. data) and Washington Department of Wildlife.

Washington
Eastern Cascades



n=493; From Richards (1989) and Washington Department of Wildlife.

The availability of prey is important. In Washington, flying squirrels reach their highest densities in old-growth forests and are more than twice as abundant in old forests than other forest types (Carey 1992). A density estimate of 0.21 $\pm$ 0.09 individuals/hectare was observed by Carey (1992) in the northern Washington Cascades. Furthermore, Carey *et al.* (1992) reported that spotted owls may depress flying squirrel numbers by up to 50 percent. Clearly, in order to find enough to eat and avoid eliminating flying squirrels from the forest, spotted owls utilize large areas to forage. Deer mice do not show consistent selection for particular stand-ages (Thomas *et al.* 1990). The high consumption of deer mice in British Columbia supports the suggestion by West (1991) that the forest deer mouse (*Peromyscus oreas*) is probably an important prey species because of its extensive use of tree canopies in older forests in western Washington and southern British Columbia.

Home Range Size

Home range[5] refers to the area in which the activities of an animal are confined during a defined period of time (Thomas *et al.* 1990). Radio-telemetry is the only current method that reasonably estimates the size of spotted owl home ranges. At present, no radio-telemetry studies have been conducted in British Columbia.

Thomas *et al.* (1990) summarized existing telemetry data from the United States using the minimum convex polygon home range estimates for pairs which were judged to have sufficient year-round location data. This was necessary because home range sizes are known to change dramatically between breeding and non-breeding seasons (Forsman *et al.* 1984). The minimum convex polygon is created by connecting the outermost points where the owl was observed; the area within the polygon, excluding bodies of water, is then calculated. Although the results summarized by Thomas *et al.* (1990) displayed variability among home range sizes, some generalization were made about home range characteristics (summarized in USDI 1992). First, all studies of home range size indicated spotted owls utilized large home ranges. Second, a large degree of overlap in home range areas occurred between members of the same pair (Forsman *et al.* 1984, Solis and Gutierrez 1990) and lesser overlap between adjacent pairs (Forsman *et al.* 1984). Third, geographic variation occurred in home range size, with a general increasing trend in size from south to north (Thomas *et al.* 1990). Fourth, home range size increased when the amount and quality of suitable habitat within the home range

[5] In this document, the term "home range" is synonymous with "activity centre". Home ranges are determined by radio-telemetry while activity centres are delineations of areas used by owls based on estimates of home range sizes.

decreased (Carey 1985, Forsman *et al.* 1984, Thrailkill and Meslow 1990). Conversely, pairs with the smallest annual home ranges were generally found in areas where the remaining suitable owl habitats were contiguous.

The size of an owl's home range probably is dependent on many factors (eg. food availability, interspecific competition, amount and arrangement of suitable owl habitat in the landscape) (USDI 1992). For example, spotted owl home range sizes may be a reflection of an adaptive response to low prey abundance or variations of abundance and distribution of prey (Ward 1990). Whether the large home range size reflects landscape conditions or real biological limitations is far from clear. However, it seems reasonable to expect that spotted owls in British Columbia will exhibit home ranges comparable in size to their Washington counterparts in similar habitats.

Hanson *et al.* (1993) summarized the existing home range data for spotted owls in the Western Washington and Eastern Washington Cascade Physiographic Provinces (Table 3). To account for the variability in sizes, the median[6] annual home range was used for each physiographic province to reduce the effects of atypically large or small values. Within each annual home range, the median amount of suitable habitat also was used since this total may be a good indicator of the amount of habitat needed to sustain a pair of owls (Thomas *et al.* 1990).

For the Western Cascade Physiographic Province, spotted owl pairs utilize a median annual home range of approximately 3,321 hectares. Within the home range, Hanson *et al.* (1993) recommended that 1,451 ha (44%) of suitable owl habitat exist in the landscape. This amount of suitable owl habitat should be viewed cautiously as it only includes Old Forest habitat (Type A) and excludes Sub-mature habitats (Types B and C) that were used in equal proportion to their availability in the landscape. Had Sub-mature habitats been included then approximately 2,739 ha (82%) of suitable owl habitat should exist within a home range.

For the Eastern Cascade Physiographic Province, spotted owl pairs utilize a median annual home range size of approximately 2,675 ha. Hanson *et al.* (1993) recommended that 1,315 ha (49%) consist of suitable owl habitat within the home range. This recommendation considered habitats used in proportion to their availability, not all habitats that meet the current definitions of suitable owl habitat. Had these habitats been added, the amount of suitable owl habitat

[6] The median is middle value in a ranked series of numbers; half the numbers are above the median and half are below the median.

Table 3. Minimum convex polygon (MCP) annual home range sizes, and amounts of suitable owl habitats within the home range, for all spotted owls radio-tracked in western and eastern Washington that met the minimum requirements for analysis (Summarized in Hanson *et al.* 1993). Minimum requirements include both owls of a pair were tracked for at least 8 months, at least 80 relocation of each member, and if no extenuating circumstances invalidated the data (eg. faulty radio transmitter).

Study	Months Tracked (No. Relocations)	Home Range Size (Hectares)	Suitable Owl Habitat (Hectares)[1,2]
Western Cascades			
Allen unpubl. data	F = 12 (144) M = 12 (136)	2,554	1,455[1]
Hamer unpubl. data	F = 10 (161) M = 8 (115)	2,691	1,837[2]
Hamer unpubl. data	F = 12 (122) M = 12 (126)	3,321	1,013[2]
Hamer unpubl. data	F = 9 (121) M = 9 (130)	1,302	694[2]
Hamer unpubl. data	F = 12 (202) M = 12 (188)	7,028	1,451[2]
Hamer unpubl. data	F = 11 (192) M = 12 (245)	7,258	2,177[2]
Hays unpubl. data	F = 12 (232) M = 12 (181)	5,236	4,024[1]
Eastern Cascades			
Forsman unpubl. data	F = 12 (pair=306) M = 10	6,305	3,850[1]
Forsman unpubl. data	F = 10 (pair=444) M = 12	2,882	1,310[1]
Forsman unpubl. data	F = 12 (pair=404) M = 11	1,494	871[1]
Forsman unpubl. data	F = 12 (pair=337) M = 12	2,468	1,319[1]

[1] Suitable owl habitats includes Old Forest (late successional, old growth and mature forests) habitat and other forest types that were used at least in proportion to their abundance.

[2] Total habitat only includes Old Forest habitat. This forest type was used in greater proportions than its abundance in most radio-telemetry studies.

recommended within a home range would have been approximately 1,908 ha (71%).

Several considerations should be used when interpreting the home range estimates above. First, the small sample size and associated variability suggests the precision and accuracy of the results may be biased. Second, these recommendations were made from a spotted owl population that is declining, not a healthy owl population. The primary reason that spotted owls are in decline is loss of suitable habitat. Therefore, it is reasonable to assume that a healthy, non-declining spotted owl population requires more suitable habitat than currently available. Third, recommendations of Hanson *et al.* (1993) are a short-term strategy to protect owls found outside the designated management areas of the long-term management strategy. Had these designated management areas not currently exist, then the recommendations most likely would have been more conservative towards protecting habitat for the owl (D. Hays, pers. comm.). Fourth, telemetry studies in the US have shown an increasing trend in annual home range size as one move northward (Thomas *et al.* 1990). If this trend extends into BC then the annual spotted owl home range in the province may be larger than those found in Washington.

Several studies have attempted to determine the amount of suitable owl habitat required to maintain a pair of spotted owls. Bart and Forsman (1990) observed that below 40% suitable owl habitat within the landscape resulted in the elimination of spotted owls. Conversely, the researchers reported that increasing the amount of suitable owl habitat within the landscape increases the number of owls per square mile, pairs of owls per square mile, young per square mile and young per pair. Ripple *et al.* (1991) observed an average of 65% old and mature forests within the landscape (3,500 ha) around owl nest sites in Oregon. Given the uncertainty of the long-term viability of these owl sites, Ripple *et al.* (1990) suggested a conservative management plan that provides a minimum 74% suitable owl habitat within the landscape around nest sites (3.4 km radius). Activity centres, each approximately 3350 ha in size, were delineated around 16 owl sites in British Columbia. Analysis of the data indicated that the landscape within these centres contained an average of 60% old and mature forests.

F. Population Dynamics

No demographic data is available for BC spotted owls. There are ten confirmed breeding records (Campbell *et al.* 1990, Blackburn, 1991, Blackburn *et al.* 1993), one of which documents two fledged young (Manning Park, 1962) and another describes 3 young found in the nest cavity (Alta Lake, 1963). At 39 owl locations known to have been active during the 1985-1993 survey period, pairs were records

at 22 sites, and breeding was confirmed eight times. Persistence of owls at known locations indicates that spotted owls are a regular resident and not an "irruptive" species in British Columbia. No information is available concerning other aspects of demography including juvenile and adult survivorship; nesting-attempt and nesting-success rates; dispersal rates; and site-colonization rates.

Throughout their range, northern spotted owls are considered monogamous (Thomas *et al.* 1990). Although genetic evidence is lacking, home-range studies suggest it unlikely that males might successfully impregnate more than one female in any given breeding season. Mark-recapture studies indicate that pair-bonds generally persist from year-to-year, although cases of both male and female-replacement have been observed (Forsman *et al.* 1984). Maximum age of spotted owls in the wild is unknown, but estimates of ten to fifteen years have been proposed (Barrowclough and Coats 1985, Marcot and Holthausen 1987).

In Oregon and California, spotted owls are capable of breeding at age two (Noon and Biles 1990, Barrows 1985, Miller *et al.* 1985), but the proportion of birds which breed at this age is unknown (Noon and Biles 1990). Spotted owls are capable of reproducing annually but there is considerable year-to-year and pair-to-pair variation. Forsman *et al.* (1984) determined that an average of 62% of pairs attempt to breed in any given year (range of 16-89%). Spotted owl pairs produce clutches of 1-3 eggs (Ehrlich *et al.* 1988, Forsman *et al.* 1984), although Bent (1938) suggested that they occasionally produce clutches of four. Available data are insufficient to determine if clutch sizes increase with latitude, a trend reported for other North American owl species (Murray 1970). Most spotted owl demographic studies are based on brood rather than clutch sizes, which is understandable given the difficulties involved in checking treetop nests. Forsman *et al.* (1984) found that 26 of 46 broods (56%) contained two, 16 (35%) contained one, and 4 (9%) contained three young. Equal sex ratio of young is assumed by most authors, although there are no empirical data to support this.

In Oregon, young spotted owls leave the nest in June and generally disperse from the immediate area after September (Forsman *et al.* 1984). Using radio-telemetry, dispersal movements of up to 156 kilometres have been reported (Gutiérrez *et al.* 1985), although the median dispersal distance from all studies is 26.2 km (summarized in Thomas *et al.* 1990). Very long-distance dispersal movements are undoubtedly underestimated in the data given the inherent difficulties of radio-tracking a relatively small animal (and transmitter), together with small sample sizes (Miller and Meslow 1985). However, most juveniles apparently settle in territories relatively close (less than 40 km) to their place of birth (Thomas *et al.* 1990).

As in other raptors, survivorship of juvenile spotted owls is comparatively low (Newton, 1979). An estimated 11-22% of fledged spotted owls survive their first winter (Barrowclough and Coats 1985, Noon and Biles 1990, Thomas *et al.* 1990). Age-specific survivorship of adults is not well understood, but estimates of 71-92% for first-year birds, and 85-97% for two-year-and-older birds, have been given (Noon and Biles 1990, Thomas *et al.* 1990). A number of studies have employed Lotka-Leslie matrix methods (Lotka 1956, Leslie 1945) to portray spotted owl life-history characteristics and population trends (Barrowclough and Coats 1985, Marcot and Holthausen 1987, Lande 1988, Noon and Biles 1990); these are summarized in Table 4. Calculations of finite population growth rate (lambda) from life-table analyses generally suggests declining populations throughout spotted owl range in the Pacific Northwest (Thomas *et al.* 1990).

The frequency and magnitude of successful spotted owl dispersal has been the subject of considerable research in the United States involving both radio-telemetry (eg. Miller and Meslow 1985, Gutierrez *et al.* 1985) and simulation modelling (Thomas *et al.* 1990, Doak 1989).Juvenile spotted owls undergo dispersal behaviour from their natal areas in the fall. Studies in the United States have shown that the direction of dispersal is random and the distances travelled generally ranged between 14 and 48 km (Gutierrez *et al.*, 1985; Miller, 1989).

Life-table analyses published to 1990 are displayed in Table 4.

Genetics[7]

Maintaining the genetic variability of a population reduced to $\leq$ 500 individuals (< Ne) becomes increasingly risky and at the same time more critically important to the population's recovery (Grumbine 1992, Gilpin and Soule 1986). Sustainability of genetic variance is dependent on habitat contiguity across the landscape for species dependent on late seral stage forests, such as spotted owls and grizzly bears, for example (Grumbine 1992). Conservation biologists are becoming increasingly aware that genetic conservation is an integral part of endangered species management (Hoffman and Parsons 1991).

Although the current status of the Northern spotted owl exceeds 500 individuals, reproductively isolated metapopulations may not. Insularization effects of these metapopulations increases with increased habitat fragmentation (Wilcove *et al.* 1986), resulting in localized reduced genetic variance (Grumbine 1992). Theory suggests this reduced variability can be a consequence of founder effects,

[7] Prepared by Astrid Van Woudenberg.

Table 4. Published life-table statistics for spotted owls (summarized from Thomas *et al.* 1990).[1]

Life-table[2] Parameter	Lande	Marcot and Holthausen	Barrowclough and Coats	Forsman Coast (OR)	Forsman Olympic (WA)
s_0	0.11	0.11	0.19	0.22	0.15
s_1	0.71	0.96	0.85	0.59	0.93
s	0.94	0.96	0.85	0.81	0.93
b	0.24	0.24	0.34	0.31	0.28
T	3	2	3	2	2
w[3]	-	15	10	-	-
r	-0.040	-0.170	-0.237	-0.153	-0.025
lambda	0.961	0.840	0.789	0.858	0.975

1 Table adapted from Noon and Biles (1990). Data are from Lande (1988), Marcot and Holthausen (1987), Barrowclough and Coats (1985), and E. Forsman (summarized in Thomas *et al.*, 1990). Life-table nomenclature follows standard practice and refers to females only.

2 Population parameters are as follows: s_0 = post dispersal probability of survival to age 1; s_1 = probability of survival to age 2; s = probability of adult annual survival; b = number of female fledglings produced annually/adult female; T = average female age at first reproduction; w = average maximum reproductive age; r = intrinsic rate of natural population increase; *lamda* = finite population rate of increase.

3 Models used by Lande (1988) and Forsman (summarized in Thomas *et al.*, 1990) employed a maximum female age based on the cumulative result of annual adult survivorship rates.

increased incidence of inbreeding and/or genetic drift. The resulting metapopulation may have a greater incidence of deleterious recessive characteristics, reduced adaptability to environmental change, and/or higher susceptibility to disease. Ralls et al, (1986) argue that inbreeding is largely theoretical and undocumented; they suggest that if an individual's mating opportunity is only with a close relative, they will either disperse or not mate at all. Regardless of the strategy employed, the effective overall panmictic population size is reduced.

Specifically, there are metapopulations of spotted owls which are partially isolated, at the very least. The Olympic Peninsula sub-population is an example of one (Thomas *et al.* 1990). In B.C., insularization effects of the present fragmented SOCA system may not be a problem to dispersing individuals within SOCAs, however dispersal between SOCA's may be inhibited.

The importance of peripheral populations has been cited for a number of reasons. Peripheral populations may be important to some species for re-colonizing central or interior range populations upon their reduction. The importance of edge populations in a founder effect role has also been suggested (Merrell 1981). Hoffman and Parsons (1991) theorize that as fragmentation of critical habitats continues, genetic variability is a necessary stress response, particularly when escape is not possible.

Relative to the distribution of the species, the entire B.C. spotted owl population could be considered a peripheral population, adapted best to the northern limits of the species range. Inhabiting a climatically harsher and less predictable environment, the B.C. population may have the greatest genetic diversity best suited for adaptation. Southern counterparts of the spotted owl population may be closely adapted to their habitats and lack the ability to adapt to a rapidly changing environment. For these reasons, the northern range of the spotted owl may play a critical role in the future survival of the species in North America.

Little is known of the present genetic variability of spotted owls and if this is a healthy level. Some electrophoretic analyses have been completed and a study is being initiated in Oregon to compare individuals genetic diversity (J. Carlson per. comm.). To ensure genetic variability is maintained through management, Hoffman and Parsons (1991) suggest monitoring genetic diversity in areas of the genome that might be important for future environmental adaptations.

G. Threats to the Northern Spotted Owl

Habitat Availability

The amount of owl habitat that existed before timber harvesting is unknown, but probably 30% or less of prelogged low-elevation old-growth forests remains (K. Klinka, pers. comm., J. Pojar, per. com.). Although not all old-growth forests may have been occupied by spotted owls, this large decrease suggests that the remaining habitat represents only a small portion of the area previously occupied by the owl.

The recovery of spotted owls in Canada is limited by habitat availability. Complete recovery implies a situation in which spotted owls would re-occupy areas once inhabited by the species. In reality, complete recovery is impossible given the dramatic changes in land-use which have occurred in the province during the past century. For example, the forests adjacent to the lower Fraser River, which likely provided owl habitat in historic time, are now almost completely converted to urban and agricultural uses. The land area within the range of the owl is broken down into parks, private lands and Provincial Crown Forests. Although private lands may provide suitable owl habitat, these areas probably will be excluded from long-term spotted owl management.

At present, the range of the spotted owl does not overlap with the Canadian National Parks system. The current provincial and regional parks system provides, or eventually will provide, suitable owl habitat conditions that are protected from future timber extractions. Although the park system currently include young and old-growth forests, over time approximately 110,096 ha of future potential suitable owl habitat may exist within the system (Table 5). Most of this habitat occurs in two geographic areas with 64 % occurring within Golden Ears, Garibaldi and Judge Howay, and 25 % occurring within Manning, Skagit and Cascade. Unfortunately, the two geographic areas are poorly interconnected with a linear distance of approximately 85 km between these areas. Given that only 2.6 % of juveniles disperse this distance, successful dispersal between these two areas is probably extremely low.

Provincial Crown Forests is managed to integrate timber harvesting with other concerns such as recreation and wildlife management. These forests can be broken down into operable and inoperable forests. Operable forest represents the total land area that contributes to, and is available for, long-term timber supply. For the most part, these forests occur along valley bottoms and are more productive in terms of tree growth and species abundance and diversity than inoperable forest. Inoperable forests represents the total land area that does not contribute to the

Table 5. Current habitat availability within the range of the spotted owl in British Columbia.

Land Allocation	Forested Area (ha)	Current Potential Owl Suitability[1] (%)	Owl Suitability in 100 years
Parks[2]			
Manning, Skagit & Cascade	27,380	40 - 60 %	70 - 90 %
Garibaldi	32,589	60 - 80 %	70 - 90 %
Golden Ears & Judge Howay	37,350	50 - 70 %	70 - 90 %
Others	12,777	40 - 60 %	70 - 90 %
	110,096		
Fraser TSA[3]			
Operable Forest	261,608	39 %	12 %
Inoperable Forest	308,658	50 - 70 %	70 - 90 %
	570,266	45 - 56 %	43 - 54 %
Soo TSA[4]			
Operable Forest	140,584	41 %	5 - 15 %
Inoperable Forest	167,111	74 %	70 - 90 %
	307,695	59 %	
GVWD Watersheds[5]			
Capilano	12,626	66 %	-
Seymour	11,653	68 %	-
Coquitlam	10,554	73 %	-
	34,833	69 %	

1 Suitability is based on forest age classes of 7, 8 & 9 (120 years old or greater).

2 Total area includes non-forested areas.

3 Total includes areas north of Boston Bar that are not known to be inhabited by spotted owls. Information is from Fraser Timber Supply Analysis (1993).

4 Total includes areas west of Pemberton that are not known to be inhabited by spotted owls. Information is from Draft Soo TSA Forest Management Plan (1993).

5 Information provided by Derek Bonin (pers. comm.).

long-term timber supply. These forests include areas defined as unavailable for harvest for terrain-related or economic reasons, areas with high recreational value, and areas that are environmentally sensitive. In general, these habitats are found at higher elevations and may be less productive in species abundance and diversity. These habitats may represent marginal spotted owl habitat.

With the exception of areas north of Boston Bar (ie. Nahatlatch River), the Fraser Timber Supply Area overlaps the southern portion of the current known spotted owl range. This area encompasses approximately 570,266 ha of Provincial Crown Forest of which approximately 261,608 ha (46%) constitutes operable forests and 308,658 ha (54%) constitutes inoperable forest (Table 5). Between 45 to 56% of this total may be considered as suitable owl habitat (trees aged greater than 120 years old). However, a large proportion of this habitat is small in area, fragmented and isolated from areas of suitable habitat. Although some land-use initiatives are proposed over the long-term, current projections estimate that the amount of potential suitable owl habitat within the operable landbase will be reduced by up to 70% over the next 100 years.

With the exception of areas west of Pemberton, the Soo Timber Supply Area overlaps the northwestern portion of the current known spotted owl range. This area encompasses approximately 307,695 ha of Provincial Crown Forest of which approximately 140,584 ha (46%) constitutes operable forests and 167,111 ha (54%) constitutes inoperable forest (Table 5). Approximately 59 % of the Provincial Crown Forest may be considered as suitable owl habitat. However, like the Fraser TSA, a large proportion of this habitat is small in area, fragmented and isolated from other areas of suitable habitat. Over the long-term, reductions to the amount of suitable owl habitat within the operable landbase may be comparable to the Fraser Timber Supply Area.

The Greater Vancouver Water District Watersheds encompass approximately 34,833 ha of forests of which approximately 69 % constitutes potential suitable owl habitat (Table 5). Although the future state of these lands is uncertain, probably no less than 50 % of the land areas will be unsuitable owl habitat.

Random Environmental Events

It is generally accepted that small populations are vulnerable to extinction through random environmental or demographic events (Gilpin and Soulé 1986). Consecutive years of poor reproduction or high adult mortality, as well as, catastrophic events such as wildfires, storms and other natural events can result in quick extirpations of small populations. Because wildlife managers cannot control these events, the only recourse is to provide for populations large enough

to withstand their effects, and close enough together to facilitate recolonization if and when extirpations occur (Soulé 1987).

Existing data is inadequate to state with any certainty how many spotted owls are "enough" to overcome the risk of extinction through random demographic or environmental events. Theoretical studies support the generalization that small, fragmented populations are at a greater risk than large, contiguous populations (Noon and Biles 1990, Doak 1989). One simulation based on relatively optimistic population parameters (age at first reproduction = 2 years, annual fecundity = 0.33, probability of successful fledging and dispersal = 0.11) indicated that small initial populations (less than 25 owl pairs) went extinct within 150 years (Thomas *et al.* 1990). It is for this reason that Thomas *et al.* (1990) recommends management of large habitat blocks capable of supporting 15 or more owl pairs, versus the single pair "spotted owl habitat areas" (SOHAs) originally proposed by the U.S. Forest Service (USDA 1986).

The management implications of these analyses are important. First, low observed fecundity would appear to preclude rapid population growth, or quick repopulation of areas after extirpations have occurred (Forsman *et al.* 1984, Marcot and Holthausen 1987, Barrowclough and Coats 1985). It is presently unknown whether fecundity could be enhanced by management (eg. through silvicultural prescriptions which increase prey populations: Thomas *et al.*, 1990). Second, high adult survivorship will probably ensure a lengthy time lag between changes in environmental carrying capacity and population response. More importantly, the already very high observed adult survivorship rates (0.85 to 0.97) provides very little potential for increase through management.

Given variability in reproductive rate similar to that found by Forsman *et al.* (1984), and other population parameters similar to those given by Noon and Biles (1990), it is highly unlikely that the current spotted owl population in the province can be expected to survive the test of time if isolated from other owl populations in the United States. Thus, it is essential that the management of spotted owls in the province be in conjunction with the owl population and management strategies in Washington.

Meta-population Structure

Northern spotted owls are increasingly concentrated within islands of suitable habitat surrounded by a sea of human-modified landscapes. This type of population structure, in which a total population consists of smaller sub-populations that are isolated in space, has been termed a meta-population (Shaffer 1985). Dispersal is a key ingredient of the meta-population model, for

animals dispersing between patches may buttress existing sub-populations, provide a rescue effect for sub-populations which are declining, or provide seed for recolonization. For this reason, the frequency and magnitude of successful spotted owl dispersal has been the subject of considerable research effort involving both radio-telemetry (eg. Miller summarized in Thomas *et al.* 1990, Gutiérrez *et al.* 1985, Miller and Meslow 1985) and simulation modelling (Thomas *et al.* 1990, Doak 1989).

Several recent simulation models incorporate spatial considerations with spotted owl demography (Thomas *et al.* 1990, Doak 1989, Lande 1988). Unfortunately, data with which to validate these models (ie. empirical patch extirpations or recolonization rates) are lacking, and the result is a wide range of values which predict meta-population survival or extirpation depending on the choice of parameters used. Different assumptions of average dispersal distance, the total quantity of suitable habitat within dispersal range, and the proportion of habitat likely to be searched by a dispersing owl before either establishing a territory or dying, exerts a radical influence on survivorship of the meta-population in these models. Based on an estimated 32.5% of the total landscape being suitable spotted owl habitat and a search efficiency which allows dispersing owls to search 3% of the total landscape, Thomas *et al.* (1990) determined that clusters of 15-20 pairs would be stable assuming moderate connectivity (dispersal) between clusters. This result provided an additional rationale for the Thomas *et al.* (1990) proposal that spotted owl managed in clusters of 15 or more pairs wherever possible.

Competition with Barred Owls

The conservation of spotted owls may be complicated by the recent expansion of Northern barred owls into the Pacific Northwest (Campbell *et al.* 1990, Taylor and Forsman 1976, Grant 1966). First recorded within British Columbia in 1943 (Munro and Cowan 1947), the species is now sympatric with spotted owls in most portions of the Pacific Northwest (Hamer *et al.* 1989).

The recent expansion by barred owls is particularly interesting because it remains unclear whether successful colonization of the Pacific Northwest was "natural", a population response to land-use changes (particularly clearcut logging), or a combination of these or other factors. Replacement of one congener by another may present a classic practical example of the competitive exclusion principle. As described by Gause (1934), competitive exclusion states that no two species can inhabit the same ecological niche, for one must invariably be more successful and eventually cause the extinction of the other. Competitive exclusion presumably occurs naturally, although most evidence for its existence comes either from human-induced introductions of species, or habitat modification (Elton 1958).

The effect of barred owls on the spotted owl populations is unclear. Assuming equivalent barred/spotted owl response rates (owls/km surveyed) to taped calls of spotted owls, surveys conducted in British Columbia suggest that barred owls are four times more abundant than spotted owls (Blackburn *et al.* in prep.). In comparing habitat use, Blackburn (1991) observed similar barred owl response rates in old-growth and young forests stands of various quantities and fragmentation. This suggests that the barred owl is not being overly selective towards older forests. Alternatively, most spotted owls were detected in large, contiguous stands of old-growth forests.

Hamer *et al.* (1989) were successful in documenting divergent life-history characteristics of barred and spotted owls in the Mount Baker region in Washington. Their analysis indicated that barred owls are more flexible in choice of prey, exhibit much smaller annual home range sizes (barred owl HR = 205-1,356 ha; spotted owl HR = 988-7,261 ha), forage less often in older forests, and may utilize a greater range of nest cavity sizes.

Spotted owls and barred owls appear to be some what spatially segregated. Although both species have been observed at various elevations, barred owls tend to occupy low elevational habitats that contain young forests with some riparian and hardwood components (Hamer *et al.* 1989, Dunbar *et al.* 1991, Blackburn *et al.* in prep.). Spotted owls tend to occupy mid to high elevations where contiguous, old-growth forests still remains. In general, these lower elevational areas have been harvested within the last 100 years and currently may provide only marginal habitats for spotted owls. As the young forests becomes more suitable for spotted owls, it is uncertain whether spotted owls will re-occupy these low elevational habitats and displace barred owls.

The barred owl's selection for younger forests is not entirely clear. Hamer *et al.* (1989) suggest that young forests provide higher abundances and/or diversity of prey items, and ideal foraging habitat for barred owls. They observed that prey selection appears to be partially segregated between the two species, with barred owls largely consuming terrestrial prey items and spotted owls largely consuming arboreal and semi-arboreal prey items. Young forests selected by barred owls exhibit a moderate to high density of trees, high canopy closure, and few shrubs or forbs in the understory (Hamer *et al.* 1989). The lack of brush make it easy for barred owls to observe, fly and attack terrestrial prey. Furthermore, the shorter canopy height of young forests enables barred owls to perch closer to the ground and provides a better advantage while hunting terrestrial prey (Hamer *et al.* 1989). Conversely, spotted owls specialize in flying squirrels, an arboreal species that is at least twice as abundant in old-growth forests than other types of forests (Carey 1992). Old-growth forests provide perching structures at various heights within the canopy that may provide better advantages when hunting arboreal and semi-

arboreal prey.

Blackburn (1991) speculated that as old-growth forests become increasingly fragmented and/or smaller in area, the habitat remains suitable for barred owls but becomes less suitable for spotted owls. Given the spotted owl's considerably larger home range size and habitat requirement, the gradual loss of habitat should impact spotted owls before it impacts barred owls. As spotted owls are displaced, habitat would become available for colonization by additional barred owls. In British Columbia, no known spotted owl has been displaced from an areas where no timber harvesting occurred. Furthermore, clear-cuts and edges caused by fragmentation may provide high abundances and diversity of terrestrial prey items.

Since 1989, hybrid crosses between barred owls and spotted owls have been confirmed at four widely separated locations within the range of the spotted owl in the United States (Thomas *et al.* 1993). Although records of hybridization are an interesting biological phenomenon, the ultimate outcome is unpredictable. Hybridization is common in nature, having been recorded in various other bird species, including two other owl species of the genus *Strix* in Europe (Scherzinger 1983). In most species where hybridization occurs it tends to be an uncommon event and the two species continue to be distinct for very long periods of time. Thomas *et al.* (1993) suspect that hybridization between spotted and barred owls is rare for the following reason. Hundreds of observers have surveyed and banded spotted owls and have confirmed several thousand pairs of spotted owls and hundreds of barred owls. Despite this massive effort, only four hybrids have been observed. This suggests that the behavioral isolating mechanisms that normally keep the two species from hybridizing are relative effective. However, the ultimate outcome is uncertain, and studies should be directed at determining this relationship.

Competitive exclusion suggests that the barred owl should drive the spotted owls towards extinction. If this is true, the spotted owl population should show signs of the barred owl effect. However, spotted owls still occupy most large stands of old-growth forests. The continued persistence of spotted owls in British Columbia, despite 40 to 50 years of barred owl occupancy, suggests that spotted owl may be able to persist for long periods of time despite relatively high densities of barred owls (E. Forsman, per. comm.).

Predation

Key avian predators to the spotted owl include the great horned owl (*Bubo virginianus*), goshawk (*Accipiter gentalis*), and red-tailed hawks (*Buteo jamaicensis*). The common raven (*Corvus corax*) also is considered a predator,

more likely preying on juveniles than adult spotted owls.

The great hroned owl is the most commonly documented predator of the spotted owl (Miller 1989). Great horned owls are abundant through much of the range of the spotted owl in North America, however, severity of this threat is difficult to measure. Relative densities of the two species in undisturbed landscapes are unknown, however, ratios of great horned owl density to spotted owl density are highest in more fragmented portions of the owl's range. Johnson (1993) found that great horned owls occupied areas that contained significantly less mature/old-growth forest and interior habitat; had greater edge to area ratios; had more shrub/forb, sapling, and shelterwood stands; and were more fragmented than those occupied by spotted owls.

III. MANAGEMENT OPTIONS DEVELOPMENT AND DESCRIPTION

A. Introduction

The primary mandate of the Canadian Spotted Owl Recovery Team is to examine the current status of the Northern Spotted Owl in Canada, develop a recovery plan for the species and oversee the implementation of the plan. Under the guidelines of the Committee for the Recovery of Nationally Endangered Wildlife in Canada (RENEW), the recovery plan for the spotted owl will outline the rehabilitative measures required to down-list the species from its Endangered status (RENEW 1991). The plan will guide all efforts in the research and management of spotted owls in Canada. The primary objective of the recovery plan is to provide a course of action which will stabilize the current owl population and eventually lead to an improvement in the status of the species.

Down-listing of the spotted owl in Canada will require the conservation of suitable owl habitat. Recognizing the potential economic effects associated with down-listing, the BC Director of Wildlife requested the Recovery Team to provide an array of management options with their associated risks to the species (see Appendix A2). Numerous options are available for the management of the spotted owl; some options provide adequate protection and some do not. This section examines the broad range of potential management options and presents six options that provide an array of protection for the owl. A socio-economic assessment of each option will be provided in a separate document.

B. Development of Management Options

Management options were developed by combining three independent parameters (Figure 5). The three parameters examined to address the management of the spotted owl in the province included 1) Range to be managed, 2) Configuration of Designated Management Areas (DMAs), and 3) Timber management within DMAs. For each parameter, various levels of protection were examined to assess their impacts on the owl population and their potential to recover the species.

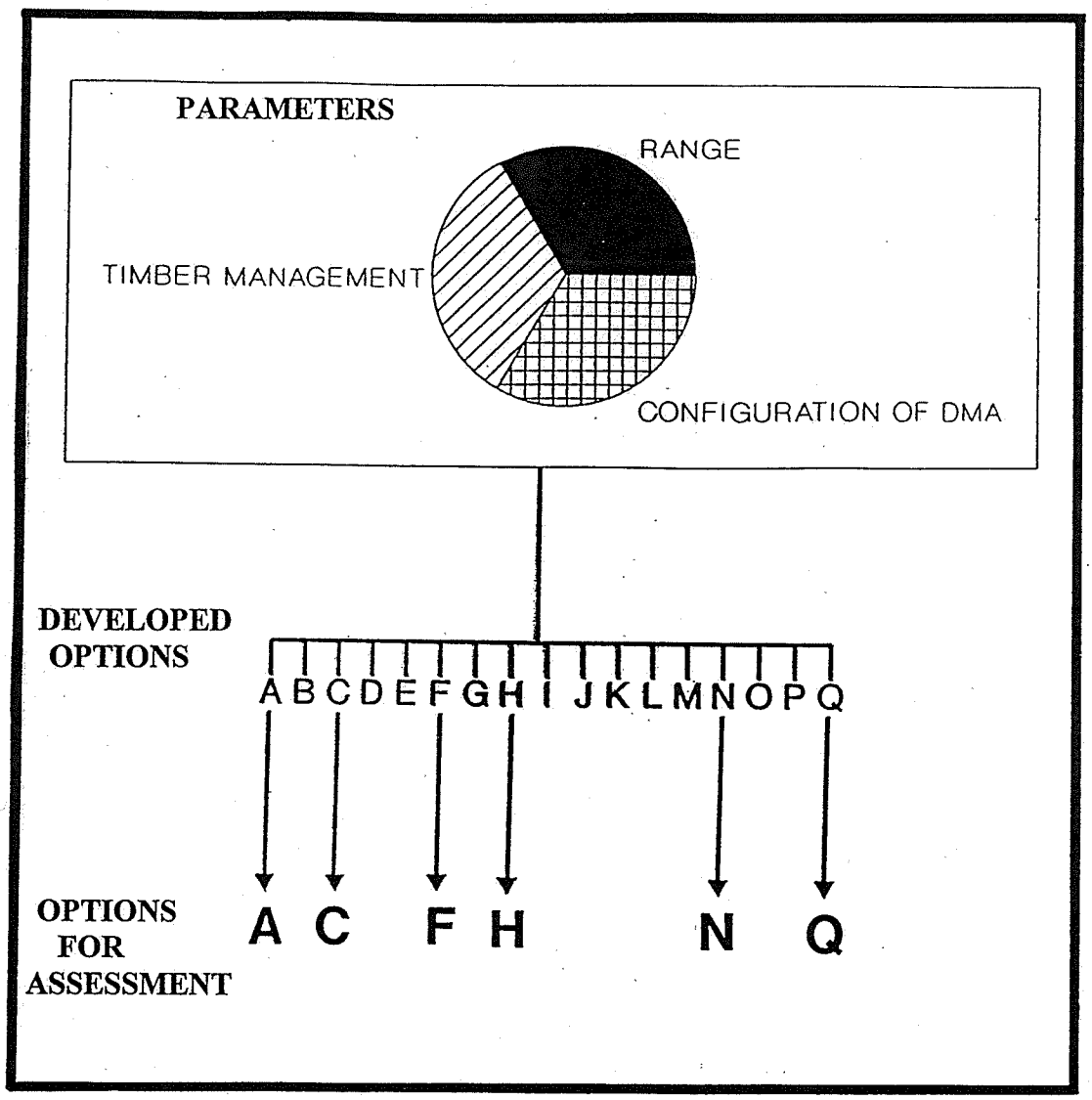


Figure 5. Conceptual framework for the development of the options. Three parameters combine to produce an option. Seventeen options were reduced to six for the biological assessment.

Parameter 1: Range of the Spotted Owl to be Managed in British Columbia

Maintaining the spotted owl across the overall range of environments occupied by the species results in a population that is less vulnerable to random environmental events (Thomas *et al.* 1990, USDI 1992). For example, habitats at different elevations, in different forest types, and in different parts of the owl's geographic range may act as a refugia for the species in the face of adverse weather conditions, rapid environmental change, and natural catastrophes such as forest diseases, insect infestation, forest fires or other unforseen changes in interactions among species. A population well distributed across the geographic and ecological conditions throughout its range provides a high likelihood that the species will survive such adverse events.

Inventories to date have determined the species' distribution within its current known range. However, some uncertainties exist concerning the "true" range of the species in the province. Although current inventories suggest that the species no longer inhabits the Squamish and Whistler vicinities (Blackburn 1991, Blackburn *et al.* in prep.), it is uncertain whether the owl occurs further northwest to Bute Inlet (unconfirmed historic record). As well, recent detections of the species further north in the Interior Douglas-fir Biogeoclimatic Zone has raised a number of uncertainties. It is unclear how far north and east the owl may occur, and, how large the population may be within these habitats.

The owls in British Columbia can be considered a peripheral population to the entire North American population. Peripheral populations are important to a species' survival for three reasons. First, the risk of extinction of a species is reduced by maintaining individuals over the widest possible distribution (Den Boer 1981, Thomas *et al.* 1990, USDI 1992). Second, peripheral populations are often sites of the most rapid genetic adaptations within a species (Thomas *et al.* 1990, USDI 1992). 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 the range (Peters and Darling 1985).

Maintaining old forests throughout the managed range would benefit numerous other species that are either dependent upon or closely associated with older forest habitats (Appendix C). Obviously, reducing the managed range would reduce the overall number and/or the amount of habitat overlap with other species.

Five Ranges were examined for the management of the owl in the province. These ranges included A) Manage the spotted owl population throughout its documented range; B) Manage the spotted owl population throughout its currently known

range; and C, D, and E) Range Reduction: manage the spotted owl population within a reduced portion of its currently known range. Figure 6 provides a conceptual model of the relationship between managed range and the risk of extirpation of the species. The following is a description and assessment of each range considered.

Range A: Manage the spotted owl population throughout its documented range in the province

Range A manages the spotted owl throughout its documented range in British Columbia. The Documented Range includes confirmed historic and current records of the species. The Documented Range extends west to Squamish River, north to Birkenhead Lake, east to Anderson River and south to the International Border (Figure 7). This range provides habitats for recolonization of areas previously inhabited by the species and allows for modification of the managed range as new inventory information is collected.

Managing the spotted owl throughout its Documented Range provides an opportunity to protect all currently known active spotted owl sites. Protecting all currently known owl sites maximizes reproductive potential of the current owl population (number of fledged young per year), maximizes the number of dispersing individuals that may occupy new and vacant habitats, and maximizes genetic diversity within the population. Furthermore, this range maximizes the overall range of environments and geographic conditions occupied by the owl, making the species less vulnerable to random environmental events.

Managing throughout the Documented Range provides the highest likelihood of maintaining a viable owl population and the lowest risk of species extirpation relative to the other Range Options (Figure 6). Furthermore, this level of range may be the only level which satisfies the criteria for de-listing the species.

Range B: Manage the spotted owl population throughout its currently known range in the province

Range B manages spotted owls throughout its currently known range in British Columbia. The Currently Known Range extends west to Capilano River, north to Birkenhead Lake, east to Anderson River and south to the International Border (Figure 7). This range allows for modification of the managed range as new inventory information is collected.

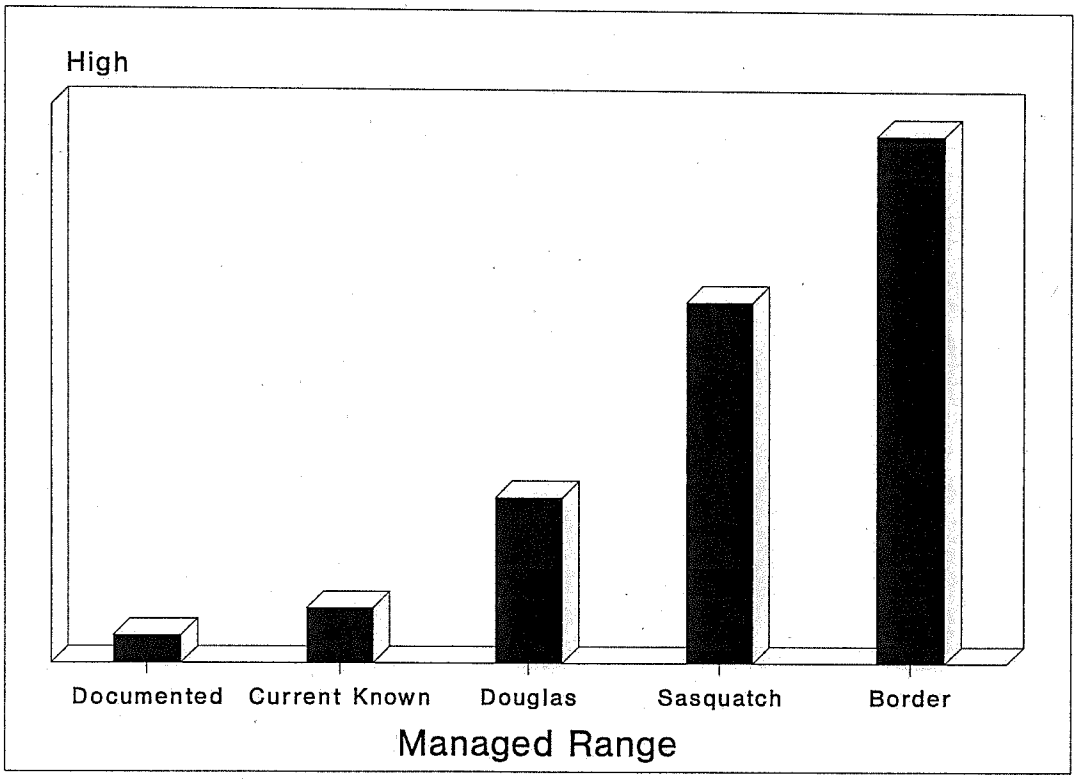
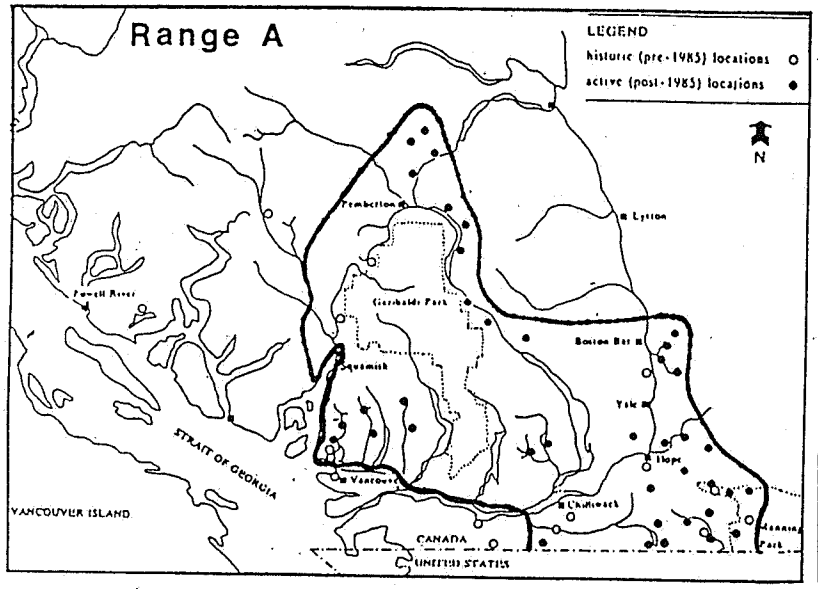
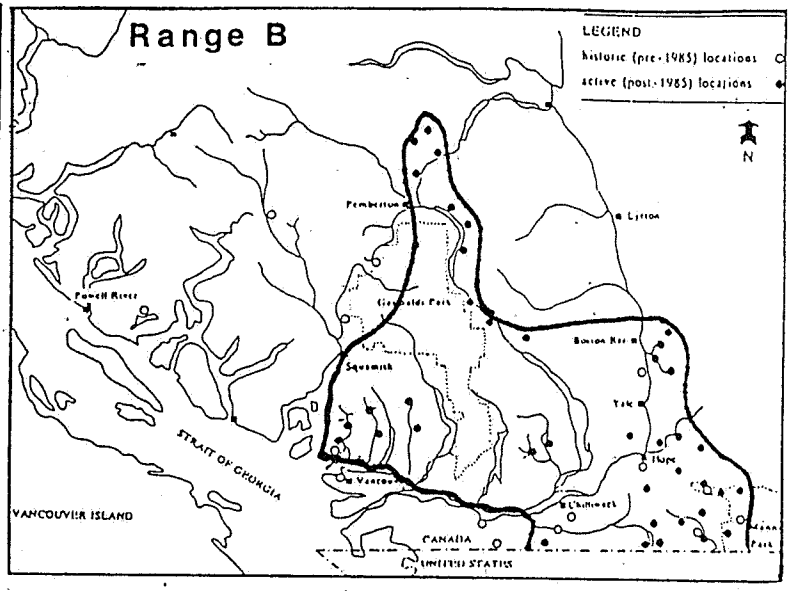
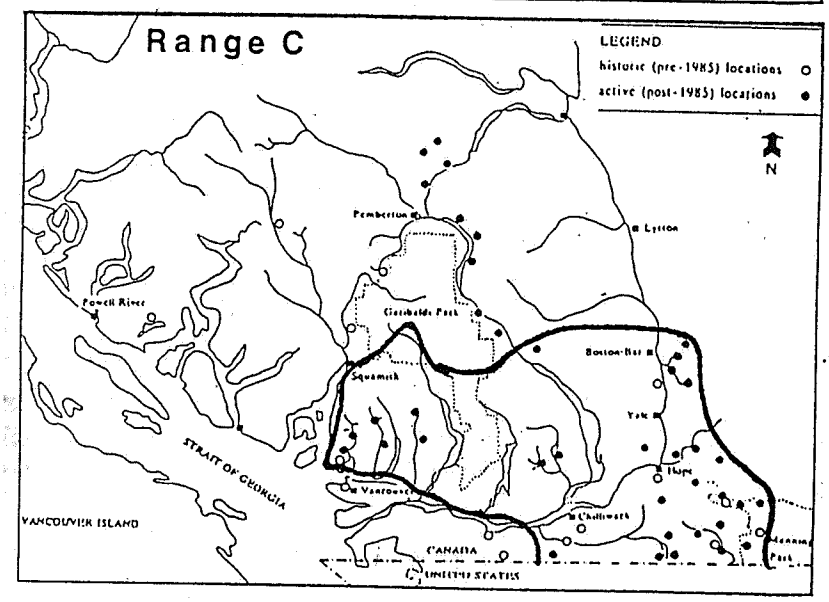


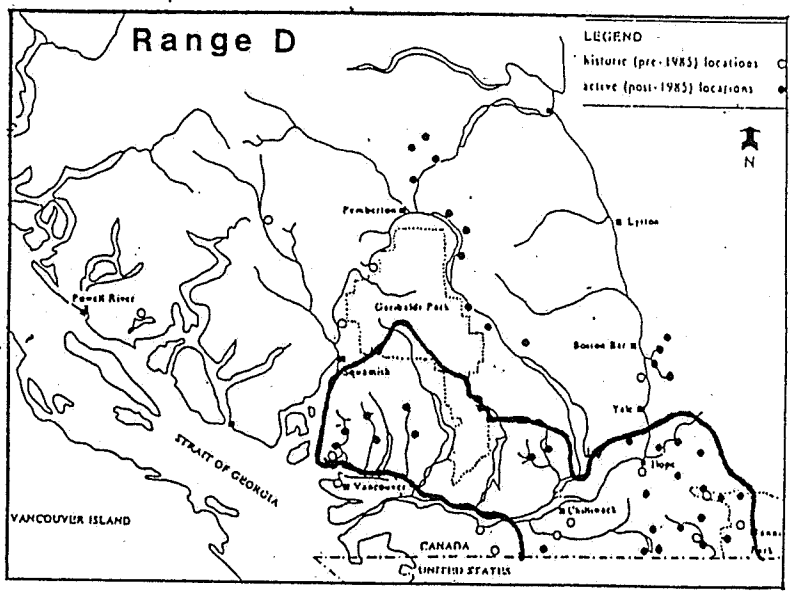
Figure 6. Conceptual model of the relative likelihood of spotted owl extirpation with managed range.

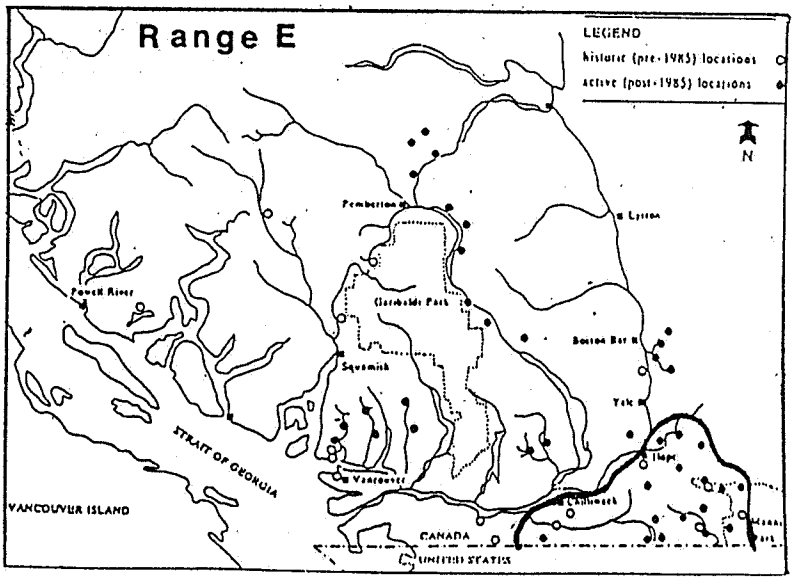
Figure 7. Range A - Documented; Range B - Currently Known; Range C - Douglas; Range D - Sasquatch; Range E - Border.











Managing the spotted owl population throughout the Currently Known Range provides similar biological benefits to the species as Range A, however, Range B does not provide habitats for recolonization of areas previously occupied by the species (excludes the Squamish and Whistler areas). As a result, this range increases the species vulnerability to chance environmental events.

Managing through the Currently Known Range provides a high likelihood of maintaining a viable owl population and a low risk of extirpation relative to the other levels of range (Figure 6). However, managing the species throughout this range does not satisfy the criteria for de-listing the species.

Ranges C, D & E: Range Reduction: manage spotted owls within a portion of its currently known range

Various levels of Range Reduction manage spotted owls only within portions of its currently known range in the province. Three levels of Range Reduction were established to represent a small (Douglas Range), medium (Sasquatch Range) and large (Border Range) range reduction (Figure 7). The Douglas Range (Range C) extends west to Capilano River, north to Douglas Creek, east to Anderson River and south to the International Border. The Sasquatch Range (Range D) extends west to Capilano River, north to Sasquatch Provincial Park, east to Sowaqua Creek and south to the International Border. The Border Range (Range E) extends west to Cultus Lake, north to Hope, east to Sowaqua Creek and south to the International Border. These Range Reductions do not provide habitats for recolonization of previously occupied areas. Conversely, they contract the range over which the owl is managed.

Over the long-term, Range Reductions do not provide any protection for spotted owls outside the managed range. As a result, the loss of known active owl sites will reduce the potential of maintaining a viable owl population in the province. Given the currently low number of owls in the province, the loss of an owl site will have a significant impact on the provincial population by decreasing number of juveniles produced annually and decreasing the genetic diversity of the population.

The security of owl populations is directly related to the total number of owl sites occupied (Thomas *et al.* 1990, USDI 1992). In comparison to Ranges A and B, any range reduction will reduce the total number of future owl sites occupied. This will result in lower likelihoods of maintaining a viable owl population in the province. Furthermore, range reduction reduces the overall range of environments occupied by the owl, making the species more vulnerable to chance environmental events.

Any range reduction around the edge of a species' geographic or elevational range could have serious biological consequences since these areas are often sites of the most rapid genetic adaptations within a species (USDI 1992). Eliminating edges of the spotted owl's range could reduce the evolutionary capability of the species. As well, the elimination of edges might be considered unwise in the face of possible widespread climatic changes, especially where the direction and magnitude of those changes are uncertain. For example, if the climate warmed through global warming, it could place increasing importance on the northern range of the spotted owl.

Managing the spotted owl population within a contracted range will provide lower likelihoods of maintaining a viable population relative to the other Ranges considered (Figure 6). Range reduction will not satisfy the criteria for down-listing the species.

Parameter 2: Configuration of Designated Management Areas (DMAs) for spotted owls

Designated Management Areas (DMAs) are delineations of Provincial Crown Forests to maintain existing and future populations of spotted owls. Ideally, areas managed for spotted owls should be large enough to support breeding pairs, juveniles, subadults and non-territorial "floaters". It is thought that "floaters" act as replacements for birds that die or vacate their territories for other reasons (Thomas *et al.* 1990, USDI 1992). The ready replacement of birds should help maintain the breeding population and the viability of the entire population. By providing sufficient amounts of suitable owl habitat across the landscape, the floater population should be maintained.

The shape of DMAs should attempt to minimize the perimeter-to-area ratio to reduce the effects caused by edge. Edge effects may increase the potential for competition with or predation by other species, and habitat degradation caused by natural disturbances (Thomas *et al.* 1990).

The viability of the owl population is dependent upon providing distances between owl sites small enough to permit successful dispersal of individuals (Thomas *et al.* 1990, USDI 1992). For example, approximately 80 % of all dispersing juveniles travel at least 12 km away from their natal area (Thomas *et al.* 1990). Although each owl site may be subject to extirpation at some point over the long-term, individuals dispersing between owl sites provide a better chance for re-establishment of vacant sites and improves the exchange of genetic material.

All forested habitats located outside DMAs can be considered the forest matrix. Forest management within the matrix is subject to current forest practices. The matrix plays an important role in providing habitats for dispersing individuals. Although the matrix does not need to provide habitat to support breeding pairs of owls, it does need to provide suitable cover and foraging opportunities for dispersing individuals. Current forest practices and new initiatives of the Forest Ministry may provide adequate amounts of suitable habitat to facilitate dispersal. These practices and initiatives include Visual Quality Objectives, Coastal Fish/Forestry Guidelines (Riparian Habitat Protection), Coastal Biodiversity Guidelines (Forest Ecosystem Networks), Forest Practices Code and Protected Areas Strategy.

Three configurations of DMAs were examined. These included A) Manage spotted owls in all forested habitats throughout the managed range (one DMA); B) Manage spotted owls throughout the managed range in large habitat blocks capable of supporting clusters of multiple breeding pairs (4 to 21 DMAs); and C) Manage spotted owls throughout the managed range in small habitat blocks capable of supporting only one breeding pair (many small DMAs). Figure 8 provides a conceptual model of the relationship between various configurations and their risk of extirpation to the species. The following is a description and assessment of each configuration considered.

Configuration A: Manage spotted owls in all forested habitats throughout the managed range in the province (one DMA).

Configuration A manages spotted owls in all forested habitats throughout the managed range. All forested habitats would be managed specifically to maintain the population with each owl home range overlapping, or nearly overlapping, adjacent home ranges. No matrix habitats would occur within the managed range. For example, if Range C and Configuration A were combined, all forested habitats within the Douglas Range would be managed primarily for spotted owls.

Managing one large DMA will maximize the interior forest conditions by minimizing the perimeter-to-area ratio. Furthermore, one large DMA is large enough to withstand complete elimination from chance environmental events. Within a given managed range, Configuration A provides the best opportunity to obtain a large owl population compared to the other configurations considered. A large owl population provides a high reproductive potential (number of fledged young per year), a high number of individuals dispersing between owl sites and maintains genetic diversity in the population. The abundance of suitable habitat associated with this configuration should ensure connectivity between adjacent owl sites and support a large floater population. A large floater population will provide

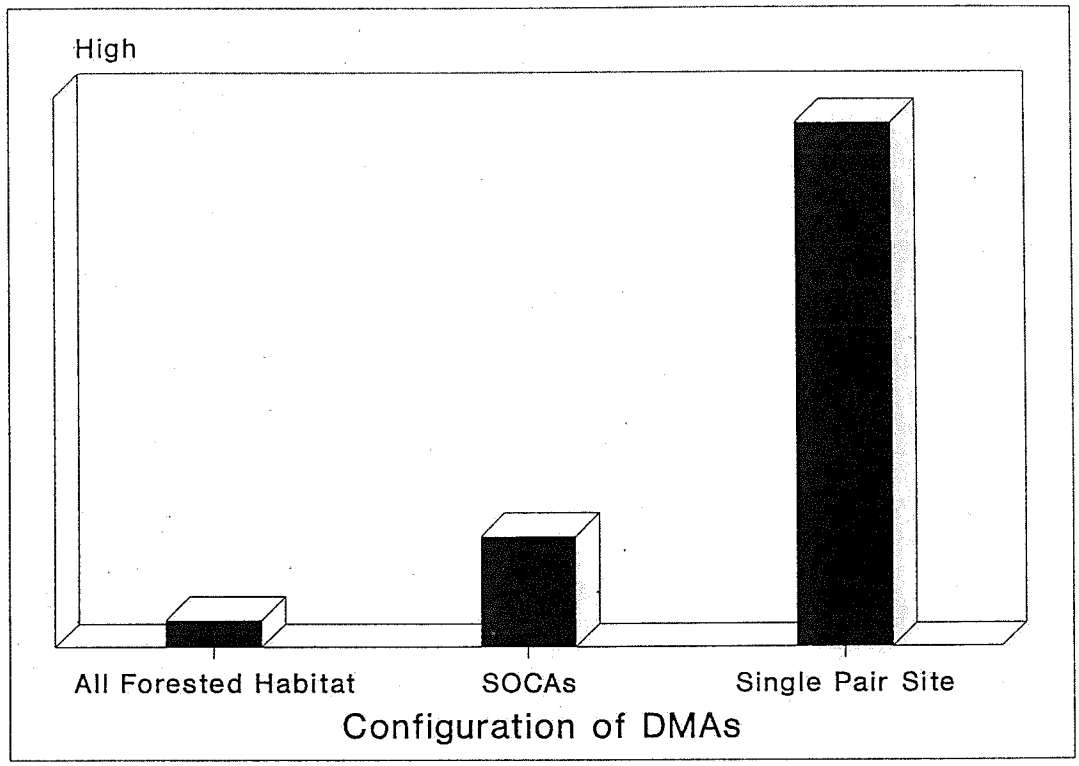


Figure 8. Conceptual model of the relative likelihood of spotted owl extirpation with configurations of Designated Management Areas.

a high likelihood that vacant owl sites will be quickly replaced.

Managing spotted owls in all forested habitats throughout the managed range provides the highest likelihood of sustaining a viable population and the least likelihood of extirpating the species relative to the other configurations (Figure 8).

Configuration B: Manage spotted owls throughout the managed range in large habitat blocks capable of supporting multiple breeding pairs (4 to 21 DMAs).

Configuration B manages spotted owls throughout the managed range in large blocks of forested habitats capable of supporting multiple breeding pairs. Habitat within these large blocks would be managed specifically for spotted owls with each home range overlapping, or nearly overlapping, adjacent home ranges. Within the matrix, forest management would be subject to the current forest practices. This type of population structure, in which a total population consists of smaller subpopulations that are spatially isolated, has been termed a "metapopulation" (Schaeffer 1985). Dispersal between subpopulations is a critical element of the metapopulation model. Therefore, distances between adjacent DMAs should be close enough that individuals can successfully disperse to another DMA. This configuration is based on widely accepted biological principles that were first applied to the spotted owl in A Conservation Strategy of the Interagency Scientific Committee (Thomas *et al.* 1990) and later applied in the Final Draft Recovery Plan for the Spotted Owl (USDI 1992).

Configuration B provides opportunities to maintain a population that is highly productive and genetically diverse. The amount of suitable habitat within large blocks should support a floater population that provides a greater likelihood that vacant owl sites will be quickly replaced. Furthermore, these large habitat blocks may be less susceptible to "edge effects" and should be large enough to withstand complete elimination from chance environmental events.

Depending on the managed range, this configuration provides a high likelihood of maintaining a viable owl population and a low likelihood of extirpating the species relative to the other configurations (Figure 8). Based on the above criteria, a Spotted Owl Conservation Area[8] (SOCA) system was delineated throughout the Documented Range. The delineation of SOCAs and a description of the biological principles is presented in Appendix D.

[8] Further use of the terms "Spotted Owl Conservation Area" or SOCA" in this document will refer to large habitat blocks capable of supporting multiple breeding pairs of spotted owls.

Configuration C: Manage spotted owls throughout the managed range in small habitat blocks capable of supporting only one breeding pair (many small DMAs).

Configuration C manages spotted owls throughout the managed range in small habitat blocks capable of supporting only one breeding pair (a minimum 3,200 ha home range per owl pair). Habitat within each block would be managed specifically to support a single reproductive owl pair. Distances between small blocks should be close enough that individuals can successfully disperse to another DMA.

A management strategy based on small habitat blocks results in DMAs with very high perimeter-to-area ratios which may cause an increased "edge effect" to the owl. In addition, this configuration has the highest likelihood of site extirpations due to catastrophic events (Diamond 1984) and the lowest likelihood of successful dispersal by individuals relative to the other configurations. Furthermore, limited amounts of habitat would be available to support the floater population which will result in a low likelihood of replacing vacant owl sites.

Configuration C provides the lowest likelihood of maintaining a viable owl population and the highest likelihood of extirpating the species relative to the other configurations (Figure 8).

Parameter 3. Timber Management within Designated Management Areas (DMAs)

Spotted owls have demonstrated a high association upon relatively contiguous, old coniferous forests for foraging, nesting and roosting (Forsman *et al.* 1977, 1984; Thomas *et al.* 1990). Suitable owl habitat is characterized as an uneven-aged, multi-layered canopy that contains numerous large trees with broken tops, deformed limbs and large cavities (Forsman *et al.* 1984). It is widely believed among spotted owl biologists that these characteristics are more important to the owl than the age of the forest stand they inhabit. Based on current inventories, suitable owl habitat characteristics in the province are predominately located in older coniferous forests (Blackburn *et al.* in prep.).

Timber harvesting of old coniferous forests is believed to be the single greatest threat to the spotted owl population in North America (Barrows 1981, Gutierrez 1985, Forsman *et al.* 1987, US Fish Wildl. Serv. 1989). Reducing the amount and connectivity of the forest within a forest ecosystem results in forest fragmentation. A reduction in the amount of suitable owl habitat across the landscape is associated with lower spotted owl densities and decreased productivity of the owl population (Bart and Forsman 1990). This may result in decreased success of

juvenile dispersal, increased competition with other species and increased predation by other species (Thomas *et al.* 1990). Furthermore, fragmentation may result in an increased susceptibility of forest stands to natural disturbances.

A primary management objective within DMAs is to provide stable or improving habitat conditions to reverse the trend of increasing fragmentation and habitat loss. These habitat improvements within DMAs should stabilize or increase the owl population. Any management prescriptions which consider various levels of timber harvest must be applied cautiously and conservatively, and will require close monitoring of the owl population.

Three levels of timber management were examined to assess potential harvesting within DMAs. Timber harvesting is not suggested or recommended within parks and other protected areas. Levels of timber management included A) No timber harvesting within DMA Reserves, B) Long-term timber harvesting within Managed DMAs utilizing modified timber harvest practices, and C) Long-term timber harvesting within Managed DMAs utilizing current timber harvest practices. Figure 9 provides a conceptual model of the relationship between the various levels of timber management and their risk of extirpation of the species. The following is a description and assessment of each timber management.

Timber Management A: No timber harvesting within DMA Reserves

Timber Management A protects all forested habitats located within DMA Reserves. Silvicultural techniques that improve habitat conditions for spotted owls would be allowed. These techniques may include thinning of young forest stands or salvage. An example of potential guidelines for silviculture and salvage is described in Appendix E.

The protection of all forested habitats within DMA Reserves would benefit the spotted owl in two ways. First, it would eliminate any further degradation of suitable owl habitat and help to stabilize current spotted owl populations. Second, the protection of forested habitats would allow for improving habitat conditions and increasing amounts of suitable owl habitat. Over time, habitat conditions within DMA Reserves would resemble large contiguous stands of old forests. This should decrease the potential for competition with or predation by other species, and habitat degradation caused by chance environmental events.

Contiguous old forest conditions within DMA Reserves should maximize the amount of home range overlap between adjacent owl sites. This in turn may provide a higher density and productivity of the spotted owl population (Bart and

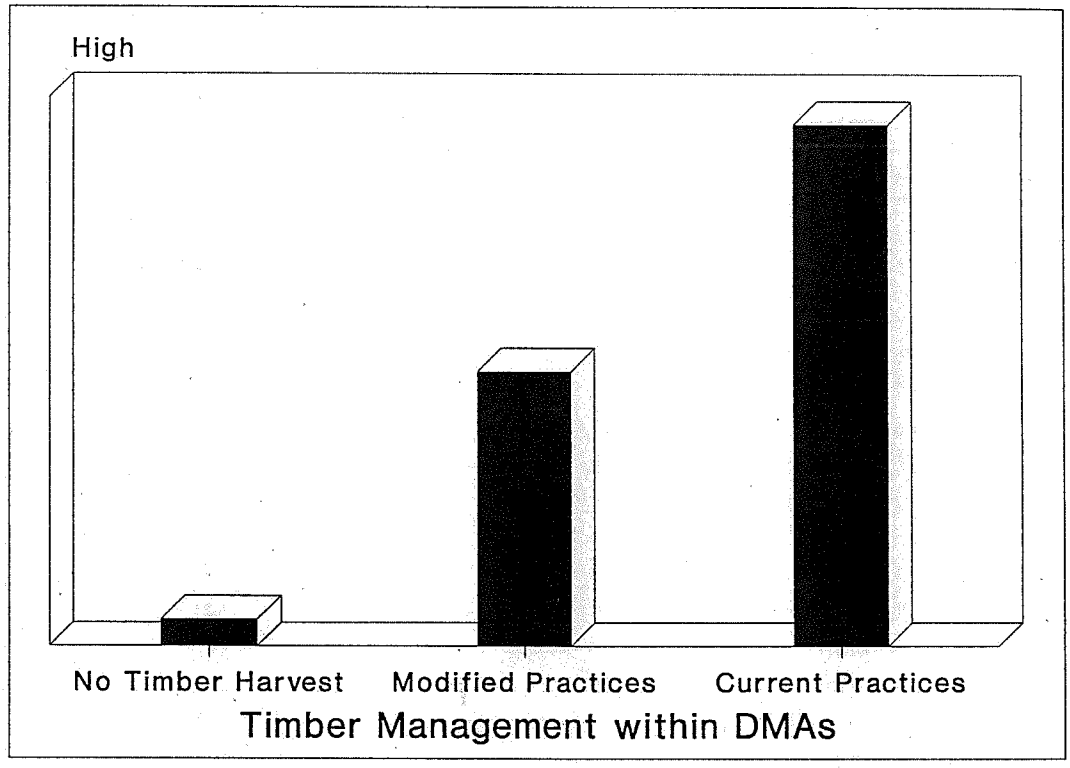


Figure 9. Conceptual model of the relative likelihood of spotted owl extirpation with various levels of timber management within Designated Management Areas.

Forsman 1990). Furthermore, maintaining a high density of spotted owls provides the least likelihood of extirpating the species since the replacement of vacant owl sites should be relatively quick.

Protecting all forested habitats within DMA Reserves provides the highest likelihood of sustaining a viable owl population and the least likelihood of extirpating the species relative to other Timber Management levels (Figure 9).

Timber Management B: Long-term timber harvesting of areas located within Managed DMAs utilizing modified timber harvest practices

Timber Management B develops a management strategy for habitats within Managed DMAs that attempts to provide long-term viability of the owl population and opportunities for timber harvests utilizing modified timber harvest practices. These modified timber harvest techniques may include: selective harvesting; retention of green trees, snags, and dead/down material; minimal fragmentation approaches; extended harvest rotations and green-up periods; and, post harvest silvicultural procedures.

Within each Managed DMA, specific areas will require immediate protection to achieve owl population and habitat availability goals. These areas include habitats within home ranges of spotted owl pairs, habitats to increase current population size, and habitats to provide connectivity between adjacent owl sites. The immediate protection of specific areas for spotted owls within DMAs should stabilize current habitat conditions. Furthermore, increasing the number of breeding pairs within Managed DMAs, excluding the management of single sites (Configuration C), should increase the viability of the owl population and decrease its risk of extirpation.

Timber harvesting within DMAs will reduce the amount of suitable owl habitat available across the landscape. This may result in a reduced number of future owl pairs occupying each DMA, reduced productivity of the owl population, reduced floater population, increased competition and increased risk of predation (Thomas *et al.* 1990). Furthermore, fragmentation of the forested habitat associated with habitat loss may reduce the amount of home range overlap between adjacent owl pairs.

It is uncertain how much habitat loss and fragmentation within the landscape can be tolerated by spotted owls, or whether this tolerance varies with location, quality of habitat and length of time since harvesting. Until more data is available, landscapes should be managed conservatively for spotted owls. If the option to

allow timber harvesting within Managed DMAs is selected, then a minimum 67% of suitable owl habitat (old and mature forests) should be maintained within each owl activity centre. This would result in Managed DMAs containing at least 67% suitable owl habitat.

All timber harvesting within Managed DMAs should be considered *experimental* and should strive to determine harvesting techniques that regrow habitat characteristics suitable for spotted owls over the shortest period of time. Any timber harvesting within Managed DMAs will require close monitoring of the owls. A monitoring program that utilizes both leg-bands and radio-telemetry should be initiated to better determine the minimal amount of suitable habitat required to maintain a viable owl population in the province. Research may indicate that owls can tolerate lesser amounts of habitat within the landscape. This in turn may allow for greater amounts of timber harvesting with Managed DMAs. Conversely, monitoring may indicate that the amount of suitable owl habitat within the landscape is inadequate and more habitat protection may be required.

Timber harvesting of forested habitats within DMAs with modified techniques will provide a moderate likelihood of sustaining a viable owl population and a moderate likelihood of extirpating the species relative to other levels of Timber Management (Figure 9).

Timber Management C: Long-term timber harvesting of areas located within Managed DMAs utilizing current timber harvest practices

Timber Management C develops a management strategy for habitats within Managed DMAs that provides for long-term viability of the owl population and opportunities for some timber harvest utilizing current timber harvest practices. Timber Management C intensifies the adverse effects on the owl population as described in Timber Management B.

Past forestry practices have resulted in clear-cuts that removed large areas of suitable owl habitat. It has been documented that spotted owls avoid large clear-cuts and other areas of unsuitable habitat (Forsman *et al.* 1984, Thomas *et al.* 1990; Hays *et al.* 1989, Allen *et al.* 1989). The avoidance of large clear-cuts probably is attributed to higher risks of predation and lower prey abundances of northern flying squirrels in northern portions of their range in the United States.

It has been suggested that suitable owl habitat may require a minimum of 80 to 120 years to develop from clear-cut stands (Thomas *et al.* 1990). In BC, the development of suitable owl habitat may require the longer time period because

of its cooler climate and shorter growing season. Current forest practices are based on an 80 year rotation; forest stands that become 80 years of age are generally available for harvest. If these practices are used within DMAs, it may prevent spotted owls from utilizing previously harvested areas.

The new Coast Planning Guidelines may create many smaller clear-cuts (maximum cut block size of 40 ha) distributed throughout the landscape. This may result in a fragmented forest. Blackburn (1991) and Hamer *et al.* (1989) suggest that as suitable owl habitat becomes increasingly fragmented and smaller in area, the habitat becomes unsuitable for spotted owls but remains suitable for barred owls. Although these guidelines may provide adequate amounts of habitat for owl dispersal, the implementation of these guidelines within DMAs may prevent spotted owls from utilizing these areas.

As discussed in Timber Management B, it is uncertain how much habitat loss and fragmentation within the landscape can be tolerated by spotted owls. Until more data is available, a minimum 67% of suitable owl habitat (old and mature forests) should be maintained within each owl activity centre. This would result in Managed DMAs containing at least 67% suitable owl habitat.

All timber harvesting within Managed DMAs should be considered *experimental* and should strive to determine harvesting techniques that regrow habitat characteristics suitable for spotted owls over the shortest period of time. Any timber harvesting within Managed DMAs will require close monitoring of the owls.

Timber harvesting of forested habitats within Managed DMAs with current forest practices will provide lower likelihoods of sustaining a viable owl population and higher likelihoods of extirpating the species relative to other levels of Timber Management (Figure 9).

C. General Description of Management Options

By combining the three independent parameters, seventeen management options were developed that spanned the scale from maximum to minimum protection for the spotted owl. These management options are displayed in Table 6 from least level of risk to the owl population (Management Option A) to highest level of risk (Management Option Q). A brief description of the various management options is described below.

Options A through M propose protecting spotted owls throughout the Documented Range in the province (Range A). At present, this range extends west to Squamish River, north to Birkenhead Lake, east to Anderson River and south to the International Border. These options attempt to provide some level of management for the owl across the broadest range of geographical and ecological conditions. Species well distributed within the geographical and ecological regions throughout their range have a lower risk of extirpation than species confined to smaller regions and ecological conditions within their range (Thomas *et al.* 1990, USDI 1992). Furthermore, these options provide an opportunity for the species to recolonize sites where extirpation had occurred in the past and allows for modification of the species' range as new information is gathered.

Options A and B propose protecting spotted owls within all Provincial Crown Forests throughout the Documented Range (DMA A). All forested habitats would be managed specifically to maintain the spotted owl population with each owl home range overlapping, or nearly overlapping, adjacent owl home ranges. Option A treats all forested habitats as "reserves" by prohibiting any further timber harvests (Timber Management A). This option provides the highest likelihood of sustaining a viable owl population and the lowest likelihood of extirpating the species in the province. Option B also provides a high likelihood of sustaining a viable population, however, forest habitats are "managed" to permit timber harvests (Timber Management B).

Options C through P (excluding M) propose managing spotted owls within the delineated Spotted Owl Conservation Area (SOCA) system, rather than all Provincial Crown Forests. The SOCA system consists of "interconnected" large habitat blocks capable of supporting multiple breeding pairs (DMA B; Appendix D). This means that habitat blocks ranging from 6,300 ha to 37,350 ha in size would be designated for spotted owl management. Between adjacent SOCAs, inter-connection distances would be no greater than 20 km apart to ensure moderately high (67%) likelihood that an individual will successfully disperse this distance (Thomas *et al.* 1990, USDI 1992). Depending on the managed range selected, this SOCA system could support an owl population that is large enough to endure random environmental events, has a high likelihood for replacement of

Table 6. Management options for the spotted owl in British Columbia.

MANAGEMENT OPTIONS	RANGE	DMA CONFIGURATION	TIMBER MANAGEMENT
A	Documented Range (Range A)	All Forested Habitats (Configuration A)	No Timber Harvesting (Timber Management A)
B	Documented Range (Range A)	All Forested Habitats (Configuration A)	Retain 67% Owl Habitat (Timber Management B)
C	Documented Range (Range A)	SOCA System (Configuration B)	No Timber Harvesting (Timber Management A)
D	Current Range (Range B)	SOCA System (Configuration B)	No Timber Harvesting (Timber Management A)
	Outside Current Range	SOCA System (Configuration B)	Retain 67% Owl Habitat (Timber Management B)
E	Douglas Range (Range C)	SOCA System (Configuration B)	No Timber Harvesting (Timber Management A)
	Outside Douglas Range	SOCA System (Configuration B)	Retain 67% Owl Habitat (Timber Management B)
F	Sasquatch Range (Range D)	SOCA System (Configuration B)	No Timber Harvesting (Timber Management A)
	Outside Sasquatch Range	SOCA System (Configuration B)	Retain 67% Owl Habitat (Timber Management B)
G	Border Range (Range E)	SOCA System (Configuration B)	No Timber Harvesting (Timber Management A)
	Outside Border Range	SOCA System (Configuration B)	Retain 67% Owl Habitat (Timber Management B)
H	Documented Range (Range A)	SOCA System (Configuration B)	Retain 67% Owl Habitat (Timber Management B)
I	Current Range (Range B)	SOCA System (Configuration B)	Retain 67% Owl Habitat (Timber Management B)
	Outside Current Range	Manage Single Sites (Configuration C)	Retain 67% Owl Habitat (Timber Management B)
J	Douglas Range (Range C)	SOCA System (Configuration B)	Retain 67% Owl Habitat (Timber Management B)
	Outside Douglas Range	Manage Single Sites (Configuration C)	Retain 67% Owl Habitat (Timber Management B)

Table 6. Continued.

MANAGEMENT OPTION	RANGE	DMA CONFIGURATION	TIMBER MANAGEMENT
K	Sasquatch Range (Range D)	SOCA System (Configuration B)	Retain 67% Owl Habitat (Timber Management B)
	Outside Sasquatch Range	Manage Single Sites (Configuration C)	Retain 67% Owl Habitat (Timber Management B)
L	Border Range (Range E)	SOCA System (Configuration B)	Retain 67% Owl Habitat (Timber Management B)
	Outside Border Range	Manage Single Sites (Configuration C)	Retain 67% Owl Habitat (Timber Management B)
M	Documented Range (Range A)	Manage Single Sites (Configuration C)	Retain 67% Owl Habitat (Timber Management B)
N	Sasquatch Range (Range D)	SOCA System (Configuration B)	No Timber Harvesting (Timber Management A)
	Outside Sasquatch Range	No Management Beyond Protected Areas	No Management Beyond Protected Areas
O	Sasquatch Range (Range D)	SOCA System (Configuration B)	Retain 67% Owl Habitat (Timber Management B)
	Outside Sasquatch Range	No Management Beyond Protected Areas	No Management Beyond Protected Areas
P	Border Range (Range E)	SOCA System (Configuration B)	No Timber Harvesting (Timber Management A)
	Outside Border Range	No Management Beyond Protected Areas	No Management Beyond Protected Areas
Q	No Management Beyond Protected Areas	No Management Beyond Protected Areas	No Management Beyond Protected Areas

vacant owl sites by floaters and provides a high likelihood of successful dispersal by juveniles.

Options C through H propose managing spotted owls in SOCAs throughout the entire Documented Range. However, options C through H propose gradual lower levels of habitat protection with corresponding higher levels of risk to the owl population. This is accomplished by the gradual conversion of SOCA Reserves (timber harvesting prohibited) to Managed SOCAs (timber harvesting permitted) in a north to south progression. As a result, the management emphasis is directed towards southern locations within the bird's range. For example, SOCA Reserves within the Border Range are the last to be converted to Managed SOCAs. Graphically, these reductions in the amount of protected merchantable (operable) habitat are displayed in Figure 10.

Options I through M propose managing some spotted owls in small habitat blocks of Provincial Crown Forests capable of supporting only one breeding pair (DMA Configuration C). This means that habitat blocks of approximately 3,200 ha (pair home range size) would be managed to support each reproductive owl pair. Inter-connection distances between adjacent owl sites would be no greater than 12 km apart to ensure a high likelihood (80%) that individuals will successfully disperse this distance (Thomas *et al.* 1990, USDI 1992). This management approach may result in an owl population that is highly susceptible to random environmental events, has a low likelihood for replacement of vacant owl sites by floaters and a low likelihood of dispersing individuals successfully locating another owl site.

Options I through M propose gradual lower levels of habitat protection for the owl with corresponding higher levels of risk. This is done by the gradual replacement of Managed SOCAs by habitat blocks capable of supporting only one breeding pair. Similar to Options C through H, the gradual conversion of Managed SOCAs to single reproductive pair sites is in a north to south progression. Therefore, Managed SOCAs within the Border Range are the last to be converted to single reproductive pair sites. Graphically, these reductions in the number of Managed SOCAs and the increases in habitat for single owl sites is displayed in Figure 10.

Options N through P propose managing spotted owls only in SOCAs within portions of its currently known range in the province (Range Reduction s). This means that spotted owls would be protected within a smaller defined range than its currently known range. Any owls located outside this defined range would have no formal protection. Options N and O propose spotted owl management only within the Sasquatch Range (Range D) and option P proposes management only within the Border Range (Range E). Only option O permits timber harvesting within SOCAs (Timber Management B). These options produce a poorly

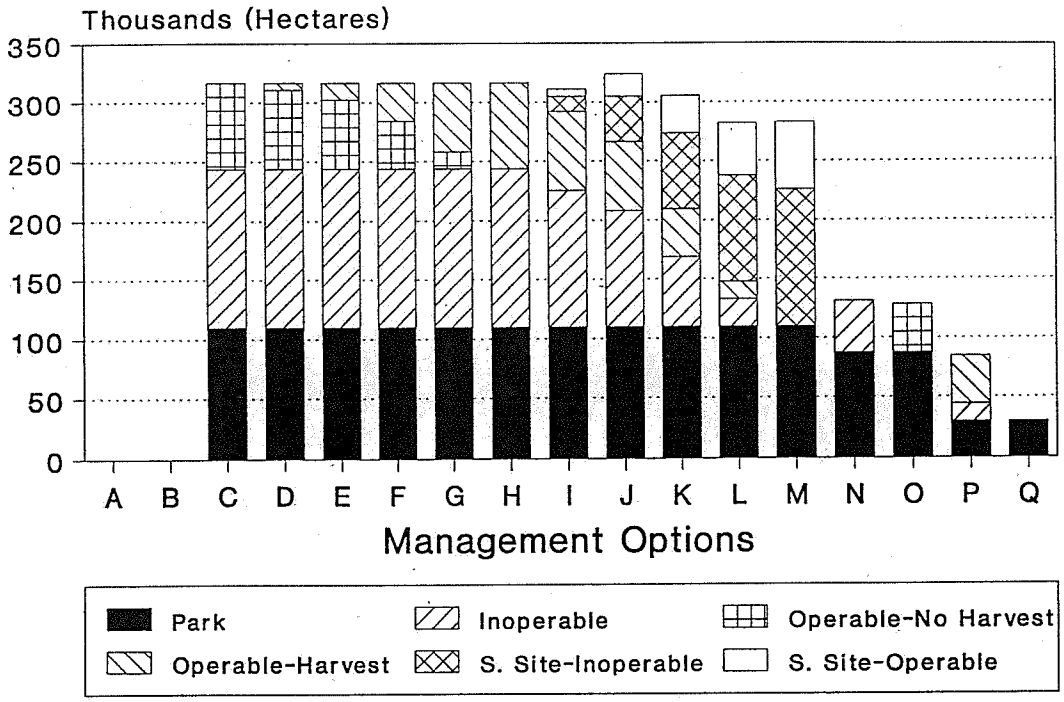


Figure 10. Forested land use within DMAs for the seventeen management options. Data for Options A and B are unavailable.

distributed owl population within its known geographical and ecological regions which results in low likelihoods of sustaining a viable owl population and high risks of extirpating the species in the province.

Option Q provides protection for spotted owls only within existing parks and other protected areas. No formal protection is afforded the spotted owl outside these areas. This option represents the lowest level of habitat protection for spotted owls and the highest likelihood of extirpating the species in the province.

D. Description of Management Options for Biological Assessment

The Recovery Team was asked by the BC Director of Wildlife to reduce the number of management options down to six options that reflect the full range of protection for the owl (see Appendix A3). Options were selected to represent the five COSEWIC status categories for species. These categories include: Extirpated - a species no longer existing in the wild in Canada but occurring elsewhere; Endangered - a species threatened with imminent extinction or extirpation throughout all or a significant portion of its range; Threatened - a species likely to become endangered in Canada if the factors affecting its vulnerability are not reversed; Vulnerable - a species particularly at risk because of low or declining numbers, small range or for some other reason, but not a threatened species; and De-listed - a species not at risk.

Specific criteria were established by SORT to provide targets by which these COSEWIC categories may be achieved. For example, the down-listing of the spotted owl from its present endangered status may only occur when certain criteria have been satisfied. Specific criteria for spotted owls in Canada for the steps from "no change in status" through to "down-listing from vulnerable to not at risk" are outlined in Table 7.

The following is a detailed description of the six management options to be considered for selection by the provincial Cabinet.

Option A: No timber harvesting in all forested habitats throughout the entire Documented Range of the bird in the province.

This option was designed to provide a very high likelihood of recovering the species to meet the de-listing criteria. Under Option A, spotted owls will be managed equally throughout the species' Documented Range in the province (Figure 11). At present, this range extends west to Squamish River, north to Birkenhead Lake, east to Anderson River and south to the International Border.

Table 7. Down-listing criteria for the Northern Spotted Owl in Canada.

No change in status, species remains Endangered.

1. Quantity of and quality of habitat is very low, and habitat conditions are expected to decline at a significant rate.
2. Populations are extremely low and likely declining with the isolation of sub-populations or individuals.
3. Current conservation measures are judged to be insufficient to protect the owl from extirpation throughout all or significant portion of its Canadian range.
4. Populations are extremely vulnerable to stochastic events.

Down-listing from Endangered to Threatened.

1. Quantity of and quality of habitat is low, but habitat conditions are stable or increasing.
2. Populations are low, but are well distributed and most are stable or increasing.
3. Current conservation measures are judged to be sufficient to protect the owl from becoming Endangered throughout all or significant portion of its range.
4. Populations are still vulnerable to stochastic events, and threats are still evident in most of their Canadian range.

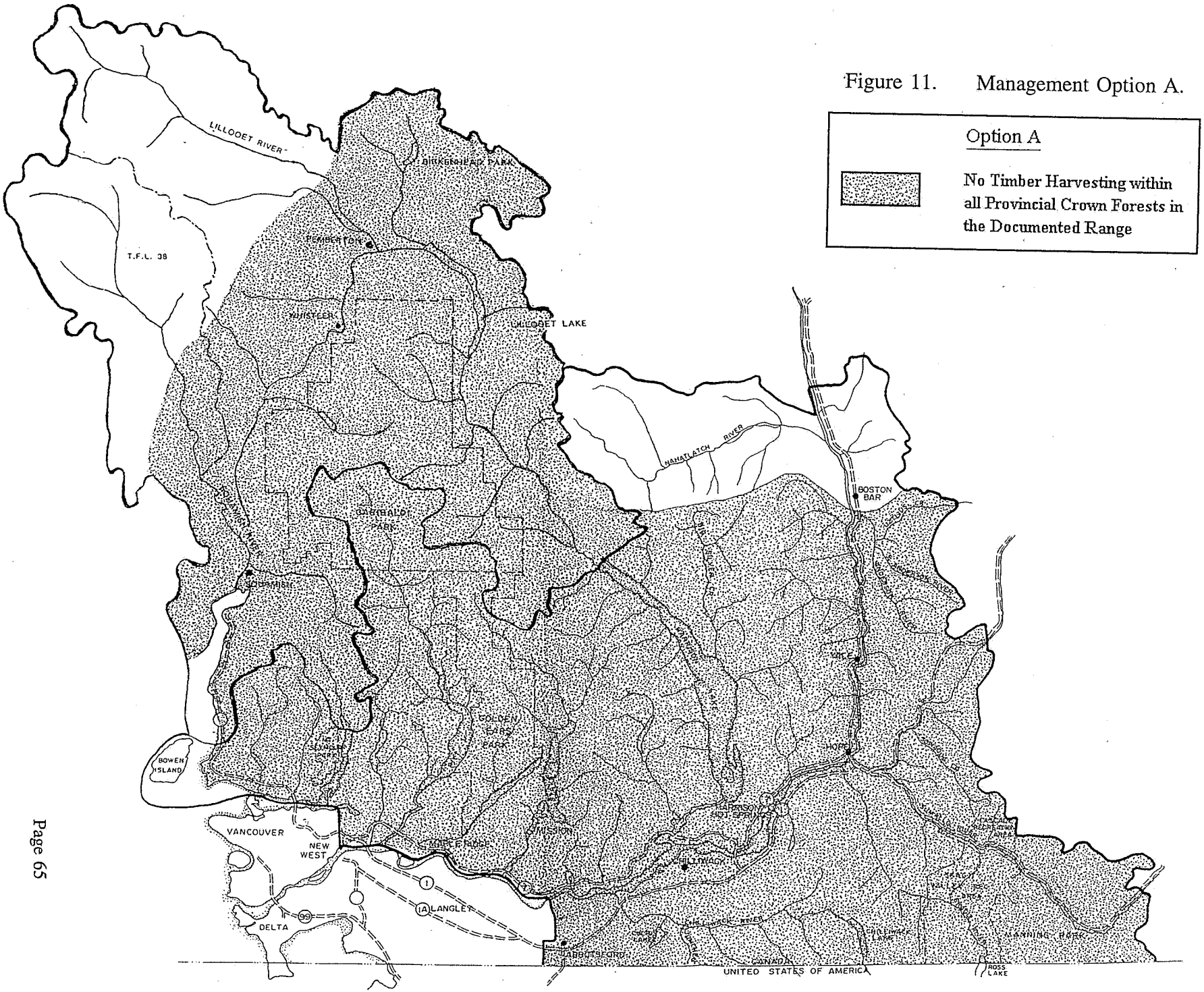
Down-listing from Threatened to Vulnerable.

1. All or the majority of habitats potentially capable of supporting owls are occupied.
2. Populations are well distributed, and have been stable or increasing for at least 7 years.
3. Populations have recovered, and current conservation measures are judged to be sufficient to protect the owl from becoming Threatened throughout all or significant portion of its range.
4. Populations are still vulnerable to major stochastic events.

Down-listing from Vulnerable to Not at Risk.

1. Population currently occupies all or most of its former geographic range.
2. Populations and habitat conditions are stable or increasing and well distributed throughout its Canadian range.
3. Conservation measures are in place which ensure continued healthy habitat conditions, population distribution, and demographic performance, such that the species is no longer at risk.
4. Population size is sufficient to withstand major stochastic events

Figure 11. Management Option A.



All Provincial Crown Forests located within this range will be managed as "reserves" (Timber Management A). This means no timber harvests will be permitted except for cutting that is designed to restore forest stands back to suitable owl habitat conditions. Cutting will primarily be confined to precommercial and commercial thinning of forest stands that have been established following harvesting. Examples of silvicultural guidelines are described in Appendix E. Cutting of forest stands will require review by a working group established to ensure consistent application of the provisions of this option.

Total forested land base contained within this area is roughly 1.5 million ha. Based on this crude estimate, the land area within Option A may be capable of supporting about 625 spotted owl pairs.

Option C: No timber harvesting in all Spotted Owl Conservation Areas (SOCAs) throughout the entire Documented Range of the bird in the province.

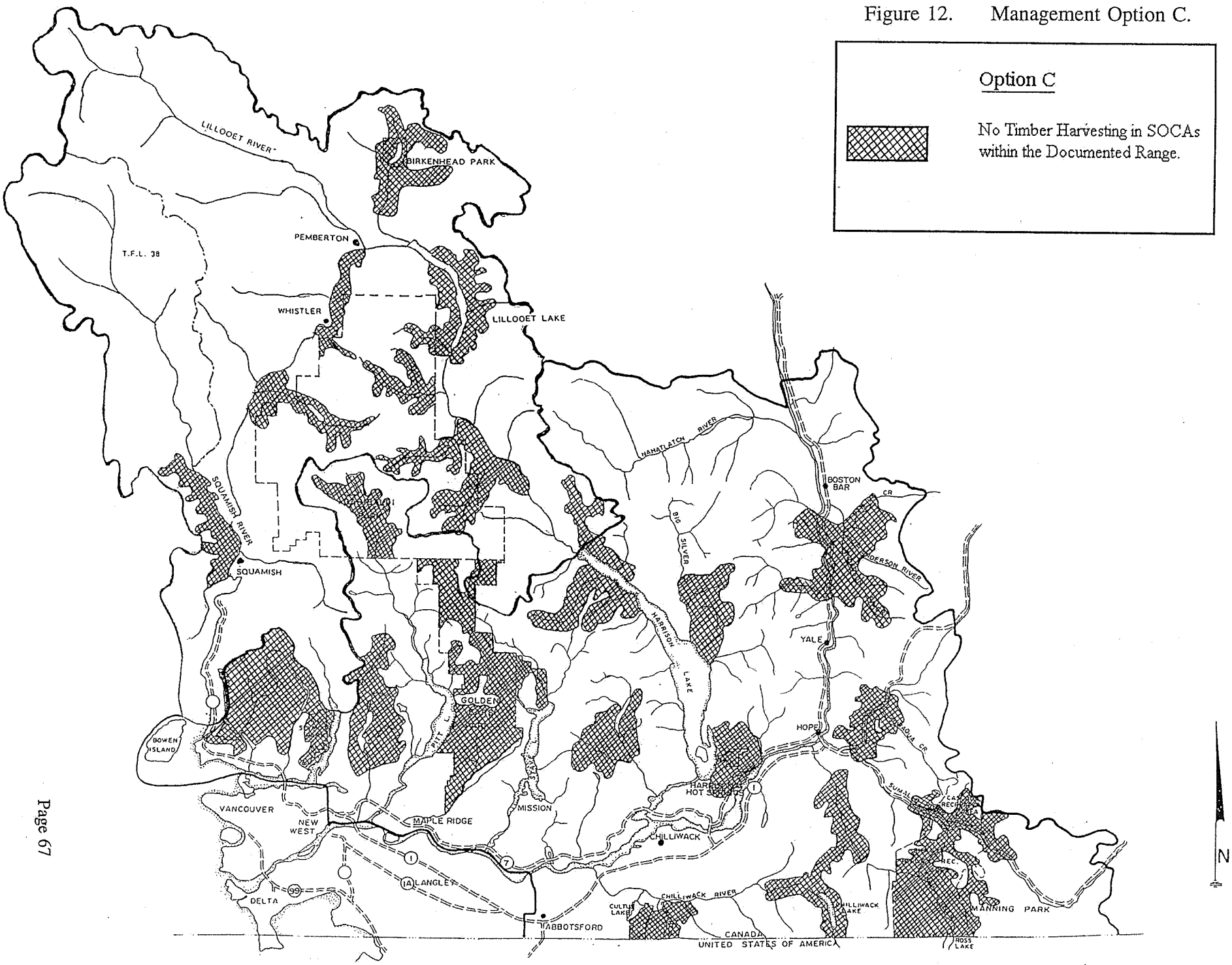
The basis for Option C is from A Conservation Strategy for the Northern Spotted Owl (Thomas *et al.* 1990) and the Final Draft Recovery Plan for the Northern Spotted Owl (USDI 1992). This option was designed to provide a likelihood of recovering the species to meet the de-listing criteria. Under Option C, spotted owls will be primarily managed within the 21 delineated SOCAs throughout the species' Documented Range in the province (Figure 12, Appendix D). All SOCAs will be treated as SOCA Reserves and should provide a high level of protection for owls throughout its range.

SOCA Reserves

SOCAs 1 through 21 will be treated as SOCA Reserves. The total area confined within SOCA Reserves amounts to 316,669 ha of Provincial Crown Forests (excluding SOCA 18, Figure 13). This land area consists of 133,700 ha of inoperable habitats, 110,096 ha of park and 72,873 ha of operable landbase.

Timber harvesting within all SOCAs will be restricted to silvicultural practices designed to restore forest stands back to suitable owl habitat conditions. Any cutting will primarily be confined to precommercial and commercial thinning of forest stands that have been established following harvesting. Examples of silvicultural guidelines are described in Appendix E. Any cutting of forest stands will require review by a working group established to ensure consistent application of the provisions of this option.

Figure 12. Management Option C.



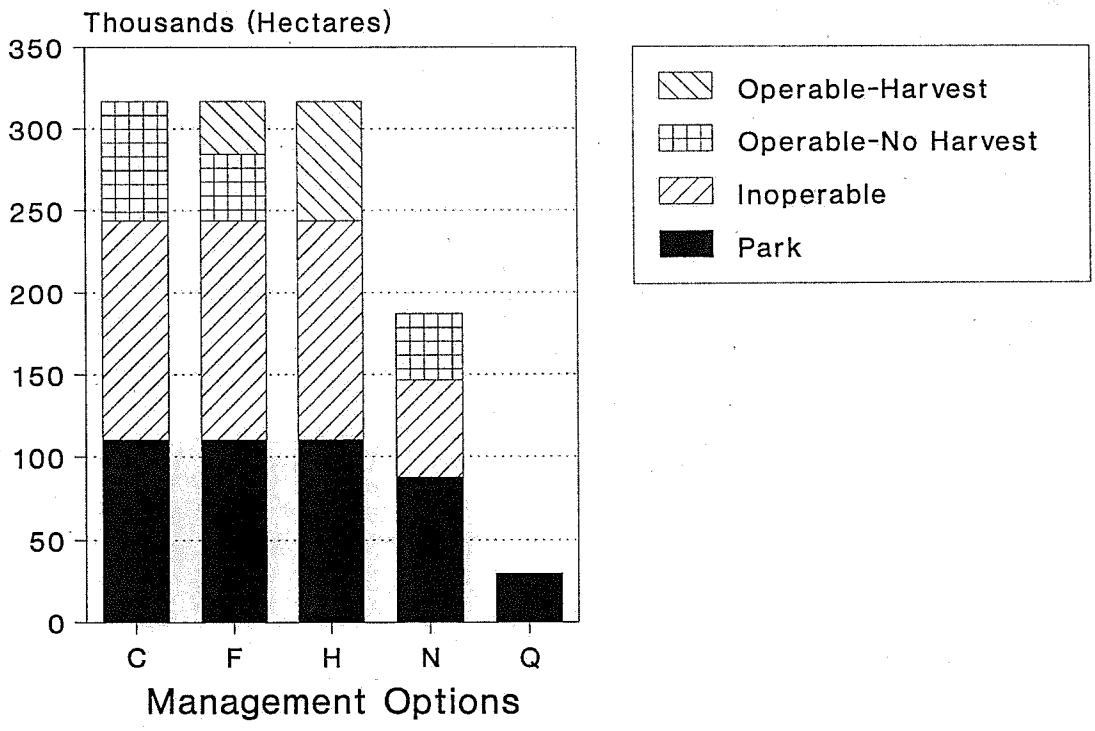


Figure 13. Forested land use within DMAs for the five of the six management options. Data for Options A are unavailable.

Matrix

All forested habitats located outside the SOCA system can be considered the forest matrix. The primary role the matrix plays in the management of the spotted owl is in the provision of habitats for dispersing individuals. Matrix habitats will attempt to provide temporary protection for all active spotted owl sites, until population levels within the SOCA system are no longer endangered.

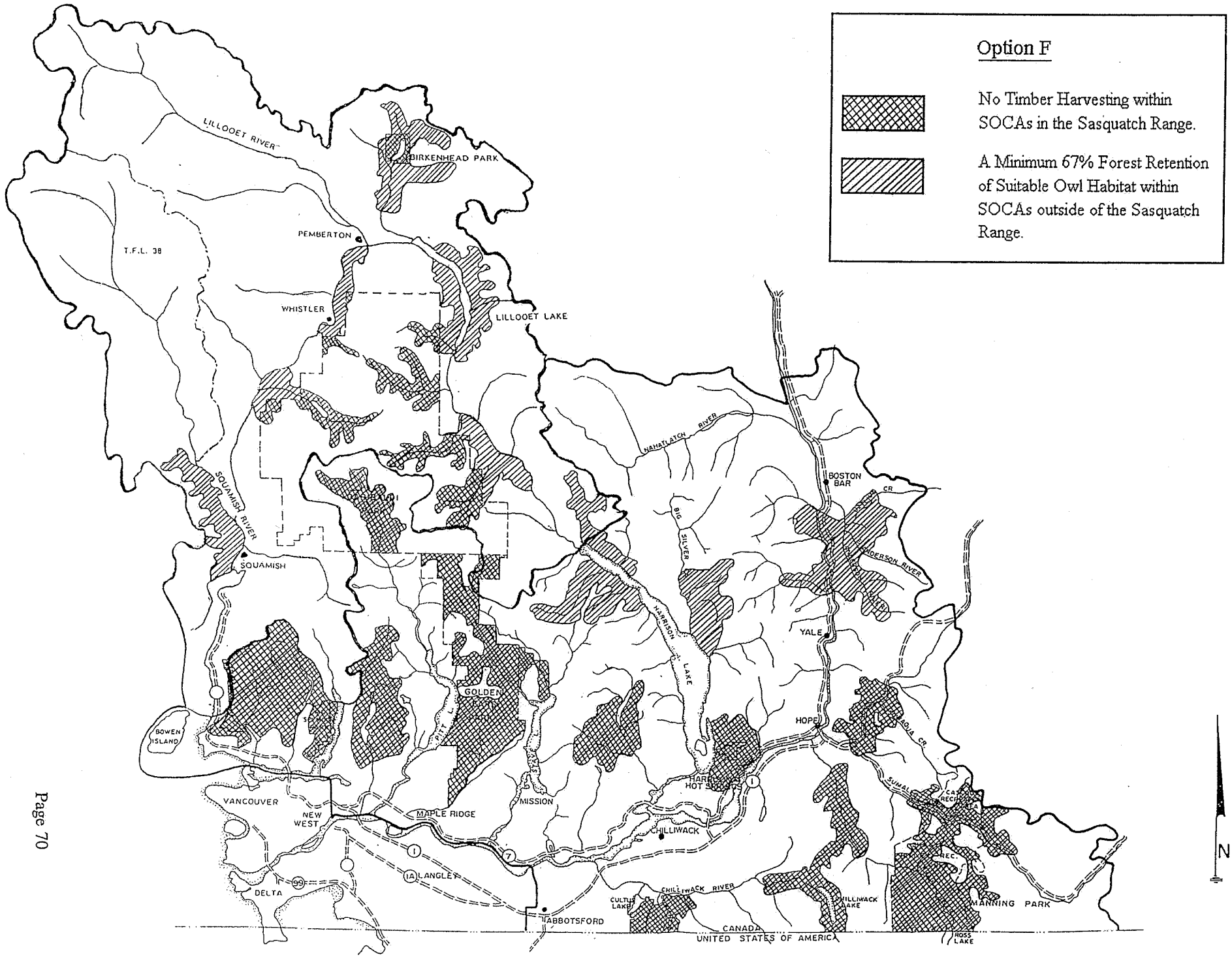
Number of Owls

Long-term management objectives for each SOCA Reserve will strive to maintain an owl distribution with each owl home range overlapping, or nearly overlapping, adjacent owl home ranges. Under Option C, a minimum 31 known active owl sites will be immediately protected (excluding SOCA 18). Over time, it is anticipated that the owl population within SOCAs will increase to approximately 127 reproductive owl sites. This estimate does not include juveniles, subadults, floaters and other resident spotted owls located outside the SOCA system.

Option F: No timber harvesting in all SOCAs within the Sasquatch Range and the retention of a minimum 67% suitable habitat in each activity centre within all remaining SOCAs throughout the Documented Range of the bird in the province (outside the Sasquatch Range).

Option F is a modified version of Option C and was designed to provide a likelihood of recovering the species to meet the Vulnerable criteria. Similar to Option C, spotted owls primarily will be managed within the 21 delineated SOCAs throughout its Documented Range in the province. However, SOCAs located within the Sasquatch Range will be treated as SOCA Reserves and SOCAs located outside this range will be treated as Managed SOCAs (Figure 14). This option provides a high level of protection for owls within the Sasquatch Range and a moderate level of protection for owls outside the range. A two-tiered approach in the management of the owl population attempts to provide a higher level of protection within the southern portion of the owl's range, in the event that managed SOCAs have greater impacts than predicted.

Figure 14. Management Option F.



SOCA Reserves

SOCAs 1 through 10 will be managed as SOCA Reserves. The total area confined within SOCA Reserves amounts to 187,011 ha of Provincial Crown Forests (excluding SOCA 18, Figure 13). This total land area consists of 58,851 ha of inoperable habitats, 87,671 ha of park and 40,489 ha of operable landbase.

Timber harvests within these SOCAs will be restricted to cutting that is designed to restore forest stands to suitable owl habitat conditions. Cutting will primarily be confined to precommercial and commercial thinning of forest stands that have been established following harvesting. Examples of silvicultural guidelines are described in Appendix E. Any cutting of forest stands will require review by a working group established to ensure consistent application of the provisions of this option.

Managed SOCAs

SOCAs 11 through 21 will be treated as Managed SOCAs. The total area confined within Managed SOCAs amounts to 129,658 ha of Provincial Crown Forests (excluding SOCA 18, Figure 12). This total land area consists of to 74,849 ha of inoperable habitats, 22,425 ha of park and 32,384 ha of operable landbase.

Options will be developed for these SOCAs that attempt to provide for long-term viability of the owl population and opportunities for timber harvest. For each Managed SOCA, a minimum 67% of suitable owl habitat will be maintained within the landscape of each owl activity centre. Until silvicultural techniques have demonstrated their capability of creating suitable owl habitat characteristics, suitable owl habitat will be defined as trees aged greater than 120 years and taller than 19.5 metres (Forest Age Class 7 or greater and Height Class 3 or greater).

All timber harvests within SOCAs will utilize modified timber harvesting techniques that may include selective harvesting; retention of green trees, snags and dead/down material; minimal fragmentation approaches; extended rotations, and post harvest silvicultural procedures. Any cutting of forest stands will require planning and review by a working group established to ensure consistent application of the provisions of this option.

Matrix

Matrix habitats will be managed as outlined within Option C.

Number of Owls

Long-term management objectives for each SOCA Reserve will strive to maintain an owl distribution with each owl home range overlapping, or nearly overlapping, adjacent owl home ranges. Management objectives for each Managed SOCA will strive to maintain an owl distribution with each owl home range nearly overlapping, or adjacent to other owl home ranges. Under Option F, a minimum 31 known active owl sites will be immediately protected (excluding SOCA 18). Over time, it is anticipated that the owl population within SOCAs will increase to approximately 115 reproductive owl sites. This estimate does not include juveniles, subadults, floaters and other resident spotted owls located outside the SOCA system.

Option H: Retention of a minimum 67% suitable habitat in each activity centre within all SOCAs throughout the entire Documented Range of the bird in the province.

Option H is a modified version of Option C but was designed to provide a likelihood that the species will meet the Threatened criteria. Similar to Option C, spotted owls will be managed within the 21 SOCAs throughout its Documented Range in the province. However, all SOCAs will be treated as Managed SOCAs (Figure 15). This option provides a moderate level of protection for owls throughout the range.

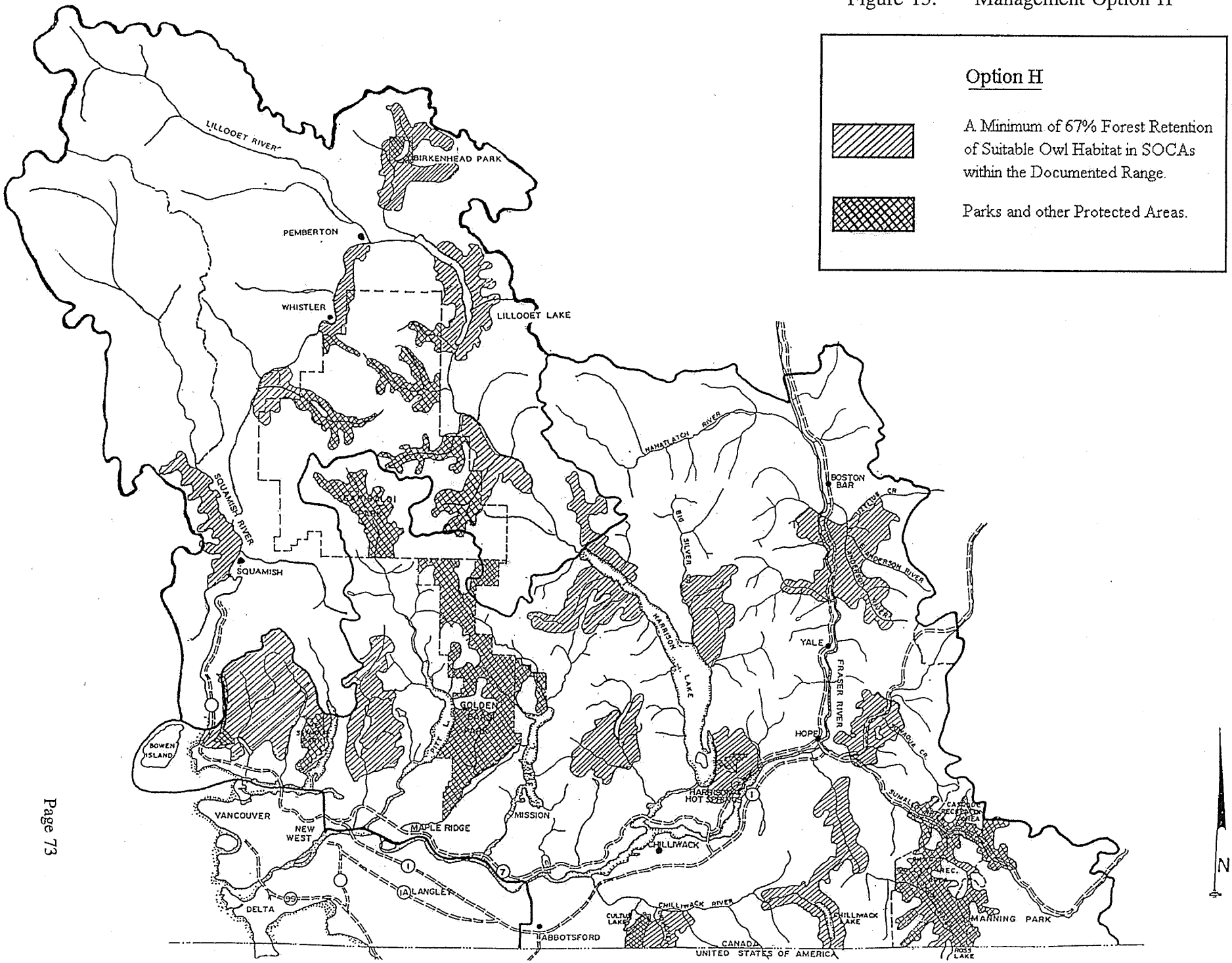
Managed SOCAs

The total area confined within Managed SOCAs amounts to 316,669 ha of Provincial Crown Forests (excluding SOCA 18; Figure 13). This total land area consists of 133,700 ha of inoperable habitats, 110,096 ha of park and 72,873 ha of operable landbase.

Options will be developed for these SOCAs that attempt to provide for long-term viability of the owl population and opportunities for timber harvest. For each Managed SOCA, a minimum 67% of suitable owl habitat will be maintained within the landscape of each owl activity centre. Until silvicultural techniques have demonstrated their capability of creating suitable owl habitat characteristics, suitable owl habitat will be defined as trees aged greater than 120 years and taller than 19.5 metres (Forest Age Class 7 or greater and Height Class 3 or greater).

All timber harvests within SOCAs will utilize modified timber harvesting techniques that may include selective harvesting; retention of green trees, snags

Figure 15. Management Option H



and dead/down material; minimal fragmentation approaches; extended rotations, and post harvest silvicultural procedures. Any cutting of forest stands will require planning and review by a working group established to ensure consistent application of the provisions of this option.

Matrix

Matrix habitats will be managed as outlined in Option C.

Number of Owls

Long-term management objectives for each Managed SOCA will strive to maintain an owl distribution with each owl home range nearly overlapping, or adjacent to other owl home ranges. Under Option H, a minimum 31 active owl sites will be immediately protected (excluding SOCA 18). Over time, it is anticipated that the owl population within SOCAs will increase to approximately 102 reproductive owl sites. This estimate does not include juveniles, subadults, floaters and other resident spotted owls located outside the SOCA system.

Option N: No timber harvesting in all SOCAs within the Sasquatch Range. No owl management beyond existing parks and protected areas outside the Sasquatch Range.

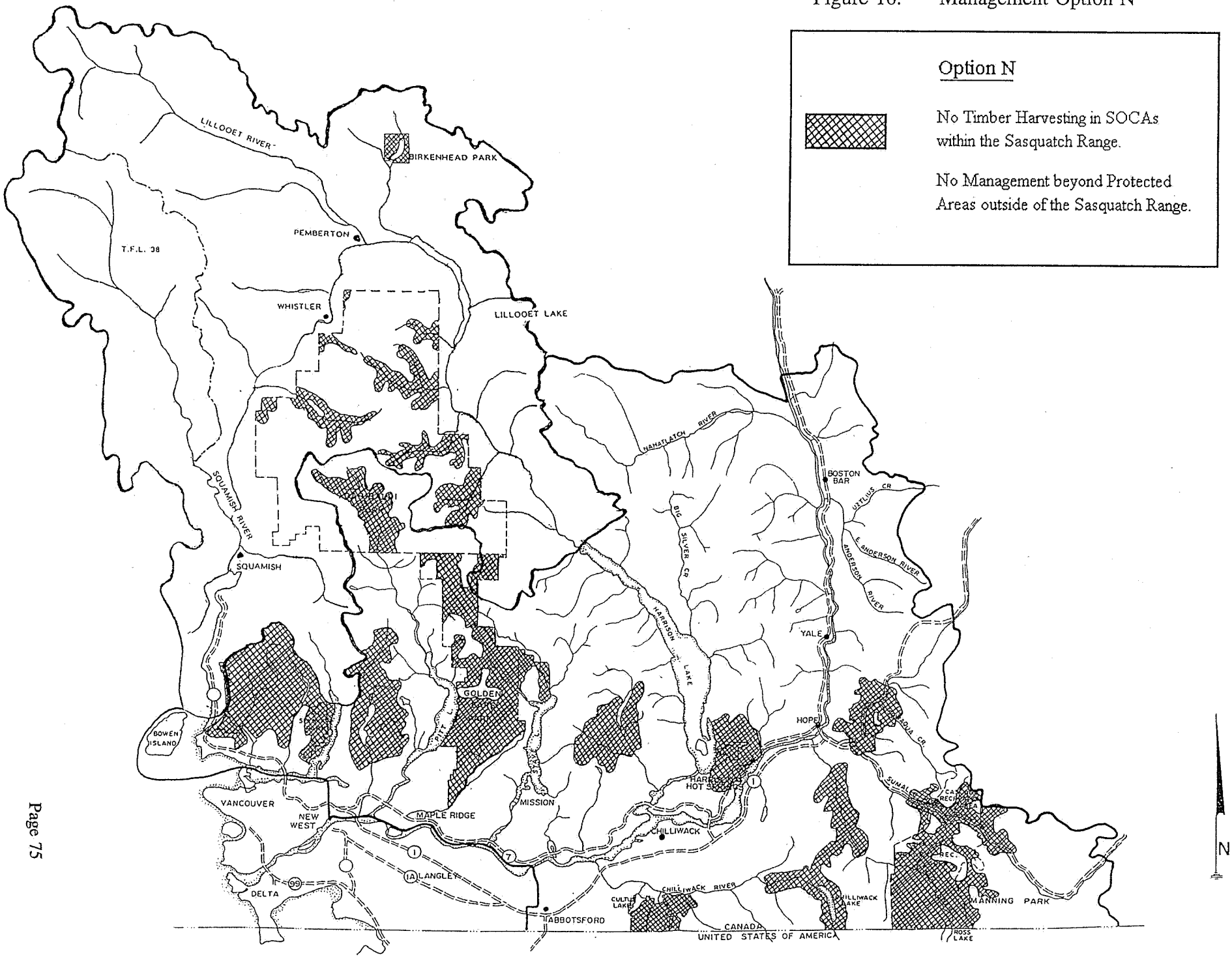
This option was designed to provide a likelihood of managing the species to maintain its current Endangered status. All SOCAs located within the Sasquatch Range will be treated as SOCA Reserves (Figure 16). This option will provide a high level of protection for owls within the Sasquatch Range and a very limited protection for owls outside this range.

SOCA Reserves

SOCAs 1 through 10 will be managed as SOCA Reserves. The total area confined within SOCA Reserves amounts to 187,011 ha of Provincial Crown Forests (Figure 13). This total land area consists of 58,851 ha of inoperable habitats, 87,671 ha of park and 40,489 ha of operable landbase.

Timber harvests within these SOCAs will be restricted to cutting that is designed to restore forest stands to suitable owl habitat conditions. Cutting will primarily be confined to precommercial and commercial thinning of forest stands that have

Figure 16. Management Option N



been established following harvesting. Examples of silvicultural guidelines are described in Appendix E. Any cutting of forest stands will require review by a working group established to ensure consistent application of the provisions of this option.

Matrix

Matrix habitats will only be managed for spotted owls within the Sasquatch Range. Matrix habitats will be managed as outlined in Option C. No management will be applied to owls located outside of the Sasquatch Range, other than those which occur in Provincial Parks and other protected areas.

Number of Owls

Long-term management objectives for each SOCA Reserve will strive to maintain an owl distribution with each owl home range overlapping, or nearly overlapping, adjacent owl home ranges. Under Option N, a minimum 22 known active owl sites will be immediately protected. Over time, it is anticipated that the owl population within SOCAs will increase to approximately 76 reproductive owl sites. This estimate does not include juveniles, subadults, floaters and other resident spotted owls located outside the SOCA system.

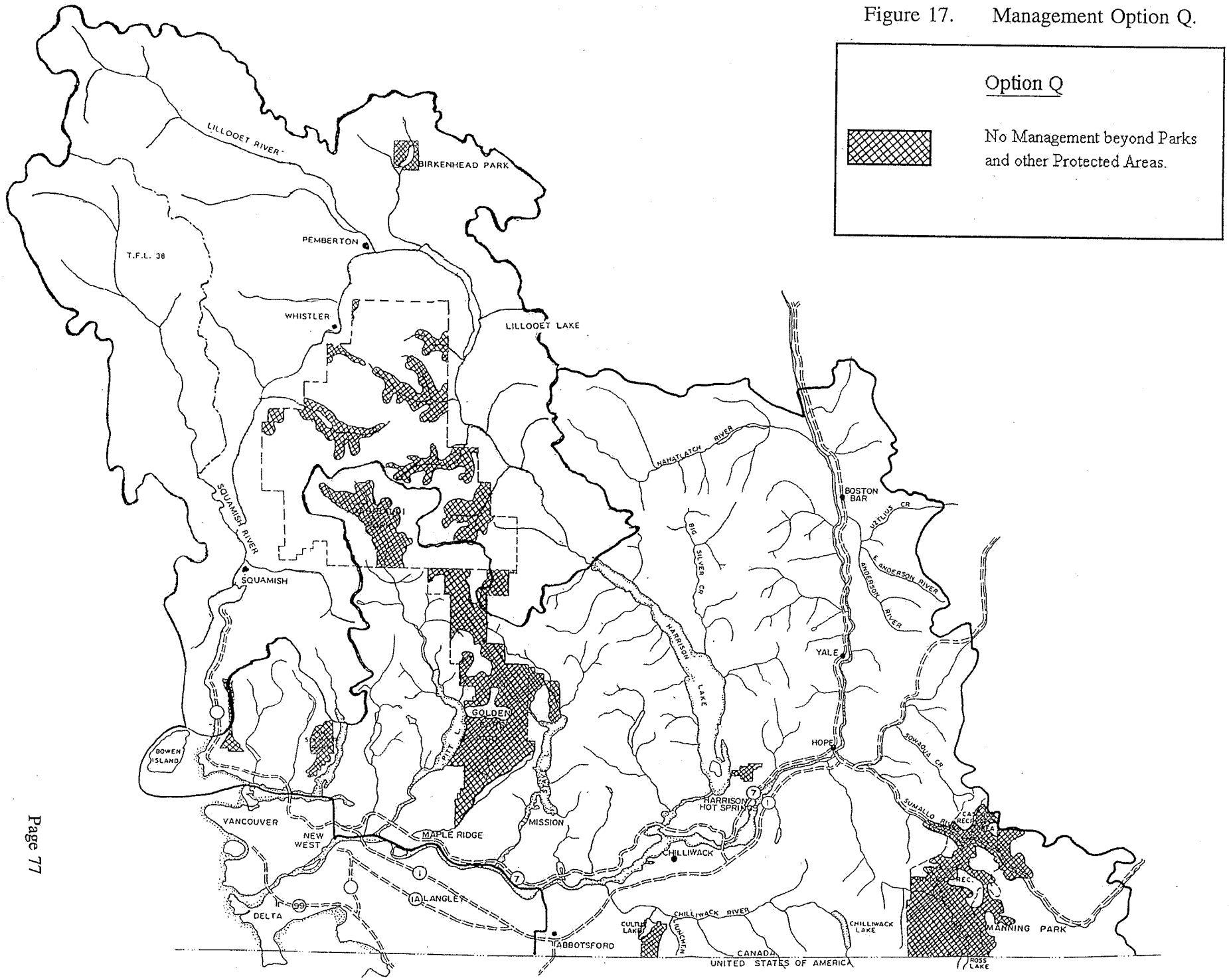
Option Q: No owl management beyond existing parks and protected areas.

This option will provide a likelihood that the species' population in the province will collapse and the owl will become designated as Extirpated (Figure 17). Under Option Q, habitats suitable for spotted owls would be maintained in two widely separated geographical locations in the province (Garibaldi-Golden Ears Provincial Parks and Skagit Valley Recreational Area-Manning Provincial Park). The lineal distance between these two areas is approximately 100 km. Based upon population models from United States, the suitable habitats occurring within the Garibaldi-Golden Ears Provincial Parks most likely could not support a self-sustaining population. The resulting population would be limited to the Skagit Valley Recreational Area-Manning Provincial Park area.

Number of Owls

Under Option Q, a minimum of 4 known active owl sites will be immediately protected. Over time the population within the Skagit Valley Recreational Area-

Figure 17. Management Option Q.



Manning Provincial Park area may increase to approximately 12 reproductive owl sites. This estimate does not include juveniles, subadults and floaters.

IV. BIOLOGICAL ASSESSMENT OF THE MANAGEMENT OPTIONS

A. Introduction

A body of scientists from resource management agencies, academic community and forest industry from both United States and Canada were assembled to provide an independent biological assessment of six management options developed by SORT. The six options evaluated were A, C, F, H, N and Q and are described in Section III. Each option was assessed relative to the five status categories of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). These five categories included: De-listed (No Designation Required), Vulnerable, Threatened, Endangered and Extirpated. The primary objective of this assessment was to estimate the likelihood that a specific option would result in a particular status category or categories that best reflect the future status of the owl. The specific question asked of the team of scientists was,

> *"Given the likely condition of habitat under a specific option, what will be the status of the spotted owl in 100 years?".*

B. Methods for the Biological Assessment

The potential effects of the six options on species' habitat and future population viability were reviewed by a team of scientists. This team was termed the Biological Assessment Team (BAT). The Biological Assessment Team involved 21 individuals and included professional biologists and foresters from resource management agencies, universities and the private sector (Appendix F). A review and assessment of the six options was conducted on February 1, 1994. Six panellists were selected to evaluate the options. Other participants at the BAT meeting acted as technical advisors to the voting panellists. Evaluations made by the panel were not viewed as precise analyses of likelihoods of habitat and population conditions, but rather as judgements of knowledgeable experts.

Results from the panel were advisory to the Spotted Owl Recovery Team who made final judgement about population viability effects. Other information considered in the assessment include reports, notes from panel discussions, published scientific reports and follow-up discussions with panel members and additional experts.

Panellist Selection

Six panellists were selected using several criteria including technical expertise with the spotted owl, ecological understanding of the species' habitat requirements, experience in conservation planning, landscape ecology and quantitative population modelling, experience with the process used to assess options by the Forest Ecosystem Management Assessment Team (FEMAT) and availability to attend the BAT meeting. Panellists were selected who could set interest group values aside to focus on the biological assessment task. A consensus was reached by the panellists that there would be no record of any individuals' votes and comments.

Assessment Process - Overview

The basic assessment process followed that described in Forest Ecosystem Management: An Ecological, Economic, and Social Assessment - Report of the Forest Ecosystem Management Assessment Team (FEMAT 1993) for making probabilistic judgements. The assessment of the six options by BAT only considered biological implications; assessments did not address socio-economic concerns. No economic, harvest level or community assessment information was provided. It was recognized that the panellists' personal understanding of spotted owl biology likely would influence their assignment of likelihood points. Our primary focus, however, was *habitat.*

BAT panellists were provided background information on the current status and biology of the spotted owl in the province through brief presentations and supplemented visual material. Information critical to the assessment, such as COSEWIC status category definitions and SORT down-listing criteria for the species in Canada also was provided. We presented an overview of the six options to be assessed with opportunities for panellists to ask questions. Technical experts were available to answer questions at any time during the panel assessments. Other materials available to the BAT panellists included satellite photographs of the entire range of the species in the province and GIS maps for the Chilliwack and Squamish Forest Districts (excluding Garibaldi and Golden Ears Provincial Parks).

The moderator explained the process of assigning likelihood points to ensure all BAT participants understood the task required and were satisfied with the overall procedure. An option not included in the formal assessment was selected and evaluated as a trial run.

The actual rating of likelihoods was individual, followed by group display and discussion. Final individual assessments were panellists' choices. Exchange of comments and information was encouraged, but we were not attempting consensus. Individual assessments were recorded and combined. Panellists were asked to comment on the overall process.

Response Scale:

Panellists assessed each option relative to the five status categories of the Committee on the Status of Endangered Wildlife In Canada. The scale was utilized to represent the full range of population status designations in Canada (Table 8). Each of the five designations describes a biological condition of risk to a population that is mutually exclusive of the other four outcomes.

De-listed:	A species not at risk (no designation required).
Vulnerable:	A species particularly at risk because of low or declining numbers, small range, or for some other reason, but not a threatened species.
Threatened:	A species likely to become endangered in Canada if factors threatening its vulnerability are not reversed.
Endangered:	A species threatened with imminent extinction or extirpation throughout all or a significant portion of its range in Canada.
Extirpated:	A species no longer existing in the wild in Canada, but occurring elsewhere.

Table 8. Description of the five status categories of COSEWIC.

Assessment of Likelihood:

For each option, each panellist assigned 100 "likelihood points" across the five status categories. A panellist could express complete certainty by assigning 100 points to a single status category; uncertainty was express by spreading points across the status categories. The pattern of likelihood points across the options reflected the panellists' rationale, knowledge base and assumptions.

The actual rating of likelihoods was individual, followed by group display and discussion. During discussions, panellists were asked to explain reasoning for their rating. The exchange of comments and information was encouraged, but their was no attempt made to achieve consensus. Discussion allowed clarification of key uncertainties and ambiguities in the options descriptions or panellists' interpretation of them. Individual assessments were recorded and combined.

Evaluation of Panel Results

Ratings were averaged across panellists for each outcome (status designation) under each option. However, before accepting these as the final assessment, we examined individual panellists' scores to look for any obvious errors or inconsistencies that may have lead to illogical results. If problems were detected, we discussed these with the individual for clarification and adjustment. Several different summaries were prepared.

C. Results of the Biological Assessment

General - The assessments of populations (options) considered either in isolation or connected to US populations were surprisingly similar. A possible reason for this is noted below. Considering the similarities, SORT felt it may be more appropriate to examine the "US connected population". This may better reflect the actual population, as there is no biological reason for the management of a population to change dramatically, based upon a political boundary (ie, the International boundary). Clearly, if a management regime was to be altered throughout a populations range, it would more appropriate to change along ecological boundaries (ie, habitat classification types).

SORT chose to examine the "connected population" because it resulted in slightly higher levels for the potential to down-list (which we believe is a more accurate way to view the recovery potential). We consider this to be more clearly the scenario that exists in BC. The population should not be managed in isolation, but instead, should be managed as a special population within one portion of the birds' distribution in North America.

Should make a statement in here that the BAT panellists likely assessed the options very conservatively, due to their unfamiliarity with the biology of the bird, topography and habitat features of the landscape in BC or the specific details of the options.

Also, should add that a number of the BAT panellists remarked that managing the spotted owl in BC should not be ignored; but should be managed as an important component of the overall population in North America. Managing the owl population in BC would be like managing the last piece of the jigsaw puzzle.

Similarity in graphs X and Y are believed to be a result of BAT panellists' recognition that the interconnections of BC and US populations likely only effect the southeast portion of SOCA system (ie, Skagit, Chilliwack and Liumchen); potential benefits outside these 3 SOCAs likely is greatly diluted. The possible connectivity with the US owl population is not a major factor that influences the entire BC population.

Trends are virtually identical, the only difference between "BC Only" and "US connected" views is that BC population when viewed in complete isolation has slightly greater risks and, conversely, lower likelihoods of down-listing.

Population of owls in BC, therefore, is not a result of a continuous stream of birds entering BC from south, but likely represents the remnants of a widely distributed resident population.

General Trends:

The general trends predicted/estimated by SORT in both the likelihoods of down-listing and potential risks to the owl population of the various options were re-affirmed by BAT panellists. The ability of the options were perceived to decline in an almost lineal relationship from A to Q (Figure Y-a). The risks to the owl population increased in the same way from A to Q (Figure Y-b).Should use both figs x and y, but use the US connected to describe assessments (ie most favourable or optimistic.

Details of Assessments - (Example of an assessment)

To consider an option for its potential to down-list, the option should have a better than 50% chance of achieving status. FEMAT selected the 80% cumulative level to achieve an outcome. What level does SORT feel comfortable with? (eg. 67%?).

eg. Option C - 16% chance of maintaining at either N or X
- 84% chance of downlisting

Option N - 48% chance of maintaining at either N or X
- 52% chance of downlisting

Assumptions: (baow, intact & viable US population,....)

OPTION A:

This option was developed by SORT to provide a spotted owl population that would be maintained in all Provincial Crown forests throughout the bird's entire documented range in the province. The Biological Assessment Team assigned the greatest number of likelihood points to the De-listed category reaffirming SORT's objective of Option A; that the option has a high potential to lead to complete de-listed of the species in Canada.

Approximately 90% of all likelihood votes were assigned by the Biological Assessment Team to categories that lead to an improvement in the future status of the bird; less than 10% of votes were assigned to designations that maintain the population at its current status of endangered (Figure 18). Approx 80% of all votes where assigned to the status categories of either De-listed or Vulnerable.

Clearly, Option A has the highest potential for de-listing, relative to other options. The only identified risk to the owl population was the very low potential to maintain the species at its current status designation of endangered (<10% chance). This threat is of no real concern as the likelihood was assessed very low and SORT recognize that considering the significant amount of habitat protected under this option, the population's abundance, distribution and viability would almost certainly increase, given that the primary threat to the species (timber harvesting) would be eliminated throughout its entire range in the province. Furthermore, this option provided no opportunity for the species to become extirpated. This option clearly is the best biological plan relative to the other options and provides the highest likelihood to recover the species in the most expedient means possible.

OPTION C:

This option was developed by SORT to provide a spotted owl population that is managed primarily within a SOCA system, rather than throughout the entire forested landscape. The SOCA system delineated in British Columbia utilized the biological principles developed by the US Recovery Plan to determine the size and location of spotted owl management areas. In this regard, Option C represents an extension of the US Recovery Plan for the species into Canada, ensuring that the last "unprotected" portion of its distribution in North America, receives consistent conservation emphasis.

Under Option C, the total land area in which the species would be managed over time is greatly reduced compared to Option A. The Biological Assessment Team recognized this reduction in owl capability and rated the option accordingly. The Biological Assessment Team felt this option would most likely result in a

Vulnerable population, rather than a de-listed population (ie, they provided the greatest number of likelihood votes within the Vulnerable status category).

Approx 85% of all likelihood votes were assigned to status category designations that would improve the current status of the species in Canada (Figure); only about 15% of the votes were assigned to status categories of either equal or lower status than its current endangered designation (Figure 18). This suggests that the Biological Assessment Team felt that Option C also provides a very high likelihood of down-listing the species. Almost 80% of all likelihood votes were assigned to only two status categories; Vulnerable and Threatened, suggesting a very high likelihood of down-listing the species.

The only risk assigned to Option C is that the species could remain at its current Endangered status, but the potential for this was considered very low. The likelihood that the population would become Extirpated was virtually nil (about 1%). In fact, this option was considered to provide a higher likelihood of De-listing the species entirely, than it was of causing the owl population to become Extirpated in the province.

OPTION F:

This option was developed by SORT to provide a spotted owl population that is managed under differing intensities within a SOCA system. Option F, like Option C, is based upon the US Recovery Plan and protects a series of inter-connected SOCA reserves within the southern portion of its range in the province. More northerly portions of the birds range are managed to allow a certain level of timber harvesting. These northern SOCAs have similarities to the Adaptive Management Areas outlined in the FEMAT Report. This approach places varying levels of risk in different geographic regions of the population, but provides a buffer from management errors by applying more conservative measures in some portions of the bird's range.

The Biological Assessment Team felt that this option provided a high likelihood of down-listing the population to the COSEWIC status designation of Threatened (ie, the majority (about 70%) of the likelihood votes were assigned to status categories higher than its current designation) (Figure 18). Unlike Option C, this option was rated as having no potential to de-list the species from the COSEWIC status designations of vulnerable species.

The single status category which received the greatest number of likelihood points was Threatened (53% of all votes). The remaining votes were almost equally shared between Endangered (26%) and Vulnerable (20%). This distribution of

points reflects a relatively high level of confidence that option F has good potential to improve the current status of the owl in British Columbia, thereby allowing the species to become down-listed to a lower COSEWIC status designation.

Although about 25% of the likelihood votes were assigned to the Endangered Category, it is likely that the condition of the current population would improve dramatically, through the elimination of the primary threat to the species (ie, timber harvesting) throughout the majority of its range within the SOCA system.

Population has a relatively high likelihood of becoming down-listed (70:30), although the chance of de-listing the species appears unlikely. The population would be expected to improve to a status of Threatened, or better.

OPTION H:

Option H was developed by SORT to provide a spotted owl population that is well-distributed across its documented range in the province within a series of inter-connected managed SOCAs. This option places a similar level of risk to all SOCAs (excluding portions of those within Provincial Parks) by allowing a certain level of timber harvesting.

The Biological Assessment Team assigned the greatest number of likelihood votes to the Threatened category (ie, 50% of all votes) and placed slightly over 60% of all votes within status categories that would lead to an improvement from its current status (Figure 18). Although 40% of the votes were assigned to categories that would not allow down-listing, the majority of those votes were placed in its current designation of endangered. Together, the two status categories, Threatened and Endangered, received the greatest number of points (a total of 85% of all votes). BAT rated Option H as having only a small likelihood of achieving a Vulnerable condition (rated at about 12%) and virtually no likelihood of resulting in the species' extirpation in the province.

A plan based on Option H, although only providing a 60:40 likelihood of down-listing, almost certainly would lead to an improvement in the species current status in the province through the protection of a network of critical habitats that greatly diminish the primary threats facing the species (timber harvesting).

OPTION N:

Option N was developed by SORT to provide a spotted owl population that would be maintained within a SOCA system only within a portion of its current documented range in the province. No management would be applied to spotted owls found outside the Sasquatch range. The Biological Assessment Team assigned the greatest number of likelihood votes within the Endangered category (46%) (Figure 18). Overall, BAT assessed this option as having only a 50:50 probability of resulting in a down-listed population. Together, 87% of all likelihood votes were assigned to the two COSEWIC status categories of Endangered and Threatened; the remainder of the votes were assigned equally between Extirpated and Vulnerable.

Although Option N was rated as providing about a 46% chance of maintaining the population at its' current designation of Endangered (ie, no change in status), the resulting population would not be as well distributed as the current population. Furthermore, Option N would extirpate numerous active owl sites and eliminate opportunities for viable populations to persist in about half of the species' documented range in the province.

OPTION Q:

Option Q was developed to drive the population of spotted owls in Canada to extirpation. The BAT panellists re-affirmed SORT's lack of confidence with a plan that provided no habitat for spotted owls other than in areas already designated as protected areas. BAT assessed the outcome of this option as having virtually no opportunity to down-list the species in Canada (less than 10%) (Figure 18). Conversely, about 90% of all assessment votes were assigned to status categories that either maintain the owl at its current designation of Endangered or cause the population to become Extirpated.

The Biological Assessment Team rated the likelihood of causing the species to become Extirpated dramatically higher under Option Q, compared to Option N. However, BAT assessed Option Q as having a slightly higher likelihood of producing an Endangered (56%) designation rather than Extirpated (33%). When the Biological Assessment Team viewed the owl population in British Columbia as genetically isolated from US populations, an almost equal number of points were assigned to the two categories.

BAT appears to support SORT's view of the future outcome of Option Q; largely a decimated population, possible surviving in the lower elevation sites of western Manning Park and the Skagit Valley Recreational Area (largely supported by

immigration from owl populations in the State of Washington.

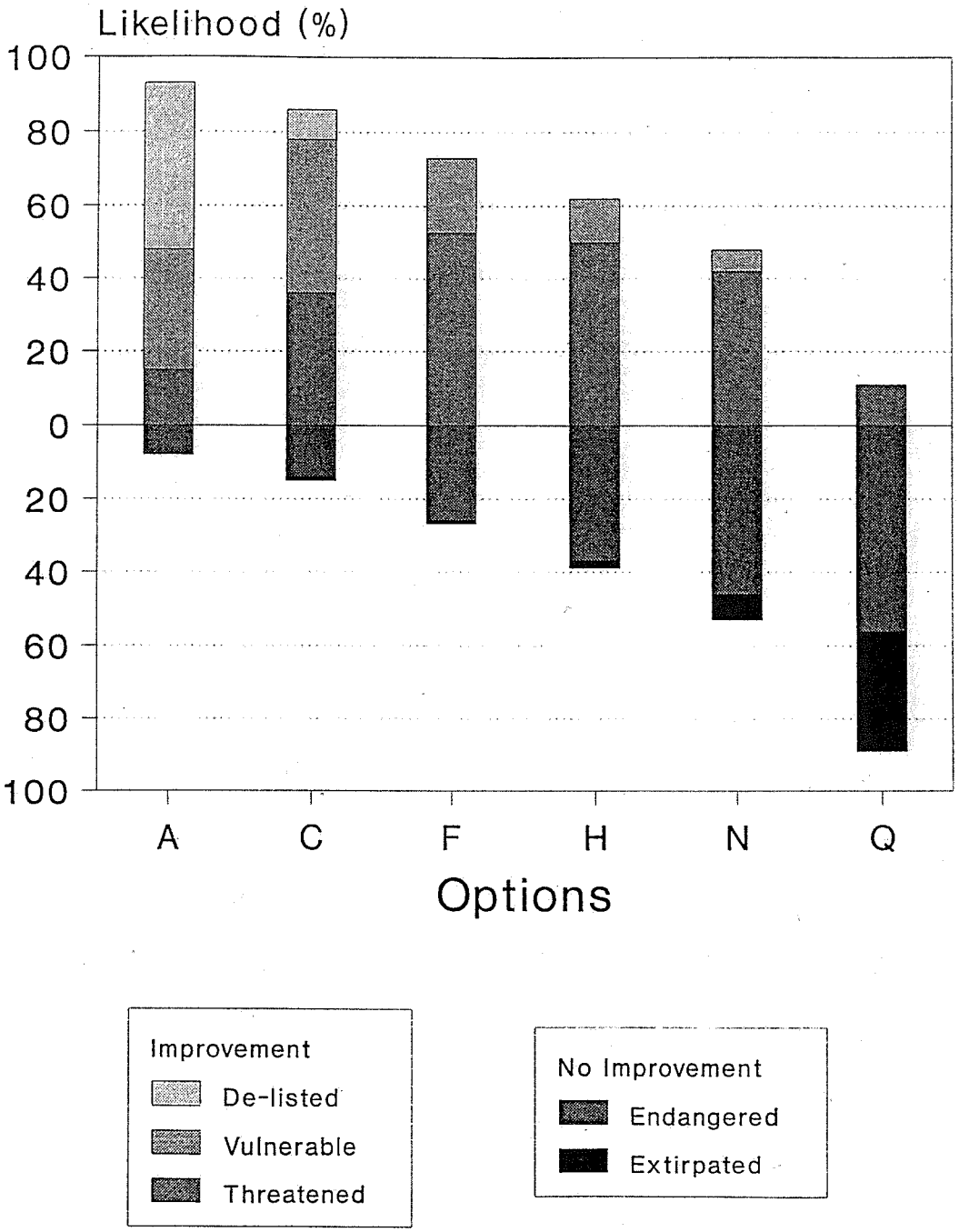


Figure 18. Biological assessment of the six management options.

V. IMPLEMENTATION OF MANAGEMENT OPTIONS

Related Land management initiatives in British Columbia[9]

Currently there are several land use and guideline initiatives which may have implications to the landbase. These include the Protected Areas Strategy (PAS), the Coastal Biodiversity Guidelines, and the Forest Practices Code. In addition to the spotted owl there are a number of other species associated with late-successional forest which are also at risk within the range of the owl (see Appendix C).

Within the range of the owl, currently the only other species at risk for which a recovery plan and management guidelines are being developed is the marbled murrelet. The two Greater Vancouver Water District SOCAs (14 and 15), as well as SOCA 17 will likely be within the area managed for the murrelet. The marbled murrelet appears to require old-growth stands for nesting and therefore habitat protection guidelines which are put in place for the murrelet will likely address some of the habitat requirements of the spotted owl where their ranges overlap.

Protected Areas Strategy

The Protected Areas Strategy (PAS) was initiated to develop a system of protected areas in B.C. to protect a diversity of biological, natural and cultural heritage resources, and to provide a variety of outdoor recreational opportunities. Protection of habitat for rare and endangered species is one of the key goals for establishing protected areas. The strategy is working towards putting approximately 12% of the landbase into protected areas, including those protected areas which already exist.

During the original Old-Growth Strategy process, four areas were deferred for the protection of owl habitat. These areas are now located in proposed SOCA's 1, 3, 4 & 5 but are much smaller than the current SOCA boundary. They are considered as Study Areas in the PAS process and are temporarily protected from development until a final decision is made on where Protected Areas will occur. In addition, all of the SOCA's which have been proposed by SORT are being considered as Areas of Interest by the PAS team. Therefore, each of the SOCA's is a candidate for becoming a Protected Area through the PAS process although they do not currently have any temporary protected status outside of existing parks.

[9] Prepared by Rob Thomson.

Extractive activities such as logging will not be permitted within any of the several potential categories of Protected Areas and the forested land within these areas will likely be maintained in a late-seral stage. The Protected Areas Strategy will likely contribute to the protection of spotted owl habitat in B.C. The degree to which this occurs will depend on how many of the SOCA's are included in the final strategy.

Coastal Biodiversity Guidelines

It is generally recognized that protected areas on their own will not be adequate for the conservation of biological diversity and a successful strategy must include a combination of protected areas with appropriate practices outside of these such that landscape level ecological processes are maintained.

The Coastal Biodiversity Guidelines have been developed as a method to maintain functioning ecosystems within the managed forest landscape. They describe a strategy for maintaining biodiversity at a landscape level through the delineation of Forest Ecosystem Networks (FEN's), as well as providing guidance at the stand level for retaining important attributes of the original forest within a harvested area. FEN's are designed to maintain a component of old forest and a degree of representation of local ecosystems within a watershed. FEN's are not preservation zones although they may include components which will not be logged because they are inoperable (eg. ESA's) or non-merchantable or are zoned out for other purposes (eg. deer winter ranges, riparian management areas).

In addition to FEN's, the guidelines provide objectives for seral stage distribution within each watershed or landscape unit (5000-50,000 ha). They require a minimum 20-40% (including the area within the FEN) to be greater than mid-culmination age. As the guidelines are currently written, they could provide for the 2100 hectares old-growth required at known owl sites and in potential owl habitat but would likely not provide the large contiguous areas of clumped owl sites included in the SOCA concept.

Application of the Coastal Biodiversity Guidelines will likely improve the habitat conditions in the forest matrix for dispersing owls and may provide temporary or longer-term refuge habitat for owls which are displaced or haven't located an adequate sized patch of habitat. If implemented, these guidelines will provide a more secure safety-net for owls outside of the SOCA's. At this time the Coastal Biodiversity Guidelines have not been formally approved for implementation

Forest Practices Code

When passed into legislation, the Forest Practices Code will set mandatory performance standards for forestry activities. Enforceable standards will be written on a provincial or regional basis which will provide the specific details for the minimum standards of operation. The current draft of the Code identifies several types of designated zones which can be applied to the forest landbase during planning of operations. These zones include riparian and streamside management zones, old growth management areas and habitat wildlife areas. Harvesting prescriptions for these areas have not been established by the code document but will likely be determined either through the development of provincial and regional standards and guidelines under the Code, or during regional (Land Resource Management Planning) or local (Local Resource Use Planning) planning processes. These designated zones will provide another tool which can be used in conjunction with the Coastal Biodiversity Guidelines to plan for relatively contiguous blocks of forest which can be managed for late-seral forest structural characteristics in the forest matrix outside of the SOCA's.

Convention on Biological Diversity

The Convention on Biological Diversity was ratified by Canada in December 1992. The international Convention calls on nations to keep as much of their environment in its natural state as possible, and to retain a healthy population of the many varied species in the wild. The Convention encourages the conservation of biological diversity, the sustainable use of components of biodiversity, and the sharing of benefits from the use of genetic resources. It requires Canada to develop a biodiversity strategy, and to see that biodiversity conservation is integrated into sectoral and cross-sectoral issues (RENEW 1993).

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Appendix A: Canadian Spotted Owl Recovery Team Terms of Reference.

Appendix A1: Canadian Spotted Owl Recovery Team Terms of Reference

Province of British Columbia
Ministry of Environment
WILDLIFE BRANCH

MEMORANDUM

To: Members, Spotted Owl Recovery Team

Date: Jan. 25/90
File: 0521

Gentlemen:

Thank you for agreeing to be a part of the Spotted Owl Recovery Team (SORT). The task of preparing a comprehensive recovery plan including objectives, costs, and feasibility of implementation will not be easy. However, the challenge must be met if we are to avoid the "owl wars" that have consumed so much time, money and energy in the U.S.

I believe you should have a draft plan ready for agency comments by September 30, 1990 and a final product by December 31, 1990. That time frame will provide us an opportunity to obtain funding to begin implementation in 1991.

I expect the Chairman to convene the first meeting in early February.

Yours sincerely,

J.H.C. Walker
Director

Appendix A2: Canadian Spotted Owl Recovery Team Terms of Reference

Province of
British Columbia
Ministry of
Environment,
Lands and Parks

BC Environment
WILDLIFE BRANCH

Parliament Buildings
Victoria
British Columbia
V8V 1X4

June 25, 1993

Dave Dunbar
Chair
Spotted Owl Recovery Team

File: 78650-20/SOWL

Re: Spotted Owl Recovery Plan

Dear Dave:

In response to the concerns of yourself and others on the recovery team I am recommending the following new approach to development of the Spotted Owl recovery plan. This should be considered as the new terms of reference for SORT. Due to the sensitive nature of issues involved, and the importance of detailing recovery options to reduce the high level of public speculation on possible economic impacts, it is clearly expected that the deadlines presented below will be met.

The new terms of reference for the Recovery Team are to:

1. Develop a list of recovery options for detailed biological and economic assessment.
2. Biologically evaluate each recovery option for the risk to owl recovery.
3. Develop an options report for public review.
4. Finalize an options report suitable for presentation to Cabinet for decision.
5. Complete the recovery plan based on Cabinet's decision for submission to RENEW.

Economic information for each option will be provided by the Ministries of Forests and Environment, Lands and Parks after SORT has completed items 1 & 2 above.

The critical deadlines for 1993 are:

1. Options list for biological and economic assessment by July 10.
2. Final SOCA lines drawn up by July 31.
3. Biological evaluation of recovery options by September 30.
4. Draft options report for public review by October 15.
5. Final options report for Cabinet by November 15.
6. Final recovery plan for RENEW one month after Cabinet decision.

A joint MOELP/MOF Communications Strategy on the spotted owl will be developed by July 31, 1993. I would expect SORT to have considerable input into that strategy.

I have taken the view that the current membership on SORT is balanced between owl interests (2 members from B.C. Environment, and 1 from Canadian Wildlife Service) and forestry interests (B.C Ministry of Forests, Council of Forest Industries, and Faculty of Forestry) but remains somewhat incomplete. The recent controversy has resulted in advocacy groups representing the Forest Sector and the Environmental community showing great interest in being involved in the activities of the recovery team. I am therefore planning to appoint one member from the Environmental community and one additional member from the forest sector. In order to maintain the scientific credibility of SORT these new members will both be professionally trained biologists or foresters, with a relevant background in forest practices or wildlife conservation. I will confirm the names of the new SORT members in the near future.

As you are aware, the Ministry of Forests have made available an additional $75,000 to undertake spotted owl inventories. Those funds should be applied to address priority gap areas (particularly those in Parks and Protected Areas Strategy study areas) in such a way that complete inventories (i.e. 5 surveys in a given area) are accomplished for each area covered. It is important that all areas that are surveyed this year receive the minimum number of surveys to satisfy the standard protocol number, even though we can't spread the surveys out over 2 years.

Yours truly,

D.R. Halladay
Director
Wildlife Branch

cc. SORT members and alternates
G. Blundell, Recovery Teams and Plans Committee, RENEW
J. Walker
J. Cuthbert

Appendix A3: Canadian Spotted Owl Recovery Team Terms of Reference

Province of British Columbia
WILDLIFE BRANCH

Ministry of Environment, Lands and Parks

MEMORANDUM

To: Dave Dunbar
Chair
Spotted Owl Recovery Team

Date: October 15, 1993

Re: Spotted Owl Recovery Options

I have received the list of 17 options respecting Spotted Owl recovery submitted October 13, 1993 by S.O.R.T.

To clearly set out options that reflect the range of considerations developed by S.O.R.T., while making sure we don't confuse those we are trying to inform or seek a decision from, it is necessary to reduce the list to a maximum of six (6) options. It is also necessary to make sure the supporting information for each of the six options is available in a clearly understandable form. All this must be available in a timely way to avoid delays in the process involving public advisory group review and a decision by government. To those ends, please work with your Spotted Owl Team to provide the following by the dates shown:

1) provide the six options with supporting information (noted below) to my office by October 25;
2) include the comments of the "outside panel of experts" by November 19 (maximum cost of $5,000);
3) include at least the following five options:
   - no timber harvesting in all forested habitats within the historic range of the owl (your option "A");
   - maintain existing known numbers of owls (endangered status);
   - increase owl numbers to place them at a threatened status;
   - increase owl numbers to place them at a vulnerable status; and
   - no owl protection outside of existing parks (your option "Q").

If your team feels it necessary they may add another option.

4) For each option provide a map of suitable scale, to indicate areas protected for owls, areas open to special logging to safeguard owls and areas open to conventional logging not designed to protect owls. On each option map indicate the distribution and numbers of owl pairs maintained by that option.
5) For each option, provide statements which confirm the purpose of protected areas indicated (ie: nesting; movement corridors; need in relation to consolidating the populations range; etc.) , a description of special logging proposed (indicate no special logging if not part of the option) and the degree of risk for maintaining the owl as a self

sustaining species. Also provide other information which sets out the pro's and con's of each option from an owl conservation perspective. Finally, provide the background report that confirms the scientific information on which your team has based its recommendations and judgements.

Once the final descriptions and supporting information for options are received from S.O.R.T. (by November 19) socio-economic information will be added for each option by specialists in the ministries of Environment, Lands and Parks, and Forests. The final options with that additional information will then be shared with members of the Spotted Owl Community Advisory Group and others who may wish to offer comment....hopefully available for delivery to them by December 15. S.O.R.T. members will also receive copies.

After the Spotted Owl Community Advisory Group has offered comment (collectively and/or individually) their comments and the final options will be passed to the Ministers of Environment, Lands and Parks, and Forests for a decision by government as to a preferred option.

If government's decision confirms an option to protect the owl, S.O.R.T. will be asked to prepare a recovery plan for that option.

If you have any questions or concerns give me a call (387-9731).

D. Ray Halladay
Director
Wildlife Branch

cc: Jim Walker
Bruce Cox
Bill Harper
Ralph Archibald
Bill Munro

Appendix B: Suitable Spotted Owl Habitat Definitions.

Hanson *et al.* (1993) classified suitable spotted owl habitat for western and eastern Washington into 3 categories: Type A, B, and C. Generally, Type A is the highest quality habitat, and Type C habitat is of marginal quality.

Western Washington

These descriptions should be used to help identify suitable habitat west of the Cascade Crest. This description most closely represents suitable habitats for spotted owl within the Coastal Western Hemlock Biogeoclimatic Zone in British Columbia.

Type A Suitable Habitat: Superior, old-growth forest habitat that has the following characteristics:

a multi-layered, multi-specied canopy dominated by large (76+ cm dbh) overstory trees (typically 37 to 185 stems/ha);

moderate to high (60 - 80%) canopy closure;

a high incidence of large trees with various deformities (eg. large cavities, broken tops, dwarf mistletoe infections);

numerous large (76 cm+ dbh) snags (typically 5+ stems/ha);

large accumulations of fallen trees and other woody debris on the ground.

Type B Suitable Habitat: Mature forest habitat that has the following characteristics:

few canopy layers, multi-specied canopy dominated by large (51+ cm dbh) overstory trees (typically 457 - 247 stems/ha, although densities as low as 86 stems/ha are possible where large diameter trees are present);

moderate to high (60 - 80%) canopy closure;

some large trees with various deformities (eg. large cavities, broken tops, dwarf mistletoe infections);

large (51+cm dbh) snags present;

accumulations of fallen trees and other woody debris on the ground.

Type C Suitable Habitat: Marginal habitat quality, usually younger stands with some old-growth/mature components and/or structural characteristics. **Type C suitable habitat is defined on the basis of use by spotted owls.**

Type C suitable habitat includes "atypical" habitat documented to be used by spotted owls in Washington. Generally, such habitat results from fire or windthrow. Fire and windthrow often result in patchy habitat, with remnants of old-growth/mature forest interspersed among younger stands and/or old-growth/mature structural components are retained.

Type C suitable habitat may also include partially harvested stands that have had less than 40% volume removed and still contain the structural components important to spotted owl (multi-layered canopies; multi-species composition; moderate to high canopy closure; some large trees; snags; down woody debris; large trees with cavities, broken tops, dwarf mistletoe infections, and other evidence of decadence).

Eastern Washington

These descriptions should be used to help identify suitable habitat east of the Cascade Crest. These descriptions most closely represent suitable habitat located within the Interior Douglas-fir Biogeoclimatic Zone in British Columbia.

Type A Suitable Habitat: Generally, these are stands within the Amabilis Fir, Grand Fir, Douglas-fir, and Ponderosa Pine Forest Zones (Franklin and Dyrness 1973) that have not been logged. Stands are typically old-growth and mature forest habitat that has the following characteristics:

a multi-layered, multi-species canopy dominated by large (51+cm dbh) overstory trees (typically 173 - 247 stems/ha, although tree densities as low as 86 stems/ha are possible where large diameter trees are present);
moderate to high (60 - 85%) canopy closure;

some large trees with various deformities (eg. large cavities, broken tops, dwarf mistletoe infections);

large (51+cm dbh) snags present (typically 7+ stems/ha);

accumulations of large (51+cm dbh) fallen trees and other woody debris on the

ground.

Type B Suitable Habitat: Generally these are stands within the Amabilis Fir, Douglas Fir and Ponderosa Pine Forest Zones (Franklin and Dyrness 1973). Stands are typically mature forest habitat that has naturally regenerated following fire or windthrow and has the following characteristics:

a multi-layered, multi-species canopy dominated by overstory trees approximately 30+ dbh. Stands must contain 20%+ fir (Douglas-fir, Grand Fir) and/or hemlock in the overstory to be considered Type B suitable habitat;

approximately 50 %+ canopy closure;

dominant live trees with various deformities (eg. large cavities, broken tops, dwarf mistletoe infections);

snags and down logs, at least some of which are of similar dbh to dominant live trees.

Type C Suitable Habitat: **Type C suitable habitat is defined on the basis of use by spotted owls.** These are usually younger stands occurring at low to mid-elevation where some old-growth/mature components and/or structural characteristics are present. This habitat often appears as a mosaic of relatively small, older stands scattered among and within younger stands. Type C habitat also includes areas of historic high-grade logging and partial entry. Type C suitable habitat known to be used by spotted owl in eastern Washington includes:

historic selectively harvested stands that have had less than 40% volume removed and still contain the structural components important to spotted owls [multi-layered canopies, multi-species composition, moderate to high canopy closure (40%+), some large trees, snags, down woody debris, and evidence of decadence and/or deformities].

stands that have most of the characteristics of Type A or B habitat, but grow on rocky or poor soils resulting in highly variable canopy closure. This habitat appears as clumps or pockets of stands with high canopy closure in a patchwork distribution.

multi-layered stands that have most of the characteristics of Type A and B habitat, but are dominated by ponderosa pine, with as little as 10% of the overstory comprised of Douglas-fir.

Type A and B habitat at elevations greater than 1524 m comprised of Douglas-fir, amabilis fir, western hemlock or a combination of these species.

Appendix C: Other Species Associated with Late Successional Forests[10]

The coniferous forest ecosystems that provide habitat for the northern spotted owl consist of an elaborate mosaic of species and ecosystem processes. The stability and diversity of these ecosystems depends on interrelationships between biotic and abiotic components, and the critical co-evolutionary links among the biotic members of the community. As a result, even the loss of one keystone species can potentially have a destabilizing effect on the functioning of the ecosystems, and stable ecosystems are important for the survival of all species within the ecosystems. When human activities threaten the viability of one species, as in the case of the northern spotted owl, it indicates an impairment of the ecosystems that species is part of.

Species closely associated with old forest habitats in the same ecosystems as spotted owls have also been negatively affected by loss of habitat. On the other hand, an improvement of habitat conditions for northern spotted owls would represent an improvement in habitat conditions for many other species that share the same ecosystem. The management and conservation of habitat for the northern spotted owl will benefit not only this endangered owl, but many other species of plants and animals. This benefit is particularly relevant for species that are closely associated with late-successional and old-growth coniferous forests, and is particularly important for those species that are currently considered at risk. Conservation of the spotted owls will help maintain functioning late-successional and old-growth forest ecosystems and will help regulate water and nutrient cycles within watersheds that are managed for spotted owls. Such a shift in forest management strategies, from one that emphasizes ecosystem simplification, to strategies that incorporate the stewardship of biodiversity as part of their goals, has significant implications for many species of plants and animals in southwestern British Columbia.

There are approximately 71 species of vertebrates that are closely associated with late-successional and old-growth forests within the range of the northern spotted owl in Canada (4 amphibians, 34 birds, 17 mammals, and 16 fish). Of these, 16 are considered to be at risk, either nationally or provincially (Table 1), and 55 are not considered to be at risk (Table 2). Table 3 provides a list of bird species, with their current status, that occur within old-growth forests in the spotted owl range in the province. Table 4 provide a list of fish species present in streams within Spotted Owl Conservation Areas.

[10] Prepared by Bill Harper and Rhonda Milliken.

Table 1. Vertebrates at risk that are associated with late-successional and old-growth forests within the range of the northern spotted owl in British Columbia.[1]

Species	Status[2]
Amphibians	
Pacific Giant Salamander	Red-listed and nationally Vulnerable
Tailed Frog	Blue-listed
Birds	
Northern Goshawk - laingi subspecies	Red-listed
Bald Eagle	Blue-listed
Marbled Murrelet	Blue-listed and nationally Threatened
Williamson's Sapsucker	Blue-listed
Flammulated Owl	Blue-listed and nationally Vulnerable
Western Screech-Owl - kennecotti subspecies	Blue-listed
Great Grey Owl	nationally Vulnerable
Mammals	
Keen's Long-eared Myotis	Red-listed and nationally Vulnerable
Townsend's Big-eared Bat	Blue-listed
Fisher	Blue-listed
Fish	
Cultus Lake Sculpin	Red-listed
Pygmy Longfin Smelt	Red-listed
Brassy Minnow	Blue-listed

1 Species list is based on Vertebrates of British Columbia (Cannings and Harcombe 1990), Report of the U.S. Forest Ecosystem Management Assessment Team (USDA et al. 1993), 1993 Red and Blue List (Wildlife Branch 1993), Canadian Species at Risk (COSEWIC 1993), and Rare Freshwater Fish of British Columbia (Cannings 1993). This list is not based on field data and should not be considered exhaustive.

2 Red-listed species are candidates for designation as either endangered or threatened. Blue-listed species are considered vulnerable or sensitive. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determine national designations.

Table 2. Vertebrates not at risk that are associated with late-successional and old-growth forests within the range of the northern spotted owl in British Columbia.[1]

Amphibians

Northwestern Salamander
Rough-skinned Newt

Birds

Barred Owl
Brown Creeper
Chestnut-backed Chickadee
Golden-crowned Kinglet
Hammonds's Flycatcher
Hermit Thrush
Northern Flicker
Pileated Woodpecker
Red-breasted Nuthatch
Three-toed Woodpecker
Vaux's Swift
Western Flycatcher
Winter Wren
Barrow's Golden-eye
Bufflehead
Common Merganser
Hairy Woodpecker
Harlequin Duck
Hooded Merganser
Northern Pygmy-owl
Red Crossbill
Red-breasted Sapsucker
Varied Thrush
Warbling Vireo
Wilson's Warbler
Wood Duck

Mammals

Marten
Townsend's Chipmunk
Northern Flying Squirrel
Big Brown Bat
Hoary Bat
Long-eared Myotis
Silver-haired Bat
Deer Mouse
Douglas Squirrel
Shrew-mole
California Myotis
Little Brown Myotis
Fringed Myotis
Yuma Myotis

Fish

Pacific Lamprey
Chum Salmon
Sockeye Salmon
Cutthroat Trout
Mountain Whitefish
Shorthead Sculpin
Coastrange Sculpin
Pink Salmon
Coho Salmon
Chinook Salmon
Dolly Varden
Longnose Dace
Torrent Sculpin

1 Species list is based on Vertebrates of British Columbia (Cannings and Harcombe 1990) and the Report of the U.S. Forest Ecosystem Management Assessment Team (USDA et al. 1993). This list is not based on field data and should not be considered exhaustive.

Table 3. Status of birds associated with old-growth forests. Data provided by R. Wayne Campbell (BC Environment)

SPECIES	MIGRATION	SUMMER	WINTER	POPULATION
Great Blue Heron		R*		D
Wood Duck		X		S
Harlequin Duck		B	X	S
Common Goldeneye	X	X		U
Bufflehead	X		X	S
Hooded Merganser		B	X	U
Common Merganser	X	B	X	S
Turkey Vulture	X	B		S
Osprey	X	B		S
Bald Eagle	X	B	R	S
Sharp-shinned Hawk	X		X	U
Northern Goshawk	X	B	X	U
Red-tailed Hawk	X	B	X	S
Golden Eagle		X	X	U
American Kestrel	X	X		U
Merlin	X		X	U
Peregrine Falcon	X		X	S
Blue Grouse		B	X	S
Marbled Murrelet		B		U
Band-tailed Pigeon	X	X	X	S
Western Screech-Owl		B	R	D
Great Horned Owl		B	X	S
Northern Pygmy-Owl		B	R	U
Spotted Owl		B	R	U
Barred Owl	X	B	R	I
Northern Saw-whet Owl	X	B	R	U
Common Nighthawk	F			U
Vaux's Swift	R,F	B		U
Black Swift	F			U
Rufous Hummingbird	F	B		U
Belted Kingfisher		B		U
Red-breasted Sapsucker	X	B	X	D
Downy Woodpecker	X	B	F	U
Hairy Woodpecker	X	B	F	U
Three-toed Woodpecker			F	U
Northern Flicker	X	B	F	U
Pileated Woodpecker		B	F	D
Olive-sided Flycatcher	X	B		D
Western Wood Pewee	X			S
Willow Flycatcher	X	B		D
Hammond's Flycatcher	X	B		D
Pacific-slope Flycatcher	X	B		S
Tree Swallow	F	B		U
Violet-green Swallow	F	F		U
Northern Rough-winged Swallow	F	B		D
Barn Swallow	F	F		S
Gray Jay	X	B	F	U

Steller's Jay	X	B	F	U
Northwestern Crow			R	S
Common Raven		B	F,R	U
Black-capped Chickadee	X	B	F,R	U
Chesnut-backed Chickadee		B	F	U
Red-breasted Nuthatch	X	B	F	U
Brown Creeper	X	B	F	U
Winter Wren		B	F	U
American Dipper	X	B	F,R	U
Golden-crowned Kinglet	X	B	F	U
Townsend's Solitaire	X	B	F	U
Swainson's Thrush	X	B		U
Hermit Thrush	X	B		U
American Robin	X	B		S
Varied Thrush	X	B	F	U
Warbling Vireo	X	B		D
Orange-crowned Warbler	X	B		U
Yellow-rumped Warbler	X	B		U
Townsend's Warbler	X	B		U
MacGillivray's Warbler	X			U
Wilson's Warbler	X	B		D
Western Tanager	X			D
Dark-eyed Junco	X	B	F	U
Brown-headed Cowbird	X	B		I
Pine Grosbeak	X	B	F	U
Purple Finch	X	B	F	U
Red Crossbill	X	B	F	U
Pine Siskin	X	B	F	U
Evening Grosbeak	X	B	F	U

Note: B - Breeds within or on edge of forest
D - Population decreasing
F - Forages over, within, or along edge of forest
I - Population increasing
R - Roosts within forest
S - Population stable
U - Population status unknown
X - Species occurs or is present; full status unknown

Prepared by R. Wayne Campbell
10 February 1994

Fish presence by species in streams in proposed Spotted Owl Conservation Areas																	
SOCA #	SOCA Name	rainbow trout	cutthroat trout	summer steelhead	winter steelhead	Dolly varden or bull trout	Rocky Mountain whitefish	kokanee salmon	coho salmon	chinook salmon	sockeye salmon	pink salmon	chum salmon	lamprey sp.	sculpin sp.	long nose dace
1	Skagit/upper Sowaqua	•				•										
2	Chilliwack/Silverhope	•	•	•	•	•	•	•	•	•				•	•	
3	Liumchen	•			•	•	•		•	•		•	•	•	•	
4	Sowaqua/Coquihalla	•		•		•										
5	Sasquatch	•	•		•			•	•	•			•	•	•	•
6	Chehalis/Statlu	•		•	•	•	•		•	•				•	•	•
7	Garibaldi/Golden Ears	•	•			•		•								
8	GVWD Coquitlam		•		•	•			•					•	•	•
9	Capilano/Seymour		•	•	•	•			•	•				•	•	
10	Upper Pitt				•	•			•	•						
11	Anderson	•														
12	Hornet/Clear	•			•											
13	Trethewey	•	•		•	•			•						•	
14	Douglas	•				•			•	•	•	•	•		•	
15	Glacier/Tuwasus	•	•		•	•	•		•	•	•	•		•	•	
16	Billygoat					•					•					
17	Lillooet	•	•		•	•	•		•	•				•	•	
18	Birkenhead	•	•			•	•	•	•	•	•			•	•	
19	Wedge/Green	•				•		•			•					
20	Cheakamus	•				•		•							•	
21	Squamish	•	•		•	•			•	•		•	•	•	•	
Comments:																
	• Additional species may be present as fish inventory is incomplete in most SOCAs.															
	• The 1993 summer steelhead return in the Coquihalla River (SOCA #4) was less than 100 adults -- this stock is a candidate for threatened/endangered status.															

Table 4. Fish presence by species in proposed Spotted Owl Conservation Areas. Data provided by Poul Bech (BC Environment).

The US Forest Ecosystem Management Assessment Team (FEMAT) evaluated 308 invertebrates species closely associated with late-successional and old-growth forests within the range of the northern spotted owl (155 insects, 25 spiders, 25 millipedes, 1 crustacean, 38 land snails, 7 slugs, 54 freshwater snails, and 3 freshwater clams) (Thomas *et al.* 1993). At this time we have no estimates of how many of these invertebrates also occur within the Canadian range of the spotted owl. Preliminary estimates of the potential arthropod fauna within the Canadian range of the northern spotted owl are displayed in Table 5.

Within the range of the northern spotted owl in Canada, there are approximately 67 species of vascular plants that are closely associated with late-successional and old-growth forests. Of these, 7 are considered to be at risk provincially (Table 6), and the remaining 60 are not considered to be at risk (Table 7). We know from work completed in the United States that a large number of non-vascular plants (bryophytes, fungi, and lichens) are also closely associated with late-successional and old-growth forests within the range of the northern spotted owl. FEMAT evaluated 106 bryophyte species (mosses, liverworts, and hornworts), 527 fungi species, and 157 lichen species (Thomas *et al.* 1993). At this time we have no estimates of how many of these non-vascular plant species also occur within the Canadian range of the spotted owl.

The lists of vertebrates, vascular plants, and arthropods in Appendices 3 to 7 are based on a large body of work generated in the United States to assess the viability of other old-growth associated species within the U.S. range of northern spotted owl (Thomas *et al.* 1993). These U.S. lists were assessed by Canadian species experts to identify which of those species also occur within the Canadian range of the northern spotted owl. It must be emphasized that these lists are not based on actual field data in Canada and should not be considered exhaustive.

Table 5. Invertebrates at risk that are associated with late-successional old-growth forests within the range of the Northern Spotted Owl.[1]

Class Diplopoda (Millipedes)
Order Chordoumatida
Family Caseyidae

Caseya benediciae	*Caseya balophila*
Caseya bucketti	*Caseya longiloba*
Caseya megasoma	*Caseya shastaensis*
Harpapha haydeniana	*Metapiana sheari*
Ochrogramma formulosa	*Ochrogramma haigi*
Oplona biturcafa	*Oplona casualis*
Oplona communia angusta	*Oplona confusa*
Oplona distincta	*Oplona exigua*
Oplona facatia	*Oplona fisheri*
Oplona goedent	*Oplona scytonoloides*
Oplona siliquae	*Tuhaphe levil*

Class Arachnida (Spiders)
Order Araneida
Family Agelenidae
Cybaeina minuta

Order Phalangida (harvestman)

Cryptomaster levlethan	*Isolactus spinosus*
Pentanychus hamatus	*Pentanychus clavatus*
Pentanychus bilabatus	*Pentanychus flavescens*
Pentanychus pacificus	

Class Insecta (Insects)
Order Orthoptera

Boonacris alticola	*Pristoceuthophilus celatus*
Pristoceuthophilus cercalis	*Pristoceuthophilus sargentae*
Tropidischia xanthostoma	

Order Hemiptera

Boreostolis americanus	*Plinthisus longisetosus*
Thylochromus nitidultus	*Eurychilopterella sp.*
Phytocoris nobiois	*Pithanus maerkelii*
Polymerus castellaeni	*Vanduzeenia borealis*
Acalypta lillianis	*Acalypta saundersi*
Derephysia foliacea	

Order Coleoptera

Cychrus tuberculatus
Promecognathus laevissimus
Omus dejeani
Acneus burnelli
Pterostichus rothi
Metrius contractus
Zacotus mathewsii
Lobosoma horridum
Cicindela columbica

Order Plecoptera

Nemoura wahkeena
Solperia fenderi

Order Trichoptera

Eobrachycentrus gelidae
Homoplecta schuhi
Lepidostoma goedeni
Homoplecta schuhi
Lepidostoma goedeni
Farula davisi
Farula reaperi
Limnephilus atereus
Oligophlebodes mostbento
Dolophilodes oregona
Rhyacophila ambilis
Rhyacophila fenderi
Rhyacophila lineata
Rhyacophila unipunctata
Cryptochia shasta
Rhyacophila genella
Ochrotrichia vertreesi
Agapetus denningi
Ochrotrichia alsea
Agapetus denningi
Ochrotrichia alsea
Apatania tavaia
Farula jewetti
Limnephilus alconura
Neothremma andersoni
Philocasca oron
Tinodes siskyou
Rhyacophila colonus
Rhyacophila haddocki
Rhyacophila mosana
Desmona bethula
Goeracea oregona
Rhyacophila siskyou
Abellan hydropsyche

Order Diplopoda

Harpaphe haydeniana

Phylum Mollusca

Fluminicola columbiana
Anodonta wahlametensis
Monadenia fidelis minor
Monadenia f. columbiana
Monadenia f. scottiana
Monadenia t. wintu
Juga hemphilli hemphilli
Juga (Oreobasis) aclifilosa
Juga (O.) checoi
Physella columbiana
Amnicola sp.
Anodonta californiensos
Monadenia f. promotis
Monadenia f. salmonensis
Monadenia troglodyteschaceana
Monadenia setosa
Juga h. dellesensis
Juga (O.) occata
Juga (O.) orickensis
Fluminicola seminalis

Lanx alta
Lanx subrotundata
Hemphillia malonei
Hemphillia glandulosa glandulosa
Prophysaon coeruleum
Monadenia f. berylilca
Monadenia f. ochromphaoous
Monadenia f. klamathica
Monadenia callipeplus
Monadenia rotifera
Vespericola shosta
Vesporicola karokorum
Vespericola columbiana columbiana
Megomphix hemphilli
Helminthoglypta hertiainideroceres hesperium
Lanx patelioides
Helisoma newberryl newberryl
Hemphillia pantherina
Hemphillia barrington
Prophysaon dubium
Monadenia f. celuethia
Monadenia f. leonina
Monadenia churchi
Monadenia crietulata
Trilobopsis raperi tehamana
Vespericola sierrana
Vespericola megasoma authales
Vorticifex neritoides
Haplotrema voyenum

[1] The species list is based on the USDI 1992 and Thomas *et al.* 1993.

Preliminary estimates of the potential arthropod fauna within the Canadian range of the northern spotted owl indicate that:

1. There are species on Vancouver Island only in old growth but this may not be true elsewhere in the province. (Scudder, pers. comm.).

2. Based on Neville Winchester's findings (only intensive study in B.C.), there are strong suggestions that there are several species with specific habitat needs which restrict their distribution to old-growth (eg. mites and beetles restricted to canopy moss). Harvesting of any intact old growth will results in the loss of species (Winchester, pers. comm.).

3. Winchester sampled an estimated 3/4 of a million insects which are not yet identified but are varied and unique. His collections show the guild structure is numerically dominated by phytophagous and predator / parasitoid species, indicating that herbivory in mature, structurally-complex forests is relatively insignificant. From this, he concludes that biodiversity in second-growth stands is altered. (Winchester, 1993).

4. John Richardson has sampled aquatic invertebrates in late-successional forest on the East coast of Vancouver Island, but has not identified his samples (Richardson, pers. comm.).

5. In Andrews Forest (Coastal Douglas Fir), Jack Latin found no species absolutely confined to old growth but ones most abundant in old growth (Scudder, pers. comm.).

6. First record of *Pseudohaida Rothi* Hatch (Coleoptera: staphylinidae amaliinae) (Campbell, J.M. and Winchester, N. In press).

7. It is clear that studies on invertebrates of old growth forests in the Pacific Northwest are incomplete; the number of known species probably represents less than half of the estimated species. Even still, within the range of the northern spotted owl, many species are endemic and some are poor dispersers (flightless) or rely on special habitats including decaying wood or aquatic habitats (eg. Thomas et al. 1993).

Table 6. Vascular plants at risk that are associated with late-successional and old-growth forests within the range of the northern spotted owl in British Columbia.[1]

Species	Common Name	Status[2]
Boschniakia (strobilacea) hookeri	Ground cone	Blue-listed
Cypripedium montanum	Mountain lady's slipper	Blue-listed
Oxalis oregana	Redwood sorrel	Red-listed
Polystichum imbricans	Narrow-leafed sword-fern	Blue-listed[3]
Pyrola dentata	Toothleaf pyrola	Red-listed
Rubus lasiococcus	Dwarf bramble	Red-listed
Rubus nivalis	Snow bramble	Red-listed

1 Species list is based on The Vascular Plants of British Columbia (Douglas et al. 1989, 1990, 1991, and in press), Report of the U.S. Scientific Analysis Team (Thomas et al. 1993), and B.C. Conservation Data Centre Tracking Lists (Douglas 1994). This list is not based on field data and should not be considered exhaustive.

2 Vascular plants Red-listed by the Conservation Data Centre are candidates for designation as either endangered or threatened, or are rare species known from fewer than 21 sites. Blue-listed vascular plants are those that may become vulnerable in the future if factors affecting their status are not reversed.

3 Assumes the U.S. listed Imbricate sword-fern (*Polystichum munitum* var. *imbricans*) is the same species as the BC Blue-listed Narrow-leafed sword-fern (*Polystichum imbricans*).

Table 7. Vascular plants not at risk that are associated with late-successional and old-growth forests within the range of spotted owls in British Columbia[1].

SCIENTIFIC NAME	COMMON NAME
Achlys triphylla	Vanilla leaf
Adenocaulon bicolor	Trail plant
Adiantum pedatum	Western maidenhair fern
Allotropa virgata	Candy stick
Arnica latifolia	Mountain arnica
Asarum caudatum	Wild ginger
Chamaecyparis nootkatensis	Alaska yellow cedar
Chimaphila menziesii	Pipissewa
Chimaphilia umbellata	Common pipissiwa
Clintonia uniflora	Queen's cup
Coptis asplenifolia	Spleenwort-leaved goldthread
Corallorhiza maculata	Pacific coral root
Corallorhiza mertensiana	Western coral-root
Disporum hookeri	Fairy bell
Dryopteris austriaca	Spreading wood-fern
Erythronium montanum	Avalanche lily
Gaultheria humifusa	Western wintergreen
Gaultheria ovatifolia	Oregon wintergreen
Goodyera oblongifolia	Rattlesnake plantain
Gymnocarpium dryopteris	Oak fern
Habenaria orbiculata	Large round-leaved rein-orchid
Habenaria saccata	Slender bog orchid
Habenaria unalascensis	Alaska rein-orchid
Hemitomes congestum	Gnome plant
Hieracium scouleri	Woolly-weed
Hypopitys monotropa	Pinesap
Listera borealis	Northern twayblade
Listera caurina	Western twayblade
Listera convallarioides	Broad-lipped twayblade
Listera cordata	Twayblade
Luzula hitchcockii	Smooth woodrush
Lysichitum americanum	Skunk cabbage
Melica subulata	Melic grass
Menziesia ferruginea	Fool's huckleberry
Monotropa uniflora	Indian pipe
Platanthera obtusata	Small northern bog orchid
Pterospora andromedea	Woodland pinedrops

Pyrola asarifolia	Alpine pyrota
Pyrola chlorantha	Greenish wintergreen
Pyrola picta	White vein pyrola
Pyrola secunda	One-sided pyrola
Pyrola uniflora	Single flowered pyrola
Rubus pedatus	Fiveleaved bramble
Selaginella oregana	Oregon selaginella
Smilacina racemosa	Solomons seal
Smilacina stellata	Star-flowered solomon-plume
Streptopus amplexifolius	Clasping-leaved twisted-stalk
Streptopus roseus	Rosy twisted-stalk
Streptopus streptopoides	Twisted-stalk
Taxus brevifolia	Pacific yew
Thuja plicata	Western red cedar
Tiarella trifoliata	Three-leaved foamflower
Tiarella unifoliata	Coolwort foamflower
Trillium ovatum	Wake-robin
Vaccinium alaskaense	Alaska huckleberry
Vaccinium membranaceum	Thin-leaved huckleberry
Vaccinium ovalifolium	Oval-leaf huckleberry
Vaccinium parvifolium	Red huckleberry
Viola glabella	Pioneer violet
Viola orbiculate	Round-leaved violet

1 Species list is based on The Vascular Plants of British Columbia (Douglas et al. 1989, 1990, 1991, and in press), and the Report of the Scientific Analysis Team (Thomas et al. 1993). This list is not based on field data and should not be considered exhaustive.

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Appendix D: Delineation of Spotted Owl Conservation Areas (SOCAs)

Spotted Owl Conservation Areas (SOCAs) were delineated that consisted of large habitat blocks capable of supporting multiple breeding pairs. This approach to spotted owl management was based on widely accepted biological principles that were first applied to the spotted owl in the Conservation Strategy of the Interagency Scientific Committee (Thomas *et al.* 1990). These principles included 1) species managed in large habitat blocks is superior to small habitat blocks; 2) movement of individuals between these blocks is critical for the maintenance and viability of clusters or local populations; and 3) provide for improving habitat conditions within these habitat blocks to reverse the trend of increasing fragmentation and habitat loss. The principles are described as follows:

Principle 1: Spotted owls managed in large habitat blocks (SOCAs) is superior to small habitat blocks that manage only single breeding pairs.

Empirical evidence and modelling in the United States have shown that clusters of 15 or more breeding pairs have much higher persistence rates than smaller isolated clusters. These clusters or local population centres can be defined as groups of breeding owls where pairs have overlapping or nearly overlapping territories.

Increasing the number of breeding pairs in a cluster should lower the risk of its extirpation since large clusters containing many breeding pairs have a better chance of sustaining themselves for many generations than smaller clusters. Small clusters are highly susceptible to extirpation. Clusters should be large enough to support multiple breeding pairs, as well as, juveniles, subadults and "floaters". It is thought that "floaters" act as ready replacements for birds that die or vacate their territories for other reasons. The ready replacement of birds in clusters should help maintain the breeding population, maintain a steady surplus of owls and maintain the viability of the entire population. As well, the larger habitat blocks associated with large clusters are less susceptible to complete elimination from natural disturbances than smaller habitat blocks.

Conversely, small habitat blocks capable of supporting only one breeding pair have high perimeter-to-area ratio which may cause an increased "edge effect" to the owl. "Edge effects" may increase the potential for competition with other species, increase the potential for predation by other species and increase the potential for habitat degradation through natural disturbance. Furthermore, single pair site management could result in an increased likelihood of local extirpation due to catastrophic events and a decreased likelihood of successful dispersal by

juveniles.

Principle 2: Distances between habitat blocks (SOCAs) must provide for movement of individuals to ensure the maintenance and viability of the spotted owl population

The management of spotted owls in SOCAs concentrate owls within "islands" of suitable habitat surrounded by a "sea" of human modified landscapes. This type of population structure, in which a total population consists of smaller sub-populations that are isolated in space, has been termed a "meta-population" (Shaffer 1985). Dispersal is a key ingredient of the meta-population model, for animals dispersing to another sub-population may support existing sub-populations, provide a "rescue effect" for sub-populations that are declining, or provide "seed" for recolonization.

Dispersal between SOCAs should maintain genetic variability within the population. Theory predicts that small populations without an influx of gene flow from dispersers lose genetic variability relatively quick through the combined effects of random genetic drift, inbreeding and founder effects. Reduced genetic variability may lead to reduced reproductive success, reduced resistance to disease, establishment of deleterious traits and reduced capacity to adapt to sudden environmental changes (Allendorf and Leary 1986, Ledig 1986, Ralls *et al.* 1986).

The viability of the owl population in the province is highly dependent upon maintaining a connection of dispersing individuals between SOCAs. Although SOCAs may be subject to extirpations at some point over the long-term, individuals dispersing to other SOCAs provides a better chance for re-establishment of vacant sites and reduces the deleterious effects caused by inbreeding. Furthermore, decreasing the distance between SOCAs and increasing the number of adjacent SOCAs should provide a higher likelihood that dispersing individual will locate another SOCA.

Principle 3: Provide for improving habitat conditions within SOCAs to reverse the trend of increasing fragmentation and habitat loss.

Within each SOCA, it is critical to provide for stable or improving habitat conditions to reverse the trend of increasing fragmentation and habitat loss. Fragmentation and loss of suitable owl habitat is associated with lower spotted owl densities. Recent studies have demonstrated that a strong positive relationship exists between the amount of older forest and abundance of spotted owls (Hays *et al* 1989). Fragmentation and habitat loss may result in decreased reproductive

productivity, decreased success of juvenile dispersal, increased competition with other species and increased predation by other species. Furthermore, fragmentation may result in an increased susceptibility of forest stands to natural disturbances. Analyses by Bart and Forsman (1990) showed that the number of owls per square mile, pairs of owls per square mile, young per square mile and young per pair increased steadily with increasing amounts of older forests. Therefore, areas of young forests within SOCAs should be allowed to develop into old forests to reverse the trend of increasing fragmentation and habitat loss, and provide for a stable and viable owl population.

Delineation Criteria of Spotted Owl Conservation Areas:

In British Columbia, SOCAs containing 15 or more breeding pairs was not feasible at present given the limited number of large contiguous old forest stands and the large distances between known adjacent owls. Furthermore, the topography of southwestern BC (high elevation mountain peaks and steep slopes) may have resulted in SOCAs that were extremely large and spatially fragmented.

Spotted Owl Conservation Areas were delineated throughout the Documented Range of the owl in the province. The location of SOCAs was based on the current knowledge of active spotted owl sites and were distributed across the landscape to ensure viable dispersal interconnections are maintained. SOCAs were delineated to provide sufficient amounts of suitable owl habitat to support a stable owl population over time. These areas incorporated active owl sites and other areas deemed necessary for long-term population growth and stability.

Wherever possible, SOCAs were designed to minimize economic impacts on the timber industry and to maximize overlaps with other land use concerns. These overlaps included utilizing areas within provincial parks, recreational areas, wilderness areas, protected areas, inoperable or non-merchantable timber, environmentally sensitive areas, visual quality objectives, forest ecosystem networks and other deletions for old forest dependent species.

SOCAs were delineated to incorporate known active owl sites to ensure immediate protection of the current known owl population. For each active owl site, an activity centre or home range, approximately 3,200 ha in size, was delineated around nest or areas of high owl detections. The area within each activity centre incorporated forested habitats that ranged in elevation from sea level to 4,500 ft. SOCAs were delineated that are capable (or eventually will be capable) of supporting three or more reproductive owl pairs (three or more activity centres). The shape of each SOCA was based on the currently knowledge of active owl sites and, wherever possible, attempted to minimize the perimeter-to-area ratio to

prevent an increased risk of extirpation caused by natural disturbances, predators and interspecific competition.

Interconnection distances between adjacent SOCAs were delineated to be no further than 20 kms (range form 10 to 20 kms) apart, edge-to-edge. Based on current information, this distance will provide a probability of up to 66% that a dispersing individual will successfully disperse this distance (Thomas *et al.*, 1990). Furthermore, SOCAs were located within the dispersal distance of two or more other SOCAs to increase the likelihood that dispersing individuals will successfully locate another SOCA.

Several SOCAs were delineated that are unknown to be occupied by spotted owls at present. These SOCAs were delineated as critical biological "stepping stones" to support the meta-population (SOCA system) and provide the necessary dispersal interconnections to maintain the viability of the owl population.

Delineated Spotted Owl Conservation Areas:

In British Columbia, 21 SOCAs were delineated throughout the Documented Range of the owl in the province (Figures 1 through 21). Table 1 provides the total area and numbers of spotted owls (current and future projections) within Spotted Owl Conservation Areas. Table 2 provides a breakdown of the land area within each SOCA.

Table 1. Total area and numbers of spotted owls (current and future projections) within Spotted Owl Conservation Areas.

Spotted Owl Conservation Area	Total Area (ha)	Currently Known Owl Sites[11]	Currently Projected Owl Sites[12]	Future Projected Owl Sites	Future Projected with 33% Harvesting
1. Skagit & Manning	30,750	6	6	13	13
2. Chilliwack & Silverhope	17,481	4	4	7	5
3. Liumchen	7,100	1	1	3	2
4. Sowaqua & Coquihalla	11,821	2	2	5	3
5. Sasquatch	9,800	0	0	4	3
6. Chehalis & Statlu	12,150	2	2	5	3
7. Golden Ears	37,350	0	4	13	13
8. Coquitlam	16,088	2	4	7	5
9. Capilano & Seymour	33,671	4	10	15	12
10. Upper Pitt	10,800	0	2	4	4
11. Anderson & Uztlius	23,449	4	5	9	7
12. Hornet & Clear	13,150	0	0	5	4
13. Tretheway	12,219	0	0	5	3
14. Douglas	8,255	1	2	3	2
15. Glacier & Tuwasus	21,950	1	4	9	7
16. Billygoat	7,200	1	2	3	3
17. Lillooet	14,885	3	4	6	4
18. Birkenhead					
19. Wedge & Green	6,300	0	0	2	2
20. Cheakamus	9,750	0	0	4	3
21. Squamish	12,500	0	0	5	4
	316,669	31	52	127	102

[11] Known active owl sites within Spotted Owl Conservation Areas

[12] Preliminary estimates of current projected owl sites.

Figure 2. Total land area within Spotted Owl Conservation Areas.

Spotted Owl Conservation Area	Area (ha)	Operable[13]	Inoperable[14]	Park[15]
1. Skagit & Manning	30,750	820	2,550	27,380
2. Chilliwack & Silverhope	17,481	6,762	10,719	0
3. Liumchen	7,100	3,522	1,337	2,241
4. Sowaqua & Coquihalla	11,821	3,405	8,416	0
5. Sasquatch	9,800	5,722	3,078	1,000
6. Chehalis & Statlu	12,150	6,774	5,376	0
7. Golden Ears	37,350	0	0	37,350
8. Coquitlam	16,088	5,310[16]	10,778	0
9. Capilano & Seymour	33,671	8,174[17]	16,597	8,900
10. Upper Pitt	10,800	0	0	10,800
11. Anderson & Uztlius	23,449	8,195	15,254	0
12. Hornet & Clear	13,150	4,542	8,608	0
14. Douglas	8,255	1,890	6,365	0
13. Tretheway	12,219	3,513	8,706	0
15. Glacier & Tuwasus	21,950	2,969	7,763	11,218
16. Billygoat	7,200	0	0	7,200
17. Lillooet	14,885	5,317	9,568	0
18. Birkenhead				
19. Wedge & Green	6,300	1,459	4,271	570
20. Cheakamus	9,750	3,415	3,534	2,801
21. Squamish	12,500	1,084	10,780	636
	316,669	72,873	133,700	110,096

[13] Total operable forest may be subjected to other harvest restrictions (ie. VQOs, ESAs, deer winter range, etc). Amount shown does not represent current standing timber; some operable habitats have been harvested previously.

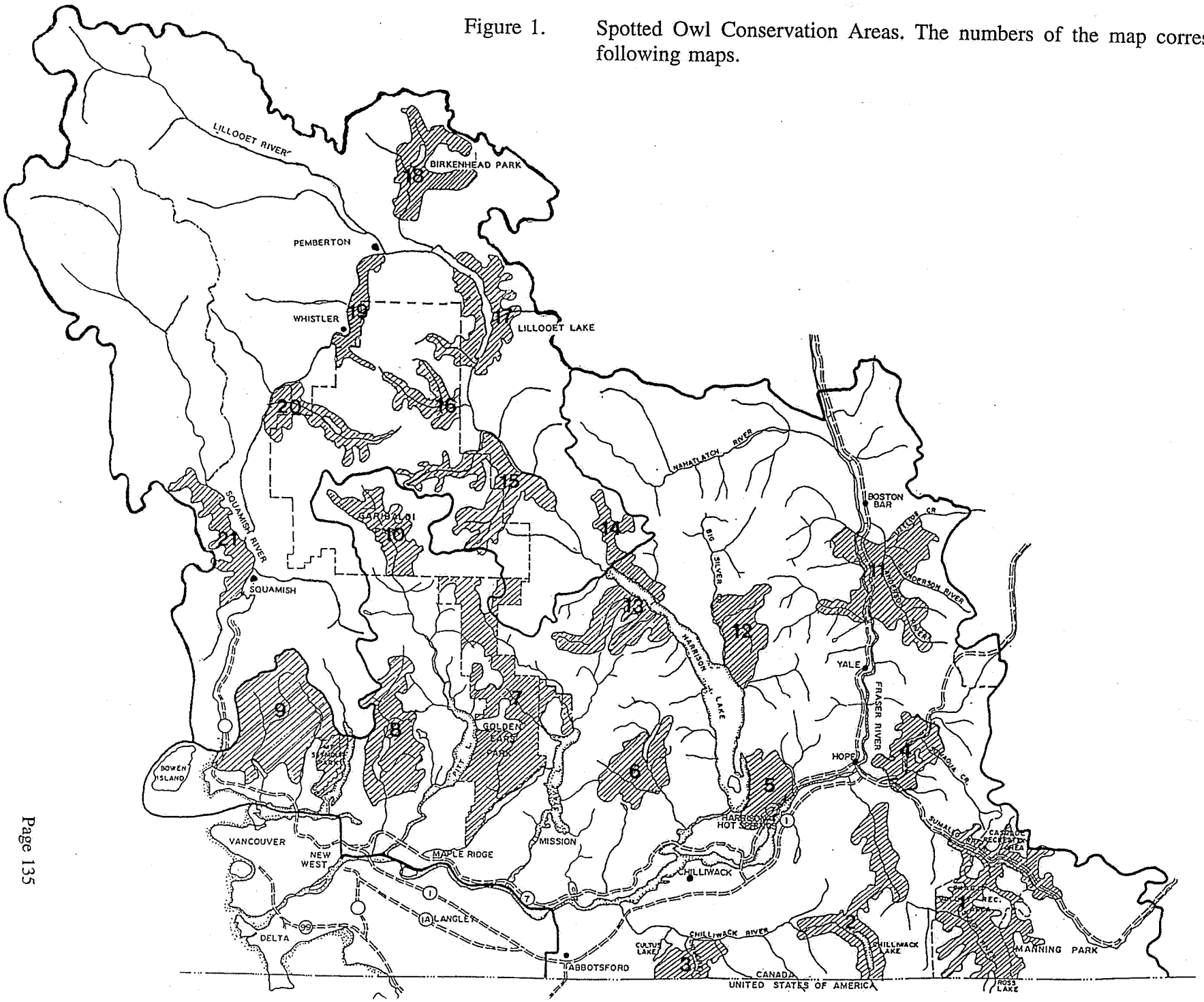
[14] Inoperable habitats includes non-forested habitats.

[15] Total area in parks includes non-forested habitats.

[16] Total amount assumes 33% operable landbase within the GVRD watershed.

[17] Total amount assumes 33% operable landbase within GVRD watersheds.

Figure 1. Spotted Owl Conservation Areas. The numbers of the map correspond to the following maps.



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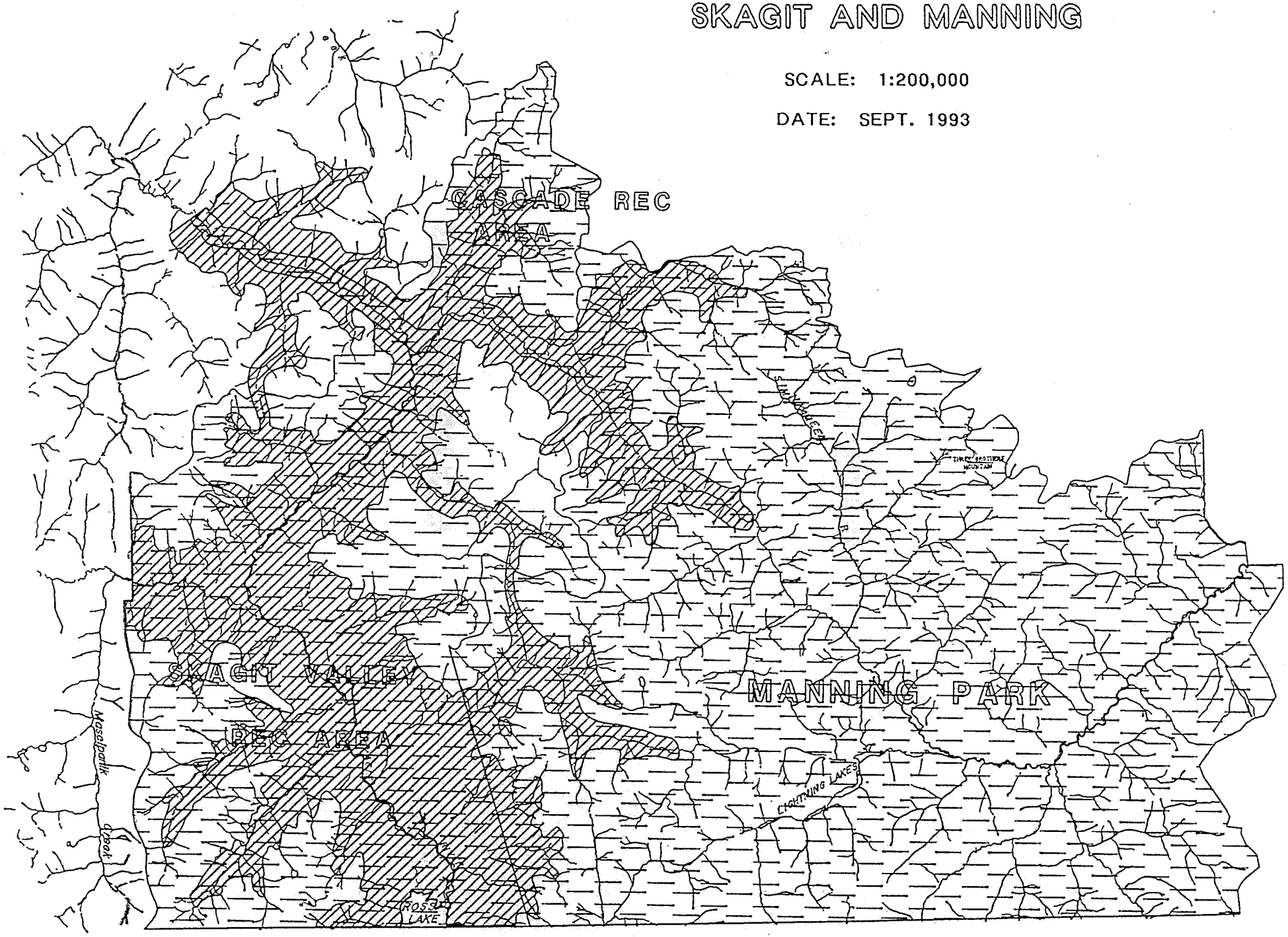
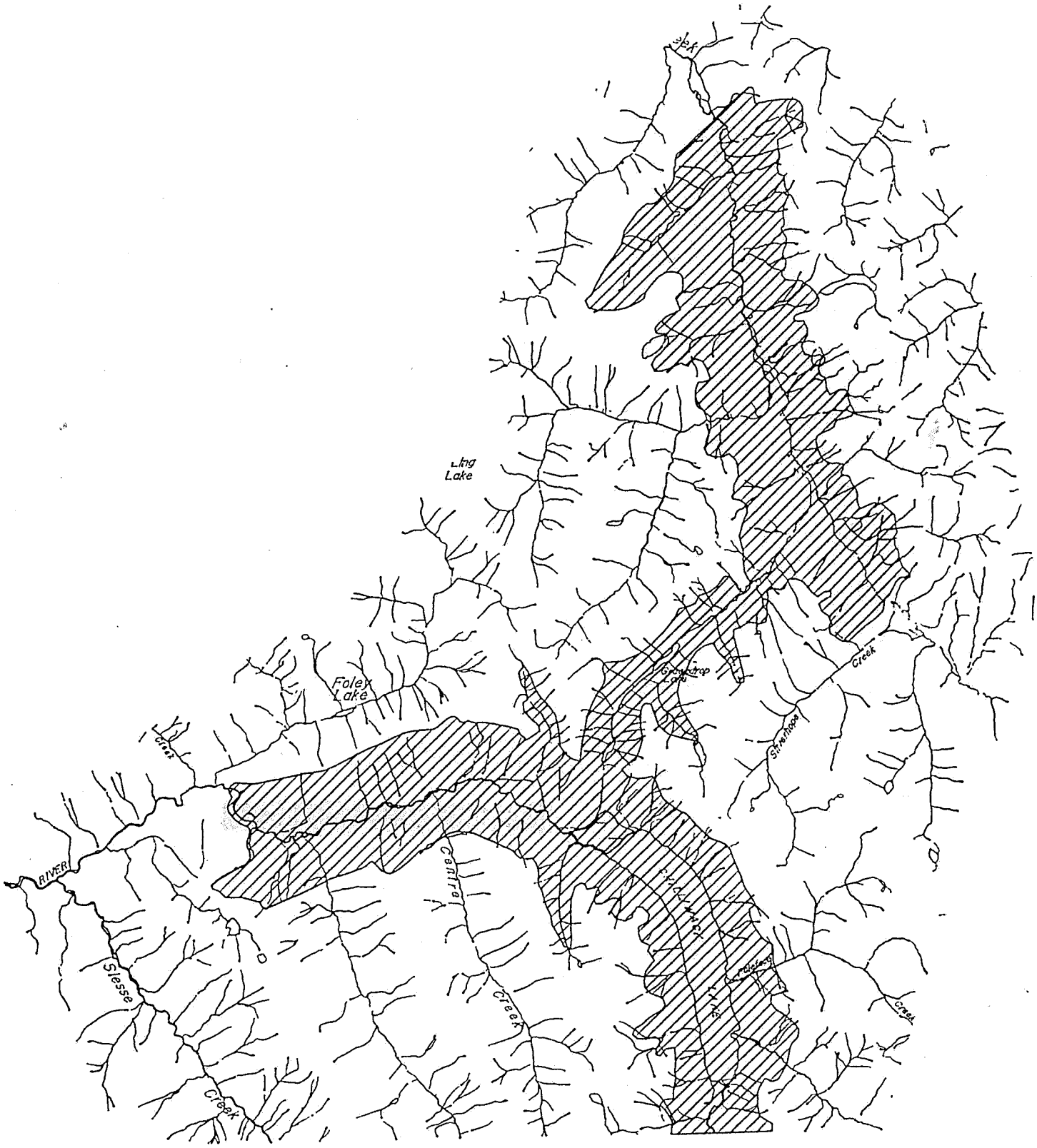
DATE: SEPT. 1993





CHILLIWACK LAKE

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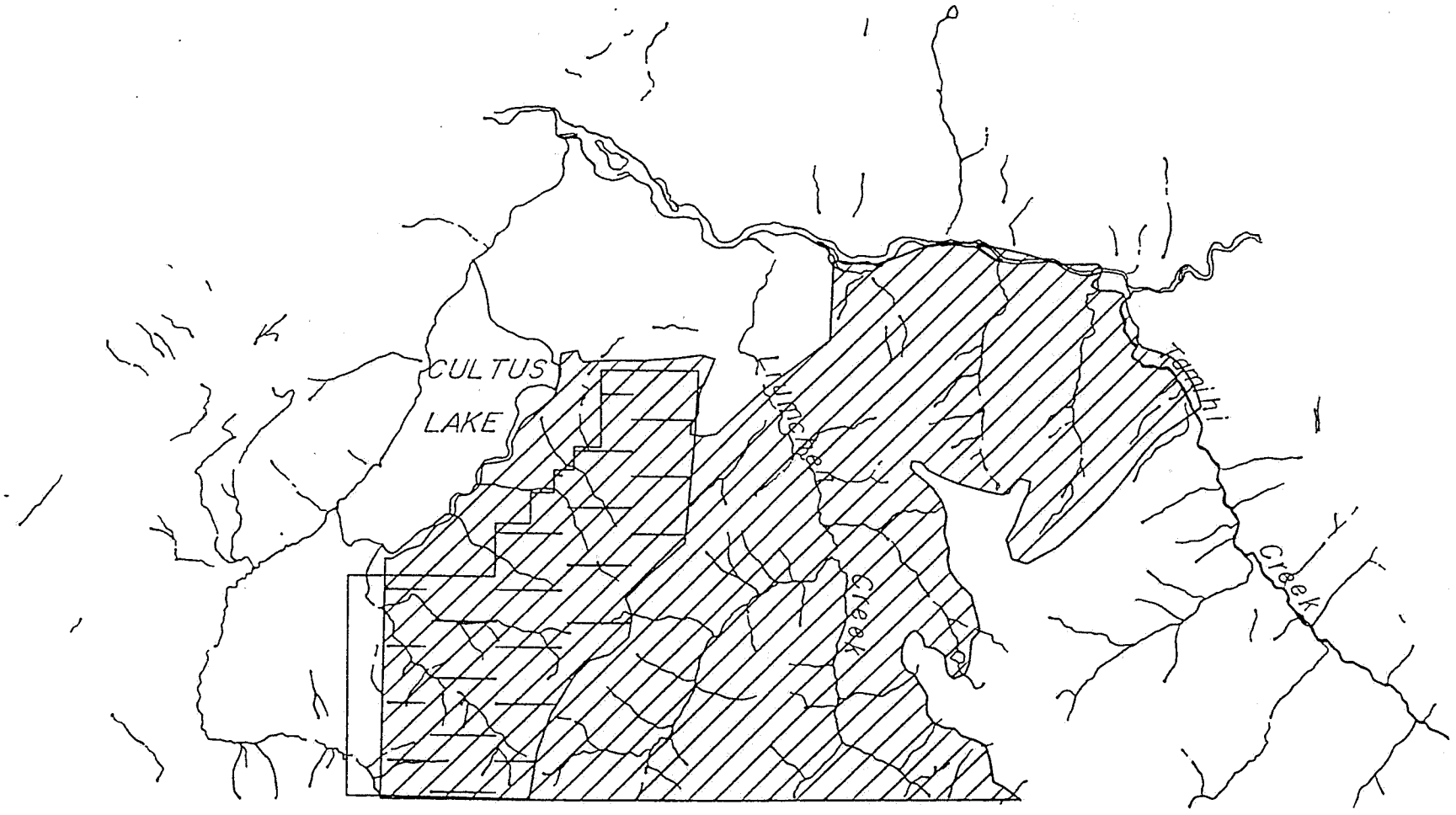
DATE: SEPT. 1993



LIUMCHEN

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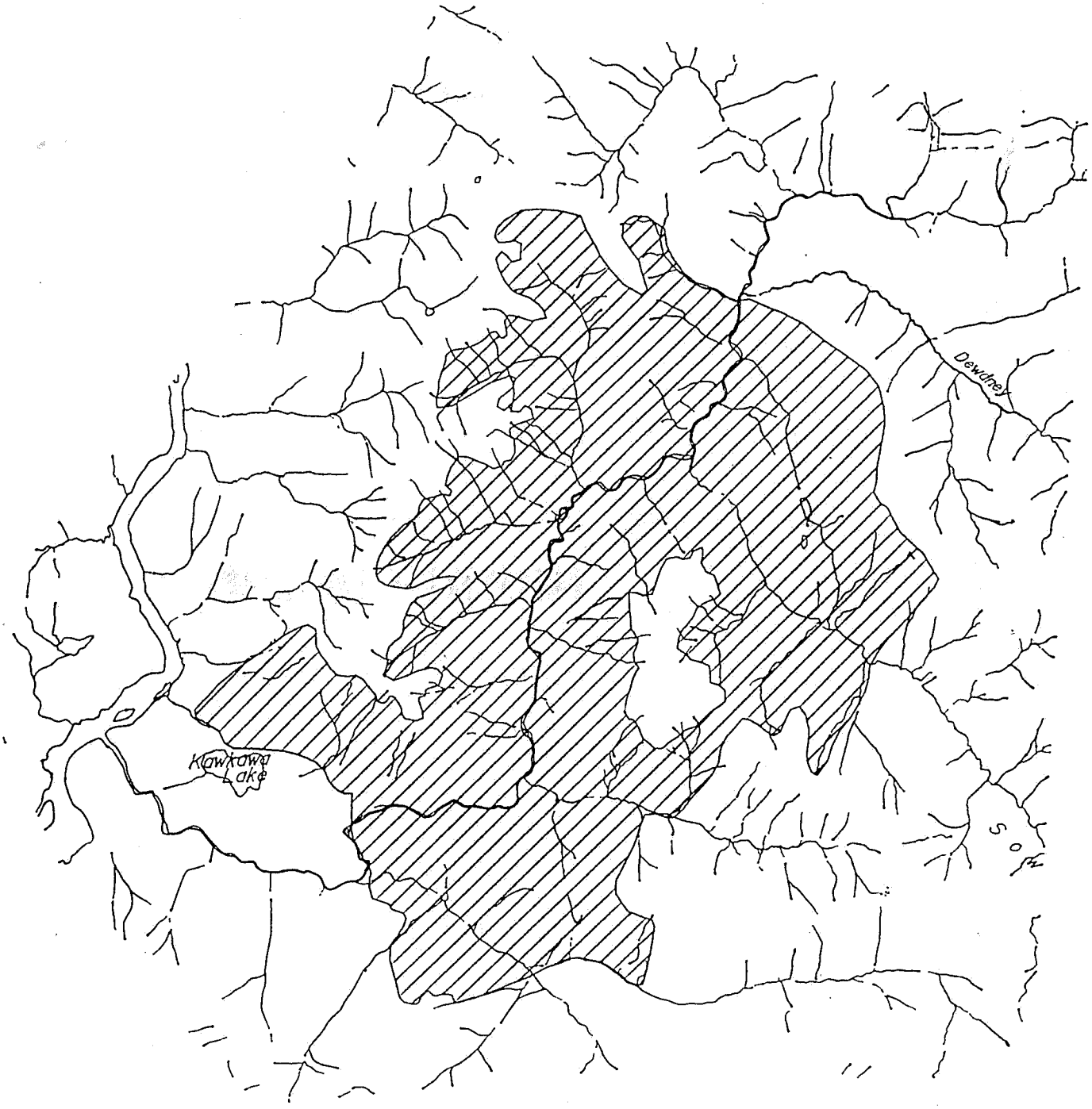
DATE: SEPT. 1993

SOWAQUA AND COQUIHALLA

SCALE: 1:125,000

DATE: SEPT. 1993



SASQUATCH

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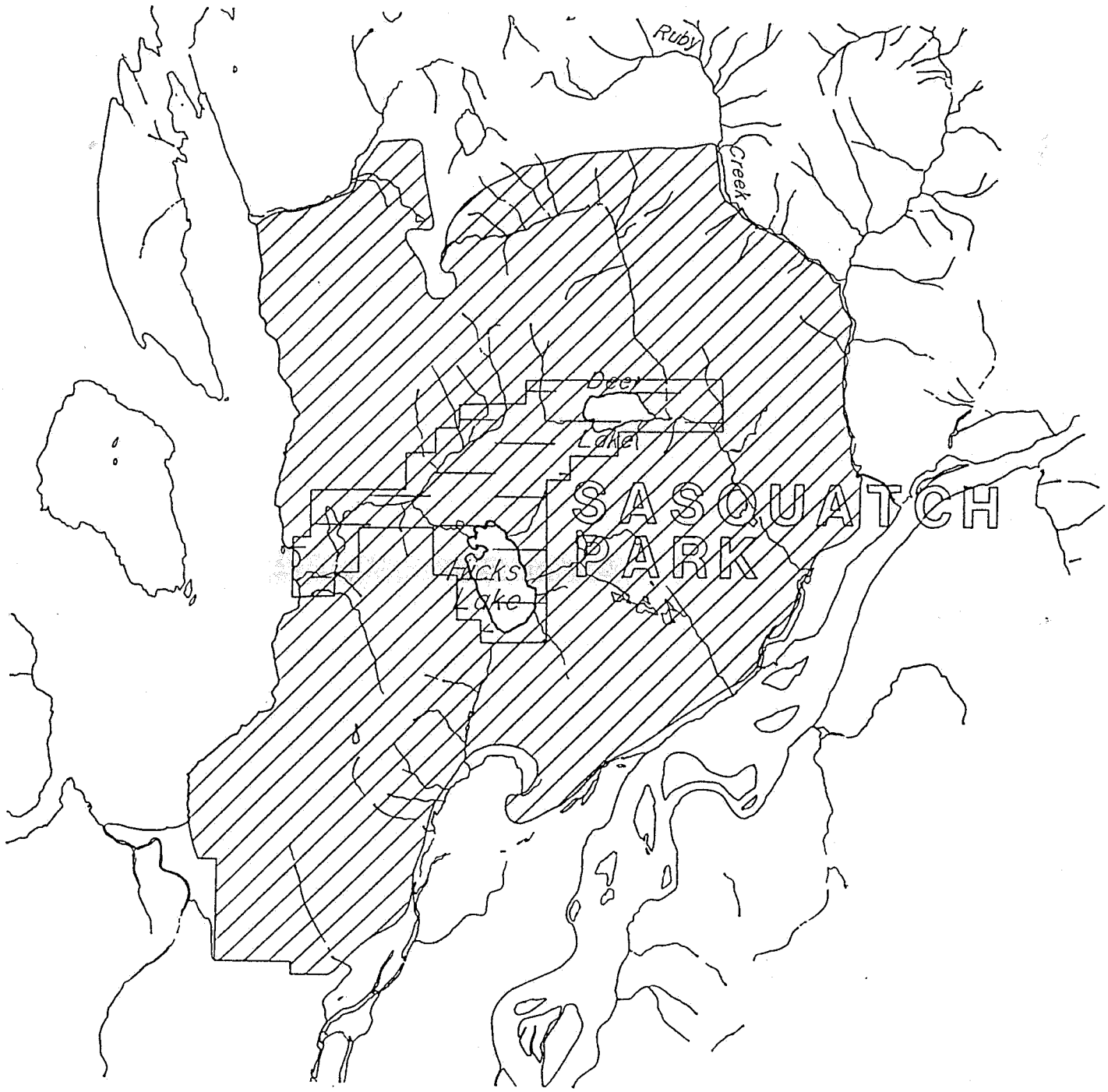


CHEHALIS AND STATLU

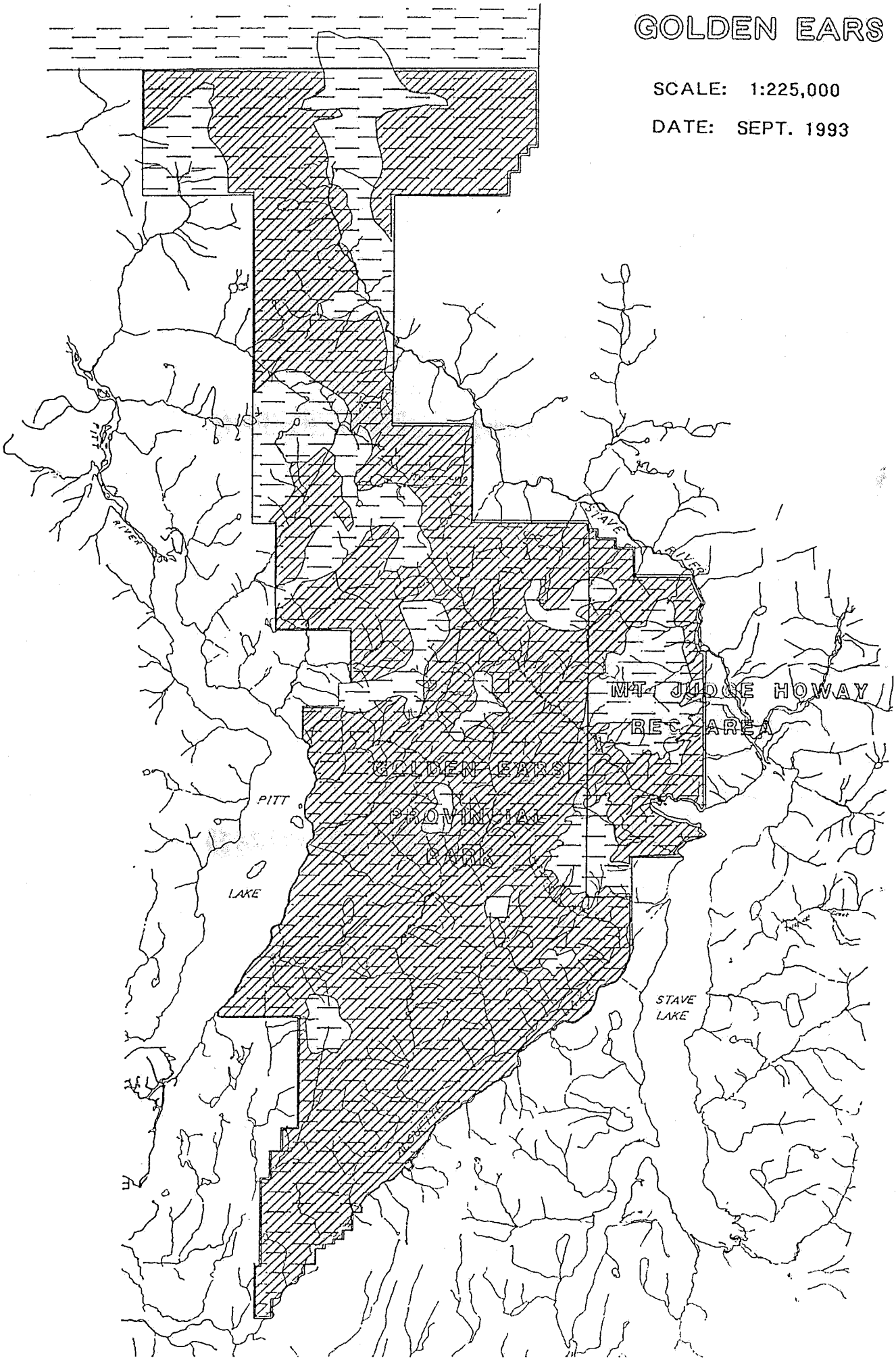
SCALE: 1:125,000

DATE: SEPT. 1993

GOLDEN EARS

SCALE: 1:225,000

DATE: SEPT. 1993



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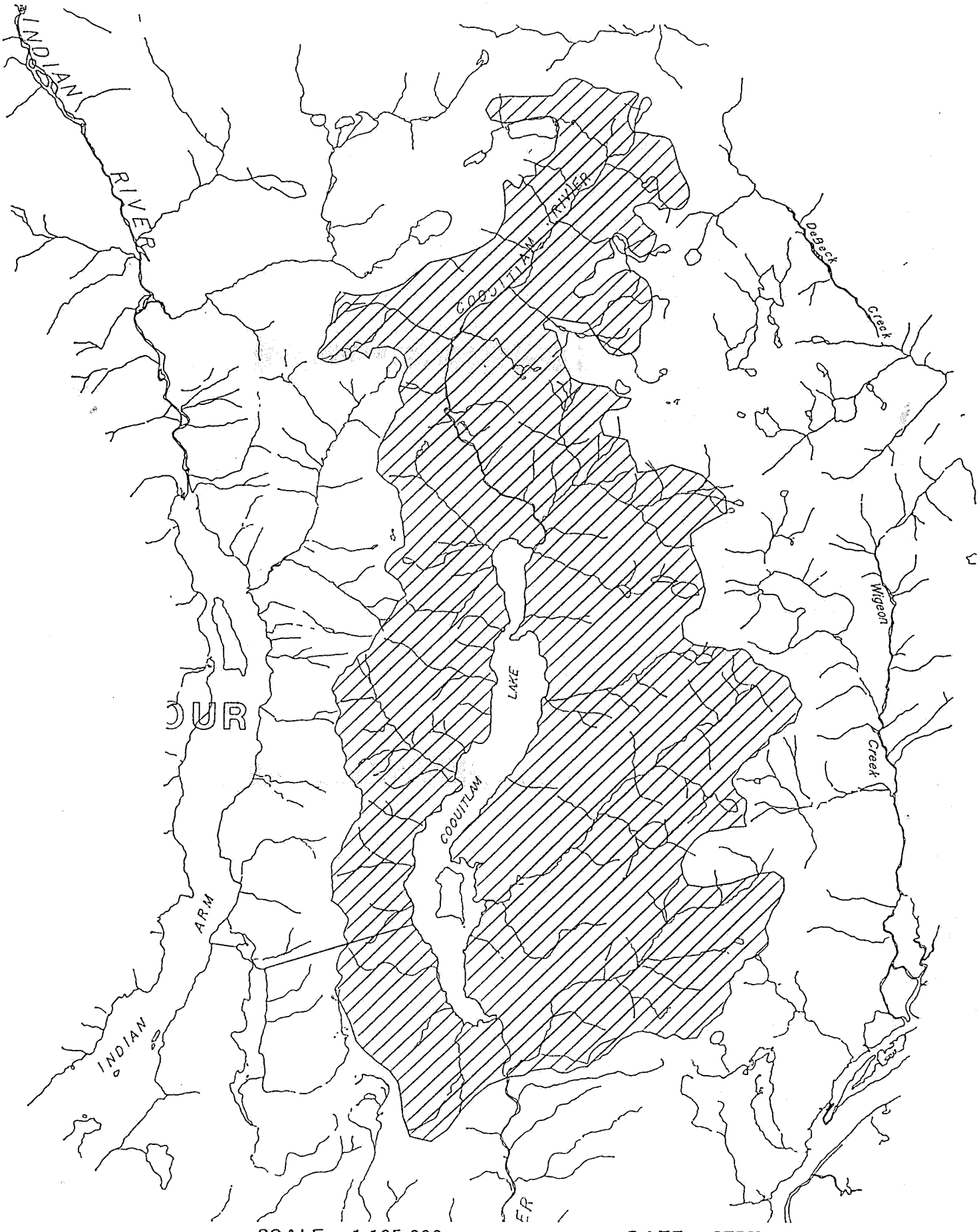

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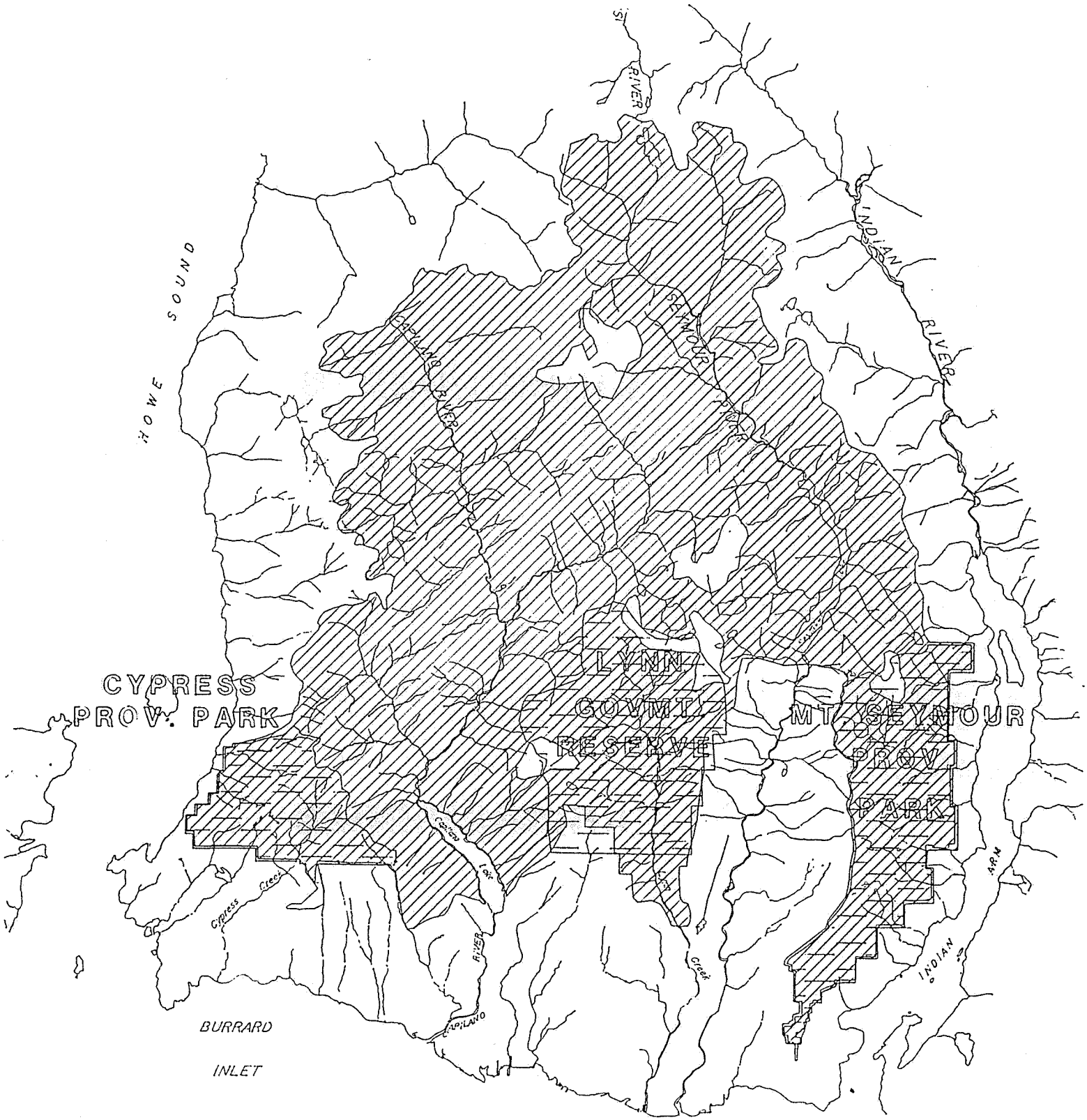

CAPILANO AND SEYMOUR

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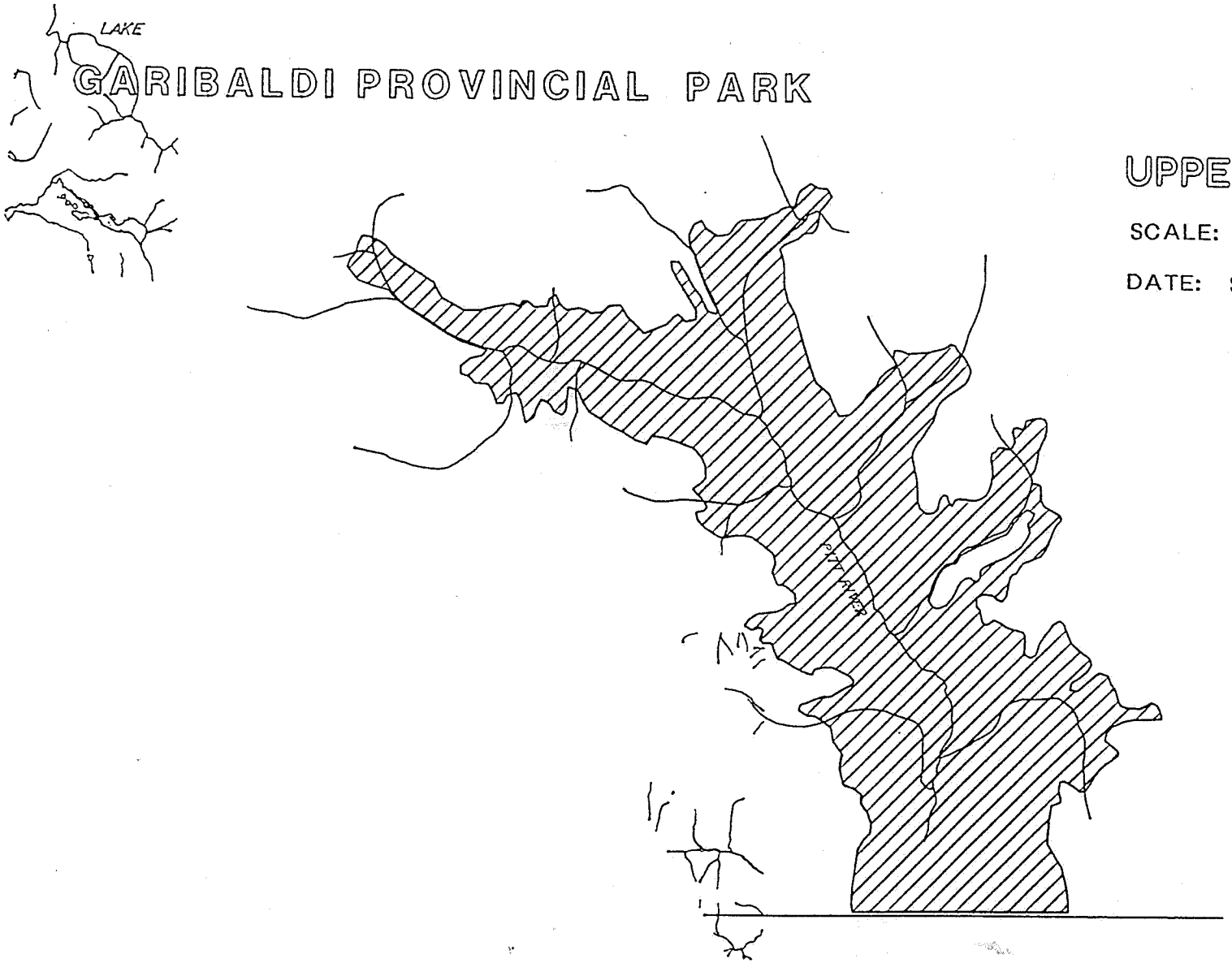

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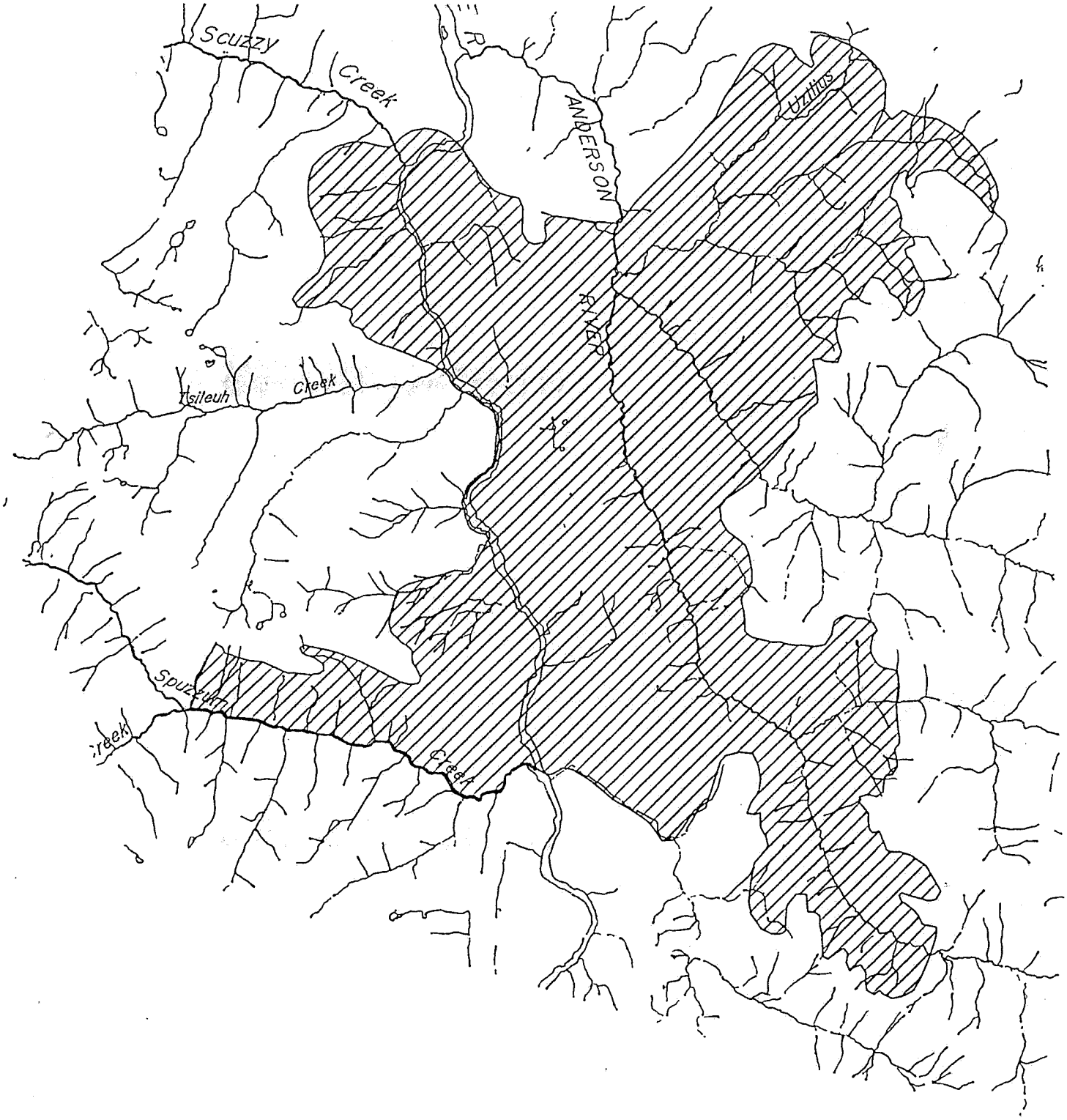

ANDERSON AND UZTLIUS

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HORNET AND CLEAR

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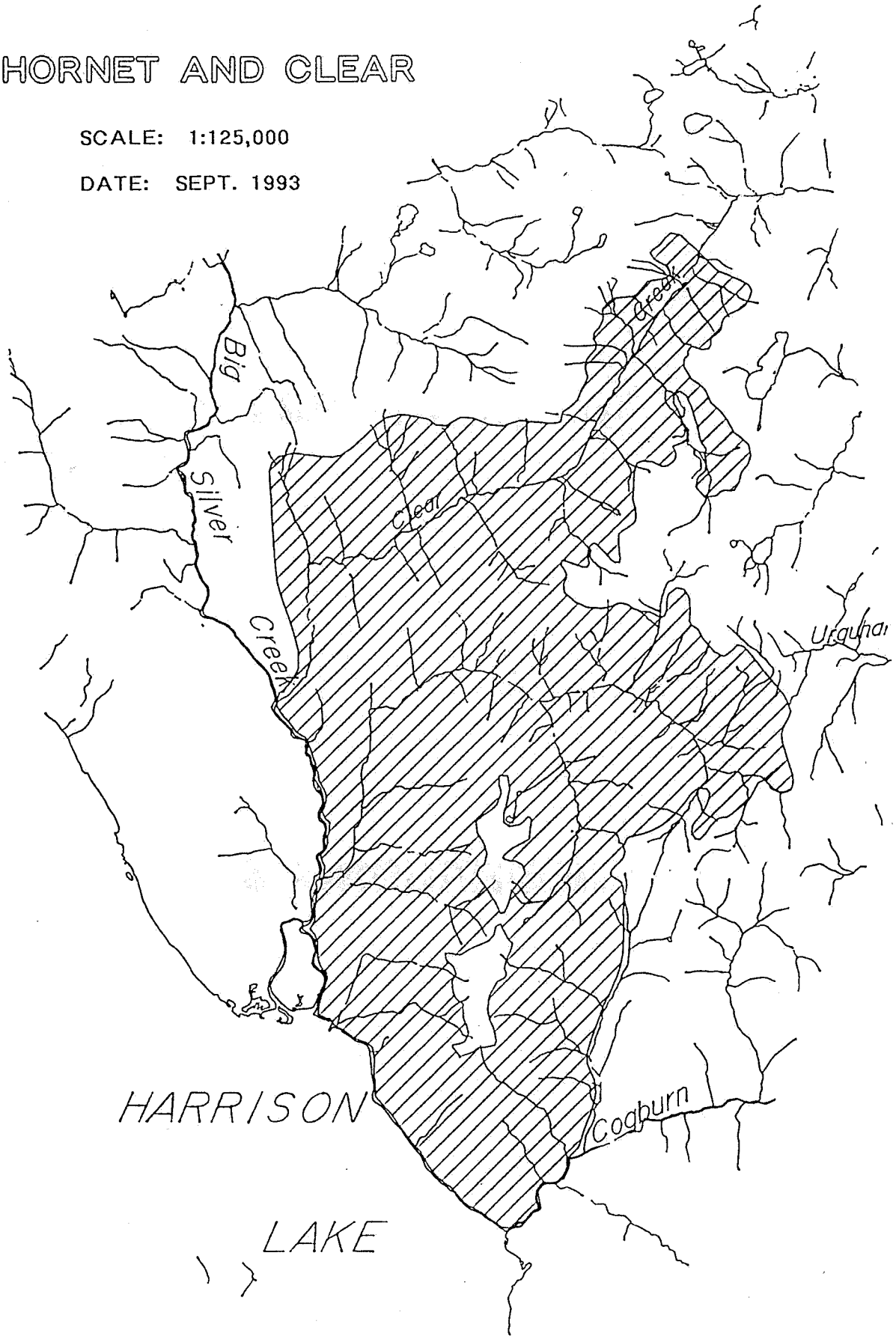
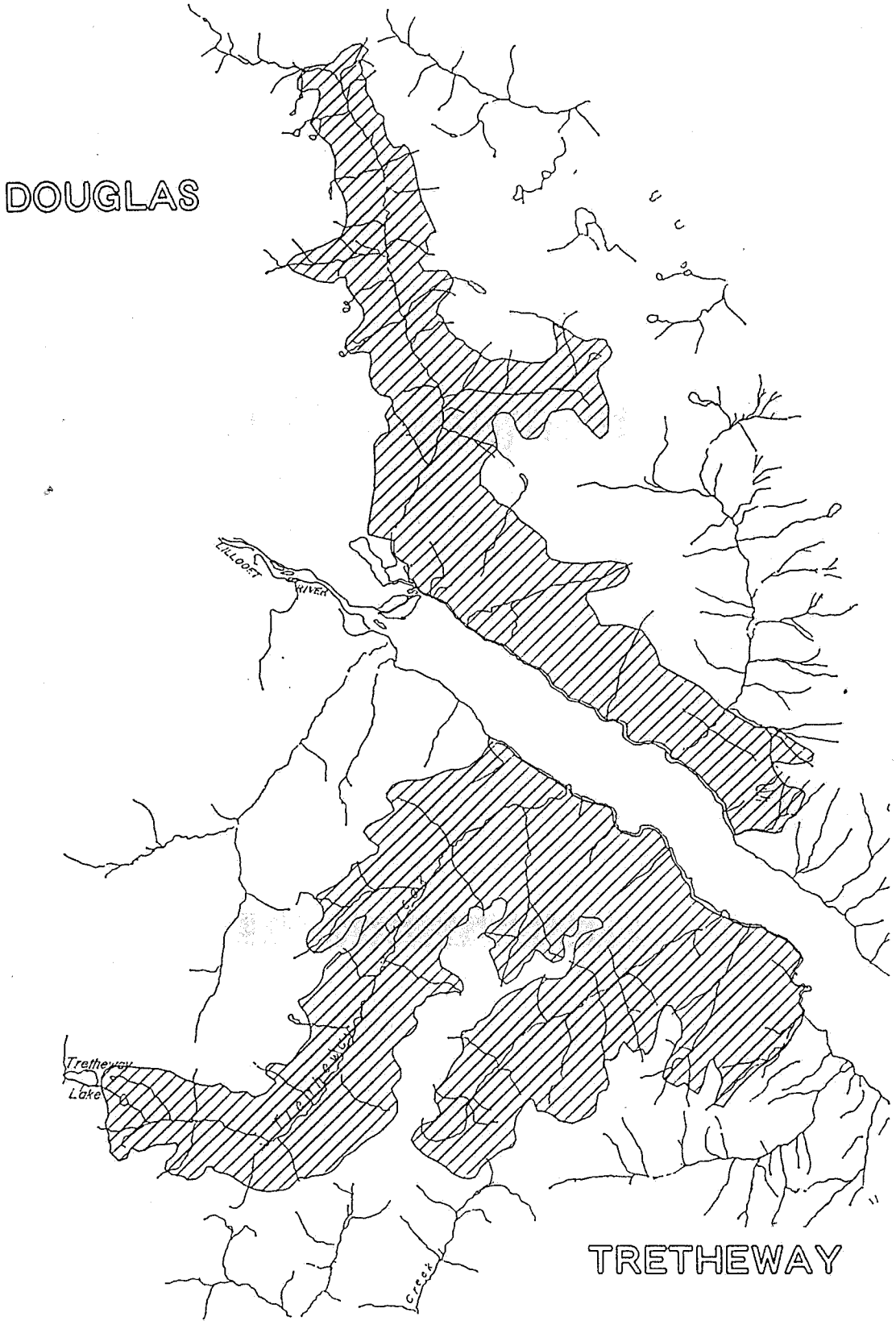
DATE: SEPT. 1993





SCALE: 1:180,000

DATE: SEPT. 1993

GLACIER AND TUWASUS

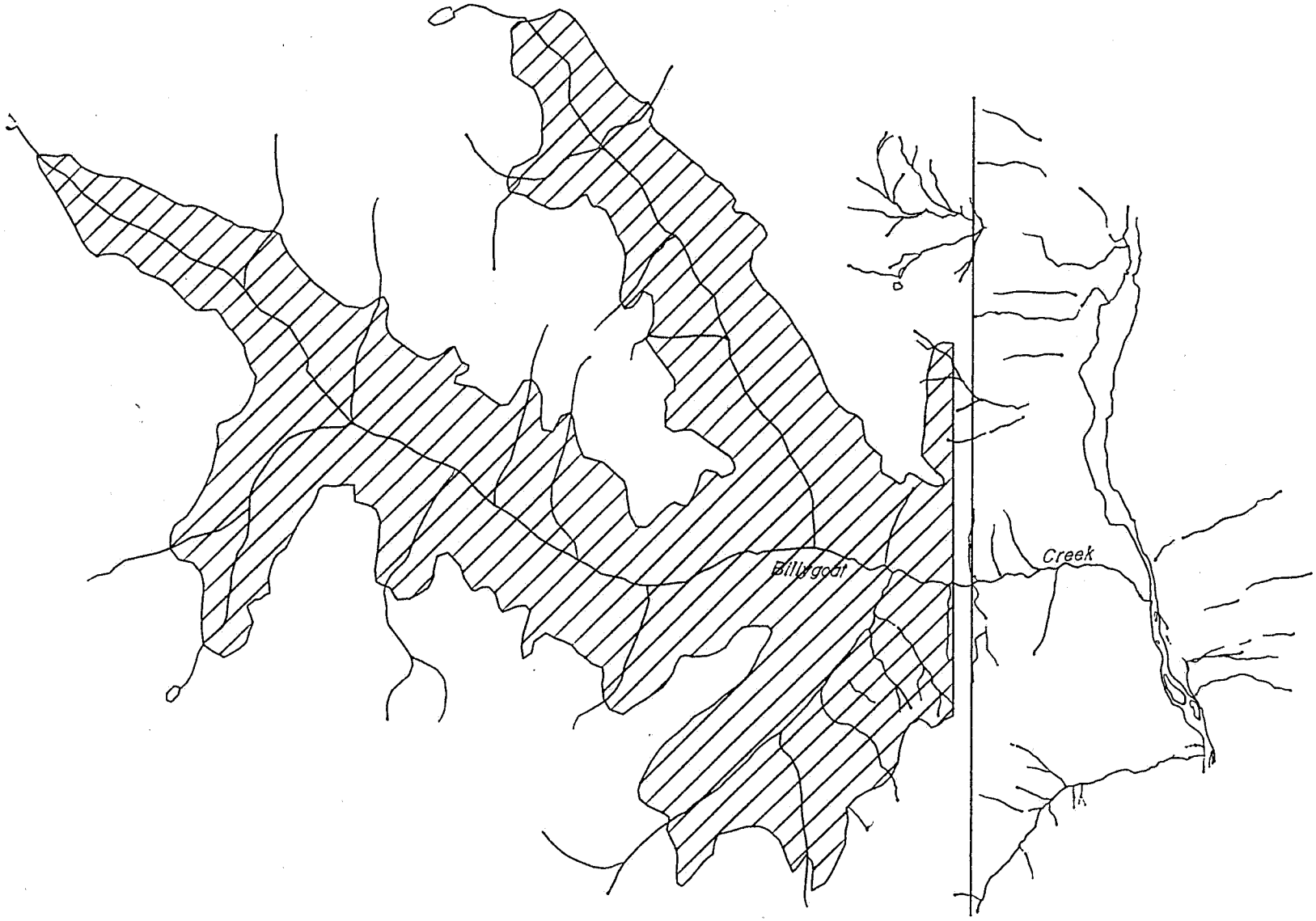
SCALE: 1:200,000

DATE: SEPT. 1993

BILLYGOAT

SCALE: 1:100,000

DATE: SEPT. 1993



LILLOOET

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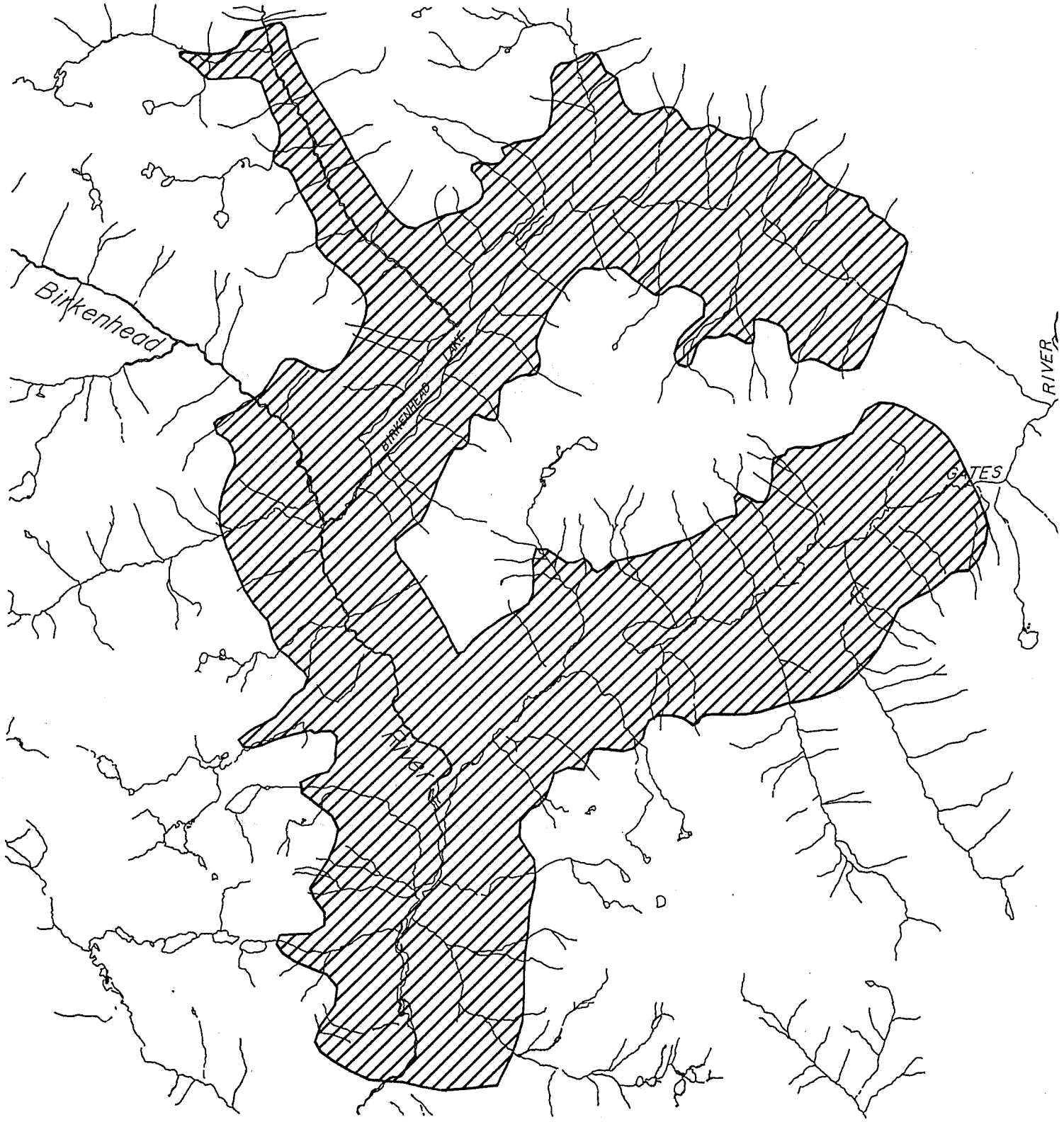

BIRKENHEAD RIVER

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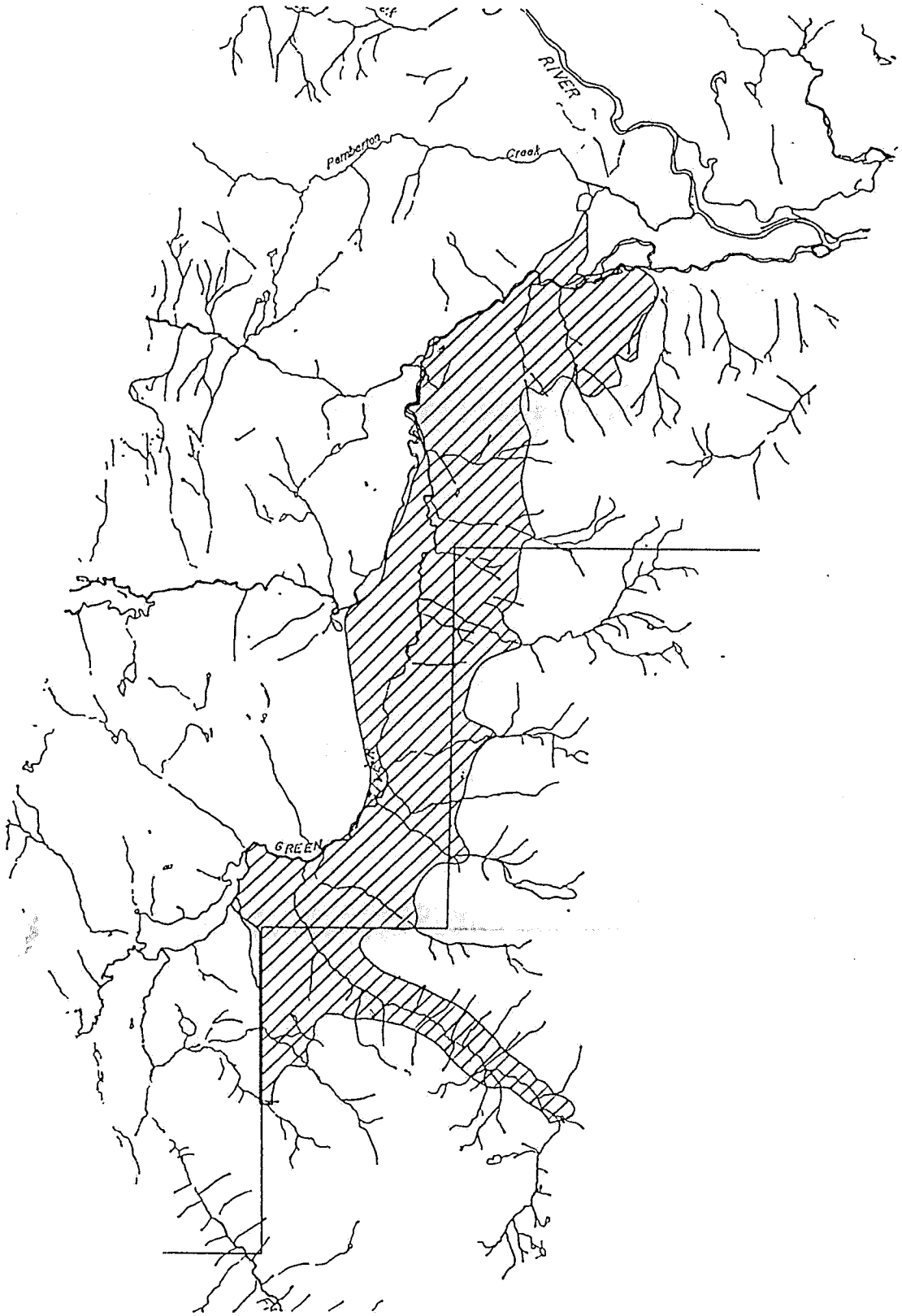

WEDGE AND GREEN

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DATE: SEPT. 1993

CHEAKAMUS

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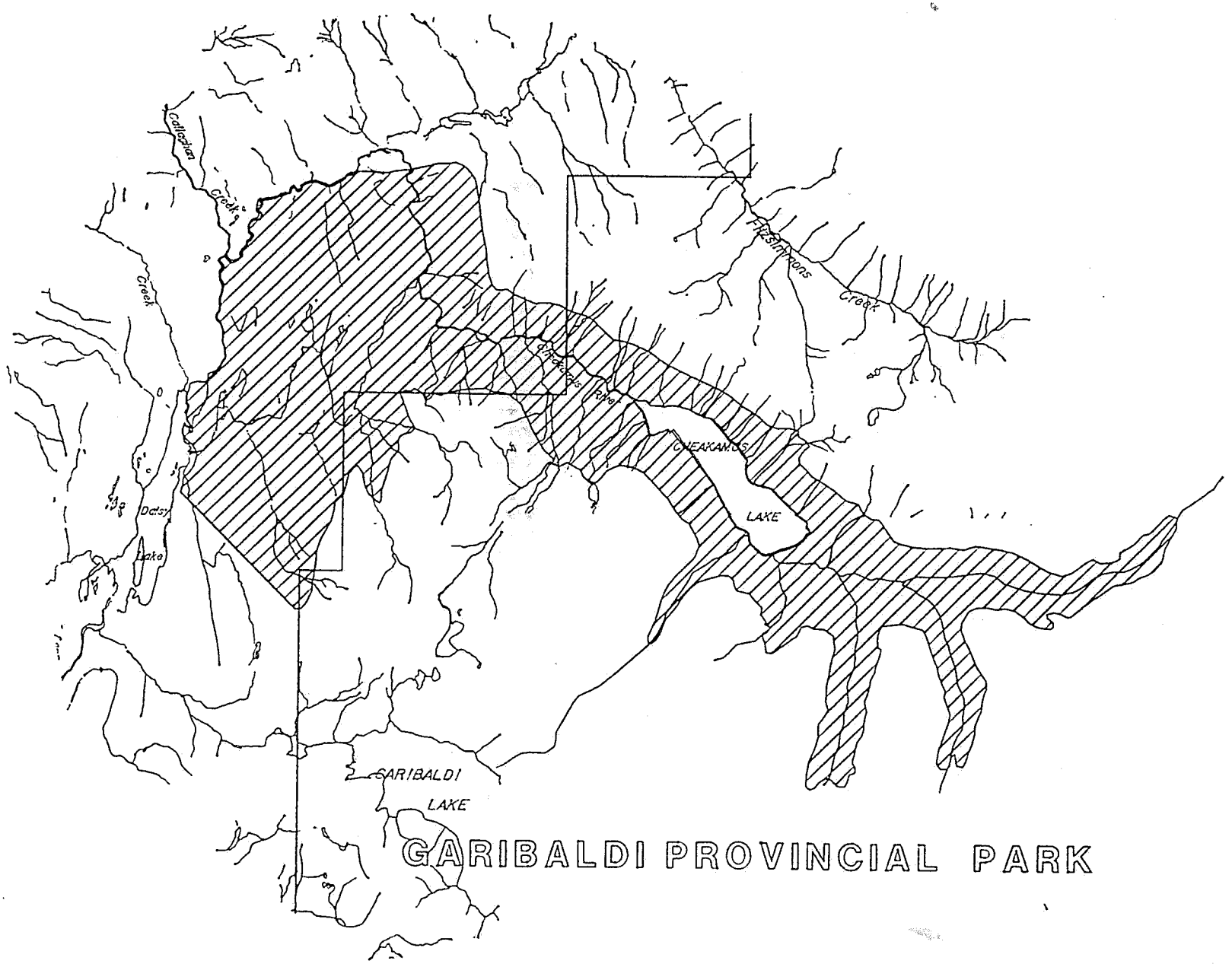
DATE: SEPT. 1993



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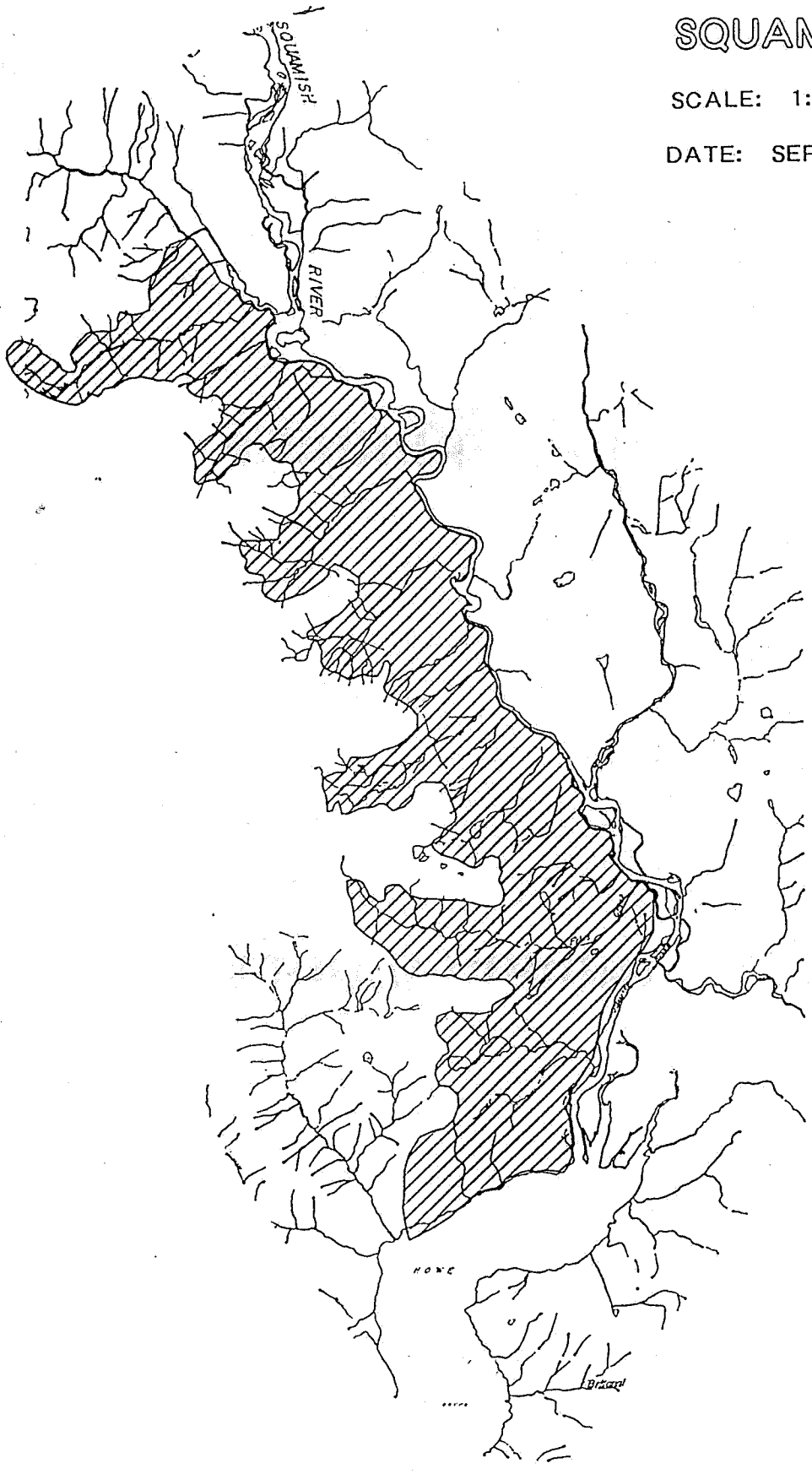

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Shaffer, M.L. 1985. The metapopulation and species conservation: the special case of the northern spotted owl. Pages 86-89 in R.J. Gutiérrez and A.B. Carey (Eds.). Ecology and Management of the Spotted Owl in the Pacific Northwest. US Forest Service General Technical Report PNW-185.

Appendix E: Example Guidelines for Silviculture and Salvage

These guidelines are extracted largely from FEMAT (1993). The following is an adaptation the guidelines in the Final Draft Recovery Plan for the Spotted Owl (USDI 1992).

Guidelines for Silviculture

The primary objective of silvicultural activities in Spotted Owl Conservation Areas (SOCAs) is to improve habitat in younger forests. These activities are encouraged if it can be shown that the development of suitable owl habitat conditions will be accelerated. General guidelines for silvicultural activities follow.

1. To safeguard the conservation benefits of SOCAs, silvicultural activities should be directed at young stands where stocking, structure, or composition will prevent or significantly retard development of suitable owl habitat conditions. This will generally include stands that are composed of trees less than 25 to 30 cm dbh, show no significant development of a multi-layered canopy stand structure, and were regenerated following timber harvest activity. There will be exceptions to these guidelines and judgement on stands to be managed will vary according to forest type and stand history.

2. Prescriptions to be used for each stand should be well thought out and documented. They will be designed to produce stand structure and components associated with suitable owl habitat conditions. These components include large trees; snags; downed and coarse woody debris; and dense, multi-layered canopies. Prescriptions should show the treatments to be applied and the anticipated effects on the stand over time. The prescription should identify key stand attributes or accomplishments that should be monitored.

3. Silvicultural activities must maintain or reduce risk of large-scale natural disturbances. For example, activities should not be implemented if they significantly increase the risk of windthrow in a stand.

4. To promote suitable owl habitat structures in the stand to be thinned, prescriptions will provide for leaving some trees as snags and others as downed wood. Those trees not needed for habitat development may be removed for commercial or fuel hazard reasons.

5. Key attributes of suitable owl habitats is their diversity and variability on individual sites and from site to site. To promote diversity and variability, a wide range of silvicultural practices should be applied, as opposed to a reliance on a limited variety of techniques.

Guidelines for Salvage

Salvage is defined as the removal of trees from an area following a stand-replacing event caused by wind, fires, insect infestation, volcanic eruptions or diseases. Salvage guidelines are intended to prevent negative effects on suitable owl habitat.

Tree mortality is a natural process in a forest ecosystem. Diseased and damaged trees are key structural attributes of suitable owl habitat. Accordingly, management planning for owl habitat must acknowledge the considerable value of retaining dead and dying trees in the forest as well as the benefits from salvage activities.

In all cases, planning for salvage should focus on long-range objectives, which are based on desired future conditions of the forest. Since SOCAs have been established to provide high quality habitat for spotted owls and other species associated with old forests, management following a stand-replacing event should be designed to accelerate or not impede the development of those conditions.

The following guidelines are general.

1. The potential for benefit for spotted owls and other species associated with old forest conditions from salvage is greatest when stand-replacing events are involved. Salvage in small disturbed sites is not appropriate because small forest openings are an important component of old forests. Salvage is not permitted in disturbed sites that are less than 40 ha in size. In addition, salvage should occur only in stands where disturbance has reduced canopy closure to less than 40%, as stands with more closure are likely to provide some value to spotted owls and other species associated with old forests.

2. Surviving trees will provide a significant residual of larger trees in the developing stand. In addition, defects caused by fires in residual trees may accelerate development of structural characteristics suitable for spotted owls and other species associated with old forests. Also, those damaged trees that will eventually die will provide additional snags. Consequently, all standing live trees should be retained, including those injured but likely to survive. Inspection of the cambium layer can provide an indication of

potential tree mortality.

3. Snags provide a variety of habitat benefits for a variety of wildlife species associated with old forests. Accordingly, following stand-replacing disturbance, management should focus on retaining snags that are likely to persist until suitable owl habitat conditions have developed and the new stand is again producing large snags. Suitable owl conditions are not associated with stands less than 80 years old.

4. Following a stand replacing disturbance, management should retain adequate coarse woody debris quantities in the new stand so that in the future it will still contain amounts similar to naturally regenerated stands.

5. Some salvage that does not meet the preceding guidelines will be allowed when salvage is essential to reduce the future risk of fire or insect damage to suitable owl habitat conditions. It is important to understand that some risk associated with fire and insects is acceptable because they are natural forces influencing suitable owl habitat development. Consequently, salvage to reduce such risks should focus only on those areas where there is a high likelihood of large scale disturbance.

6. Removal of snags and logs may be necessary to reduce hazards to humans along roads and trails and in or adjacent to campgrounds. Leaving material on sites should be considered where available coarse woody debris is inadequate.

7. Logs present on the forest floor before a disturbance event provide habitat benefits that are likely to continue. It seldom will be appropriate to remove them.

8. Some deviation from these general guidelines may be allowed to provide reasonable access to salvage sites and feasible logging operations. Such deviations should occur on as small a portion of the area as possible, and should not violate the basic intent of maintaining and creating suitable owl habitat. Although some exceptions to the guidelines may be allowed to provide access, some salvage opportunities will undoubtedly be foregone because of access, feasibility and safety concerns.

Appendix F: Participants and results of the Biological Assessment Team - February 1, 1994

Moderator: Fred Bunnell - Centre for Applied Conservation Biology, University of B.C.

Panellists:

Eric Forsman	U.S. Forest Service Corvallis, Oregon
Dave Hays	Washington Dept of Wildlife Olympia, Washington
Ken Lertzman	Simon Fraser University Burnaby, British Columbia
Joe Lint	Bureau of Land Management Roseburg, Oregon
Chuck Meslow	Oregon Cooperative Wildlife Research Unit Corvallis, Oregon
Carl Walters	University of B.C. Vancouver, British Columbia

Technical Advisors:

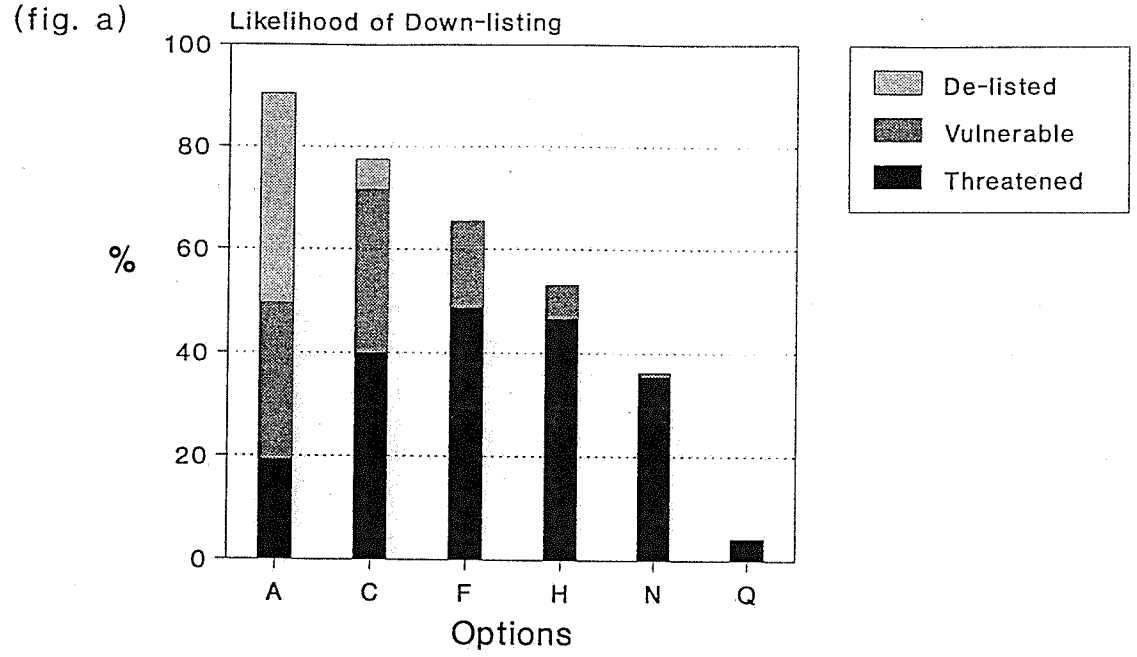
Ian Blackburn	Scientific Advisor to SORT - B.C. Environment
Derek Bonin	Greater Vancouver Watershed District
Dennis Demarchi	BC Environment
Dave Dunbar	SORT Chair - B.C. Environment
Bill Harper	SORT - B.C. Environment
David Johnson	Oregon Dept Fish & Wildlife
Gene MacInnes	BC Ministry of Forests - Chilliwack Forest District
Rhonda Milliken	SORT - Canadian Wildlife Service
Bill Rosenburg	SORT - B.C. Council of Forest Industries
Rob Thomson	SORT - B.C. Ministry of Forests
Astrid Van Woudenberg	SORT - Northwest Wildlife Preservation Society
Marty Vaughn	Beak Consultants Ltd
Mike Wallace	BC Ministry of Forests - Squamish Forest District

Recorder: Dawn Jackson - B.C. Environment

Table 1. Mean scores of the biological assessment of options.

	Option A	Option C	Option F	Option H	Option N	Option Q
British Columbia Only						
Extirpated	1	2	3	5	11	50
Endangered	9	20	31	42	53	46
Threatened	19	40	49	47	35	4
Vulnerable	30	32	17	6	1	0
De-listed	41	6	0	0	0	0
Total	100	100	100	100	100	100
Including United States						
Extirpated	0	1	1	2	7	33
Endangered	7	13	26	37	46	56
Threatened	15	36	53	50	41	11
Vulnerable	33	42	20	11	6	0
De-listed	45	8	0	0	0	0
Total	100	100	100	100	100	100

Figure X. Likelihood of Risks - BC Population Isolated from US Population



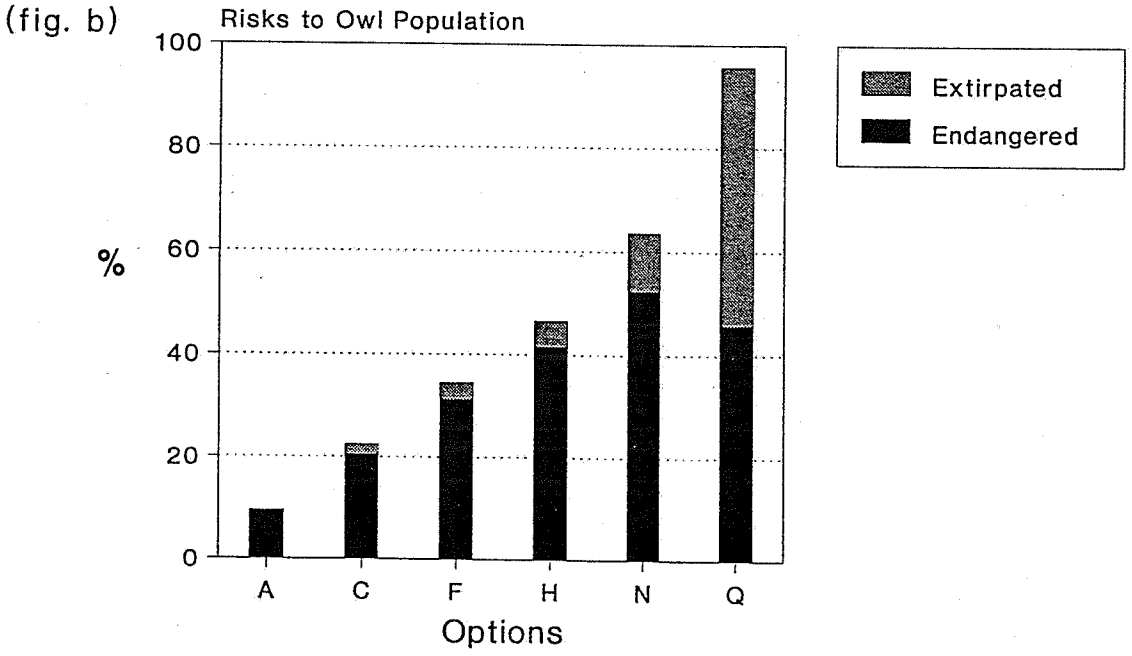
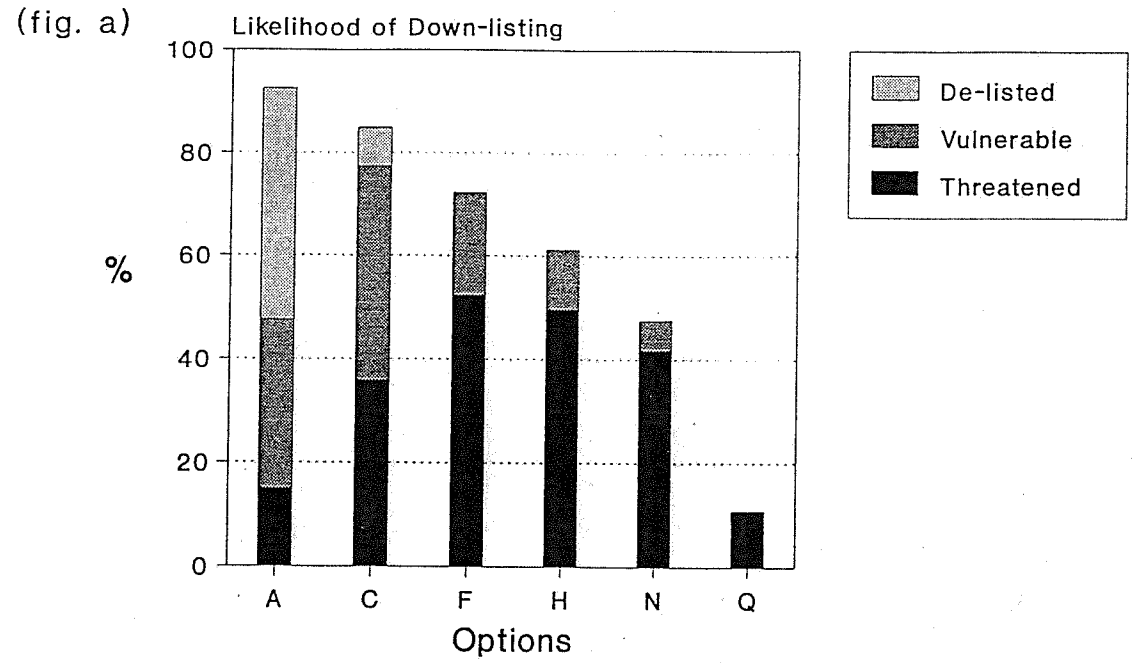
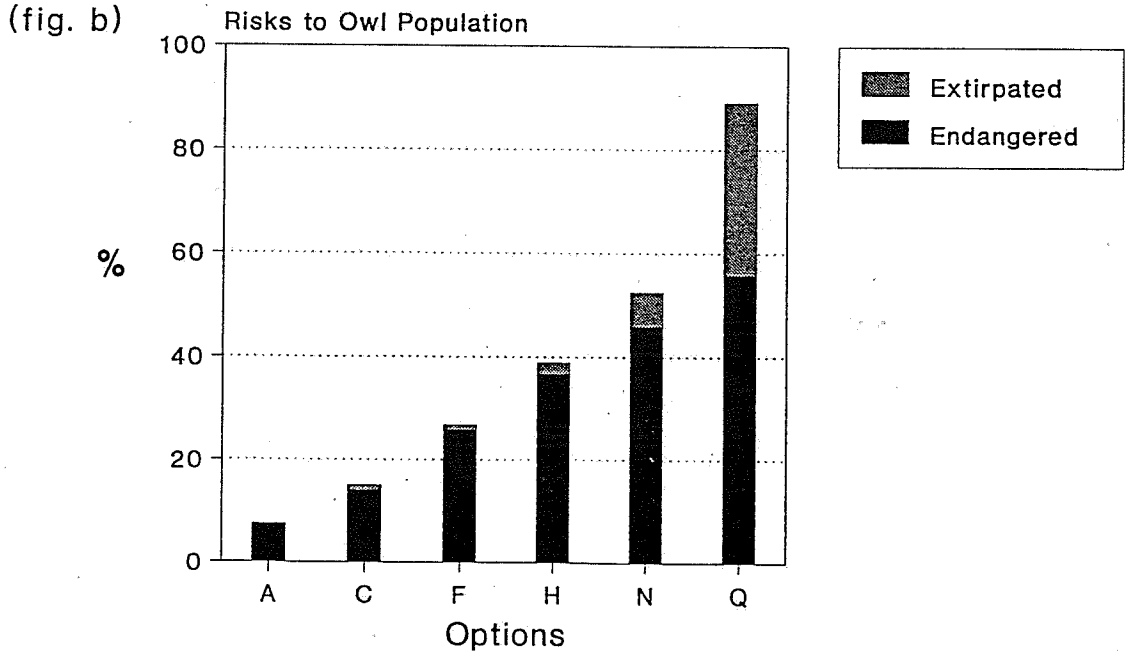


Figure Y. Likelihood of Risks - BC Population Connected with US Population





VII. GLOSSARY

Active owl site

An area where there has been a recent (< 5 years) observation of a single owl or pair of spotted owls. This may include confirmed and unconfirmed resident owls.

Adaptive management

A process of implementing policy decision as scientifically driven management experiments that test predictions and assumptions in management plans, and using the resulting information to improve the plan (USDI 1992).

Biodiversity

The variety of organisms considered at all levels, from genetic variants belonging to the same species through arrays of species to arrays of genera, families, and still higher taxonomic levels; includes the variety of ecosystems , which comprise both the communities of organisms within particular habitats and the physical conditions under which they live. (Wilson 1992)

Biogeoclimatic classification

A system of ecological classification based on a floristic hierarchy of plant associations (Pojar *et al.* 1987).

Biological diversity

See *biodiversity.*

Blowdown

Trees felled by high wind (USDI 1992).

Canopy

A layer of foliage in a forest stand. This most often refers to the uppermost layer of foliage, but it can be used to described lower layers in a multi-storied stand (USDI 1992).

Clear-cut

An area where the entire stand of trees has been removed in one cutting (USDI 1992).

Cluster

An area that contains habitat capable of supporting three or more breeding pairs of spotted owls within overlapping or nearly overlapping home ranges (Thomas *et al.* 1990).

Co-evolution

The evolution of two or more species due to mutual influence; for example, many species of flowering plants and their insect pollinators have co-evolved in a way that makes the relationship more effective. (Wilson 1992)

Colonization

The establishment of a species in an area not currently occupied by that species. Colonization often involves dispersal across an area of unsuitable habitat (USDI 1992).

Community

All the organisms - plants, animals, and microorganisms - that live in a particular habitat and affect one another as part of the food web or through their various influences on the physical environment. (Wilson 1992)

Competitive exclusion

The extinction of one species by another in a habitat through competition. (Wilson 1992)

Confirmed owl site

Confirmation of a resident owl site involves either 1) the presence of an owl within the same general area on 3 or more occasions within a breeding season, 2) the location of an owl nest or 3) by multiple owl responses over several years from the same general area (USDI 1991).

Conifer

A tree belonging to the order of Gymnospermae, comprising a wide range of trees that are mostly evergreen (USDI 1992).

Connectivity

A measure of the extent to which intervening habitat truly connects SOCAs for juvenile spotted owls dispersing among them (adopted from USDI 1992).

Contiguous habitat

Habitat suitable to support the life needs of owls that is distributed continuously or nearly continuously across the landscape (USDI 1992).

Corridor

A defined tract of land, usually linear, through which a species must travel to reach habitat suitable for reproduction or other life-sustaining needs (USDI 1992).

Critical habitat	Specific areas within the geographical area occupied by a species on which are found those physical or biological features essential for the conservation of the species (USDI 1992).
Coarse woody debris	Portions of a tree that has fallen or been cut and left in the woods (USDI 1992).
Demography	The study of birth rates, death rates, age distributions, sex rations, and size of populations - a fundamental discipline within the large field of ecology. Also the properties themselves, as in the demography (demographic traits) of a particular population. (Wilson 1992)
Density	The number or size of a population in relation to some unit of space.It is usually expressed as the number of individuals per unit area (USDI 1992).
Designated Management Area (DMA)	Delineations of habitat to maintain existing and/or future populations of spotted owls.
Dispersal	The movement, usually one direction and on any time scale, of plants and animals from their point of origin to another location where they subsequently produce offspring (USDI 1992).
Dispersal habitat	Habitat that supports the life needs of an individual animal during dispersal. Generally satisfies needs for foraging, roosting and protection from predators (USDI 1992).
Distribution (of a species)	The spatial arrangement of a species within its range (USDI 1992). This may be synonymous with its range or it may be specific to the habitat type in which it occurs within its range.
Disturbance	A significant change in structure and/or composition caused by natural events such as fires and wind or human-caused events such as cutting (USDI 1992).

Downed log — Portion of a tree that has fallen or been cut and left in the woods (USDI 1992).

Ecology — The scientific study of the interaction of organisms with their environment, including the physical environment and the organisms living in it. (Wilson 1992)

Ecoregion classification — A ecological classification that delineates large units of land representing areas with similar climatic processes, physiography, vegetation zonation, and wildlife potential. Units are mapped in a hierarchical structure from ecodomain (global), ecodivision (continental), ecoprovince (subcontinental), ecoregion (provincial), to ecosection (regional). (Demarchi et al. 1990)

Ecosystem — The organisms living in a particular environment, such as a lake or forest (or, in increasing scale, and ocean or the whole planet), and the physical part of the environment that impinges on them. The organisms alone are called the community. (Wilson 1992)

Ecosystem services — The role played by organisms in creating a healthful environment for human beings, from production of oxygen to soil genesis and water detoxification. (Wilson 1992)

Empirical — Derived from direct observation or experimentation (USDI 1992).

Endangered species — An indigenous species, subspecies, or geographically separate population that is threatened with imminent extirpation or extinction throughout all or a significant portion of its range. (COSEWIC 1993)

Extended rotation — A period of years that is longer than the time necessary to grow timber crops to a specific condition of maturity (USDI 1992).

Extinct species

An indigenous species, subspecies, or geographically separate population formerly indigenous to Canada that no longer exists anywhere. (COSEWIC 1993)

Extinction

The termination of any lineage of organisms, from subspecies to species and higher taxonomic categories from genera to phyla. Extinction can be local, in which one or more populations of a species or other unit vanish but others survive elsewhere (see *extirpated*), or total (global), in which all the populations vanish. When biologists speak of extinction of a particular species without further qualification, they mean total extinction. (Wilson 1992)

Extirpated species

An indigenous species, subspecies, or geographically separate population no longer known to exist in the wild in Canada, but occurring elsewhere. (COSEWIC 1993)

Floaters

Nonbreeding adults and subadults that move and live within a breeding population, often replacing breeding adults that die; nonterritorial individuals (USDI 1992).

Forest fragmentation

The change in the forest landscape, from extensive and continuous old forest to a mosaic of younger stand conditions (USDI 1992).

Guideline

A policy statement that is not a mandatory requirement (USDI 1992).

Home range

The area within which an animal conducts its activities during a defined period of time[1] (USDI 1992).

Hybrid

An offspring that results from the mating of individuals of different races or species (USDI 1992).

Hybridization

The crossing or mating of two different varieties of plants or animals (USDI 1992).

Immigration	Movement of individuals into a population (USDI 1992).
Inbreeding	Mating or crossing of individuals more closely related than average pairs in the population (USDI 1992).
Interspecific competition	The condition of rivalry that exists when a number of organisms of different species use common resources that are in short supply, the condition that occurs when the organisms seeking that resource nevertheless harm one or another in the process. Competition usually is confined to closely related species that eat the same sort of food or live in the same sort of place. Competition typically results in ultimate elimination of the less effective organism from that ecological niche (USDI 1992).
Isolate	A population that is isolated (USDI 1992).
Isolation	Absence of genetic crossing among populations because of distances or geographic barriers (USDI 1992).
Juvenile	For spotted owls, a juvenile is normally considered to be any bird that is less than one year old (USDI 1992).
Keystone species	A species, such as the sea otter, that affects the survival and abundance of many other species in the community in which it lives. Its removal or addition results in a relatively significant shift in the composition of the community and sometimes even in the physical structure of the environment. (Wilson 1992)
Landscape	A heterogenous land area with interacting ecosystems that are repeated in similar form throughout (USDI 1992).
Managed forest	Any forested land that is treated with silvicultural practices and/or harvested. Generally applied to land that is harvested on a scheduled basis and

	contributes to an allowable sale quantity (USDI 1992).
Marginal owl habitat	Vegetative communities, usually forest stands, that may provide for spotted owl life needs at least intermittently. Other times, depending on other environmental factors, the life needs of spotted owls would not be met. A landscape of predominately marginal owl habitat would not be thought to sustain a viable population of spotted owls (FEMAT 1993).
Mature stand	A mappable stand of trees for which the annual net rate of growth has peaked. Stands are generally greater than 80-100 years old and less than 180-200 years old. Stand age, diameter of dominant trees and stand structure at maturity vary by forest cover types and local site conditions. Mature stands generally contain trees with smaller average diameter, less age class variation and less structural complexity than old stands of the same forest type. Mature stages of some forest types are suitable habitat for spotted owls. However, mature forests are not always spotted owl habitat, and spotted owl habitat is not always mature forest (FEMAT 1993).
Meta-population	A population comprising local populations that are linked by migrants, allowing for recolonization of unoccupied habitat patches after extirpation events (USDI 1992).
Monitoring	The process of collecting information to evaluate if objectives and anticipated or assumed results of a management plan are being realized or if implementation is proceeding as planned (FEMAT 1993).
Multi-layered canopy	Forest stands with two or more distinct tree layers in the canopy (FEMAT 1992).

Old-growth forest

A forest stand with moderate to high canopy closure; a multi-layered, multi-specied canopy dominated by large overstory trees; a high incidence of large trees with large, broken tops and other indications of decadence; numerous large snags; and heavy accumulations of logs and other woody debris on the ground (USDI 1992).

Old-growth forest species

Plant and animal species that exhibit a strong association with old forests (USDI 1992).

Overstory

Trees that provide the uppermost layer of foliage in a forest with more than one layer of canopy (USDI 1992).

Owl Detection

Each owl observed either by sound or sight during a survey.

Owl site

Any site where there has been a recent or historic observation of a single or pair of spotted owls (USDI 1992).

Population viability

Probability that a population will persist for a specified period of time across its range despite normal fluctuations in population and environmental conditions (USDI 1992).

Potential habitat

A stand of trees of a vegetation type used by spotted owls that is not currently suitable, but is capable of growing or developing into suitable habitat in the future. In general, potential habitats are stands in an earlier successional stage of forest types used by spotted owls (USDI 1992).

Predator

Any animal that preys externally on others, ie. that hunts, kills and generally feeds on a succession of hosts, ie. the prey (USDI 1992).

Radio-telemetry

Automatic measurement and transmission of data from remote sources via radio to a receiving station for recording and analysis. In this document, it refers to the tracking of spotted owls by means of small radio transmitters attached to them (USDI

1992).

Range — The geographic area or region over which an organism occurs (USDI 1992).

Recovery — Action that is necessary to reduce or resolve the threats that caused a species to be listed as threatened or endangered (USDI 1992).

Recruitment — The addition to a population from all causes, i.e., reproduction, immigration, and stocking. Recruitment may refer literally to numbers born or hatched or to numbers at a specified stage of life such as breeding age or weaning age (USDI 1992).

Reforestation — The natural or artificial restocking of an area with forest trees; most commonly used in reference to artificial restocking (USDI 1992).

Refugia — Havens of safety where populations have high probability of surviving periods of adversity (USDI 1992).

Regeneration — The actual seedlings and saplings existing in a stand; or the act of establishing young trees naturally or artificially (USDI 1992).

Rescue effect — Immigration of new individuals sufficient to maintain a population that might otherwise decline toward extinction (USDI 1992).

Roost — The resting behaviour of an animal (USDI 1992).

Roost sites — A site where an animal roosts. Can refer to daytime and night-time roosting. Sites often provide protection from environmental conditions and from predators (USDI 1992).

Rotation — The planned number of years between the regeneration of an even-aged stand and its final cutting at a specified stage (USDI 1992).

Sapling — A loose term for a young tree no longer a seedling but not yet a pole. It is generally a few feet high and 2 to 4 inches dbh, typically growing vigorously and without dead bark or more than an occasional dead branch (USDI 1992).

Second-growth — Relatively young forests that have developed following a disturbance (for example, wholesale cutting, serious fire, or insect attack) of the previous old forest (USDI 1992).

Sexual dimorphism — The differences in size, weight, color, or other morphological characteristics that are related to the sex of the animal (USDI 1992).

Silviculture — The science and practice of controlling the establishment, composition, and growth of forests (USDI 1992).

Snag — A standing dead tree (USDI 1992).

Socioeconomic — Pertaining to, or signifying the combination or interaction of, social and economic factors (USDI 1992).

Species — A group of individuals that have their major characteristics in common and are potentially interfertile (USDI 1992).

Stand (tree stand) — An aggregation of trees occupying a specific area and sufficiently uniform in composition, age, arrangement, and condition as to be distinguishable from the forest in adjoining areas (USDI 1992).

Standards and guidelines — Standards and guidelines are the primary statement of direction for land managers. In the recovery plan, standards and guidelines are recommended as actions necessary to accomplish recovery (USDI 1992).

Stochastic — Random, uncertain; involving a random variable (USDI 1992).

Subadult — A young spotted owl that has dispersed but has not yet reached breeding age. Subadults are in their second, or in some cases, third year of life (USDI 1992).

Subpopulation — A well-defined set of interacting individuals that comprise a proportion of a larger, interbreeding population (USDI 1992).

Subspecies — A population of a species occupying a particular geographic area, or less commonly, a distinct habitat, capable of interbreeding with other populations of the same species (USDI 1992).

Successional stage — A stage or recognizable condition of a plant community that occurs during its development from bare ground to climax (USDI 1992).

Suitable habitat — In the recovery plan, an area of forest vegetation with the current age-class, species of trees, structure, sufficient area, and adequate food source to meet some or all of the life needs of the northern spotted owl (USDI 1992).

Suitable owl habitat — See suitable habitat.

Survivorship — The proportion of newborn individuals that are alive at a given age (USDI 1992).

Territorial single — An unpaired owl that is defending a territory (USDI 1992).

Territory — The area that an animal defends, usually during breeding season, against intruders of its own species (USDI 1992).

Thermoregulation — The physiological and biological process whereby an animal regulates its body temperature (USDI 1992).

Threatened species — An indigenous species, subspecies, or geographically separate population likely to become endangered in Canada if the factors affecting its vulnerability are not reversed. (COSEWIC 1993)

Understory

The trees and other woody species growing under a more or less continuous cover of branches and foliage formed collectively by the upper portions of adjacent trees and other woody growth (USDI 1992).

Uneven-aged management

The application of a combination of actions needed to simultaneously maintain continuous tall forest cover, recurring regeneration of desirable species, and the orderly growth and development of tress through a range of diameter or age classes. Cutting methods that develop and maintain uneven-aged stands are single-tree selection and group selection (USDI 1992).

Unsuitable habitat

Forested lands that currently do not meet the habitat needs of spotted owls for nesting, roosting, or foraging but are ecologically capable of doing so. This habitat is deficient in tree size, canopy closure, and/or stand decadence. It results from timber harvest or natural disturbance. Also referred to as 'potential habitat (USDI 1992).'

Viability

The ability of a population to maintain sufficient size so that it persists over time in spite of normal fluctuations in numbers; usually expressed as a probability of maintaining a specific population for a specified period (USDI 1992).

Viable population

A population that contains an adequate number of individuals appropriately distributed to ensure the long-term existence of the species (USDI 1992).

Vulnerable species

An indigenous species, subspecies, or geographically separate population particularly at risk because of low or declining numbers, small range or for some other reason, but not a threatened species. (COSEWIC 1993)

Well distributed

A geographic distribution of habitats that maintains a population throughout a planning area and allows for interaction of individuals through periodic interbreeding and colonization of unoccupied

	habitats (USDI 1992).
Wildfire	Any wildland fire that is not a prescribed fire (USDI 1992).
Windfall	Trees or parts of trees felled by high winds (USDI 1992).
Windthrow	A tree or group of trees uprooted by the wind (USDI 1992).

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