# Western Screech-Owl Conservation along the Shuswap River

Final Report

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# Dedication

This project could not run without the assistance and good humour of dozens of people on whose lands this study occurred. We had incredible assistance and cooperation from all of the landowners and we were amazed at their generosity. We thank:

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# Executive Summary

The *macfarlanei* subspecies of the western screech-owl (*Megascops kennicottii macfarlanei*) is a federally endangered owl that occurs in the dry southern interior of British Columbia. It is believed that fewer than 200 pairs occur in Canada. This species is a non-migratory resident that is assumed to rely on large, declining black cottonwood trees for nesting; loss of this habitat has been listed as the primary factor contributing to the current conservation concern. Effective conservation and habitat restoration efforts for screech-owls have been difficult to develop because very limited information is available about the ecology of this species in British Columbia, even though a conservation need has been clearly identified.

The purpose of this project was to collect information on the ecology of this species, including essential habitat requirements, so that effective population recovery can be attained. Research was needed to identify the link between screech-owls and riparian forests and determine which features of these forests are needed for nesting, foraging, and roosting. By following radio-tagged birds, we hoped to identify these features and determine the relative importance of each to life-cycle limiting factors affecting population viability. Secondly, the extension component was meant to engage landowners in active stewardship of important habitats and provide them with tools to conserve, enhance, and restore habitats to increase the productivity of screech-owls. The final component of the program assessed changes in behaviour and perceptions of landowners and feedback from end-users to increase program effectiveness.

<u>Inventory</u>

We conducted call-playback surveys for western screech-owls at 286 stations situated throughout valley-bottom habitats to the east and north of Vernon, British Columbia from 2004 to 2008 to better define the distribution of the species in this area. We detected screech-owls 59 times at 45 stations, with most detections occurring along the Shuswap River between Cherryville and Shuswap Falls. We also detected owls along BX Creek and Coldstream Creek to the northeast and south of Vernon.

The distribution of screech-owls in our survey area was quite disjointed, which was likely related to the distribution of important riparian habitats for this species. Because of the disparate distribution of suitable habitat along valley-bottom areas, the most likely linkage from the Shuswap River population of screech-owls to the Okanagan populations may be through BX Creek. It is clear that targeted conservation programs are needed to help this population of owls persist.

We collected much useful information about screech-owls during call-playback surveys that will be useful for refining future survey efforts. These include: surveys should include broadcasting female calls during the last 2 weeks of March to determine whether pairs of owls are present, surveys sites should occur within (not adjacent to) suitable habitat, and survey locations should be close to trees to provide perching sites, among others.

Research

To collect the ecological information about screech-owls that was vitally needed to help direct effective conservation, we captured and radio-tagged 11 adult screech-owls (6M, 5F) between July 2005 and January 2008. We collected 704 radiolocations of these owls in 2688 radio-days of monitoring to evaluate home range sizes and spatial organization, habitat relationships, and population characteristics.

Screech-owls in our study had large home ranges that averaged 64.5 ha (SD = 10.6, $n$ = 5), with no substantial difference in size between males and females. Owls used considerably smaller areas during the breeding season ($\bar{x}$ = 20.4 ha, SD = 15.3, $n$ = 7) than the non-breeding season ($\bar{x}$ = 88.6 ha, SD = 44.5, $n$ = 6). During the breeding season, males and females overlapped extensively, whereas outside the breeding season, males and females used different areas with very little overlap. We did not detect overlap of owls that were not part of a pair (i.e., no overlap with adjacent home ranges).

Riparian forests seemed to be a necessary component of home ranges of screech-owls; about 12 ha (or 18% of total home range area) of riparian forested habitats was needed for owls to occupy an area; we did not detect any screech-owls in areas that did not supply this critical density.

Screech-owls are a secondary cavity nester and a supply of suitable nest cavities are needed to support breeding. We identified 6 nests used by owls during 11 reproductive seasons; all nests were within cavities in large-diameter deciduous trees. Five nests were in large-diameter cottonwood trees ($\bar{x}$ = 81 cm dbh, range 43-111 cm) and one was in a large paper birch (70 cm dbh). The cavities that the owls used for nesting were created through natural decay processes (branch hole cavities) and by primary cavity nesters and occurred an average of 14 m above ground. Trees that had these features were extremely uncommon; we estimated that <0.4% of the trees in our study area were remotely similar in size and decay class as those used for nesting. After females started incubating eggs, they were observed to leave the nest between 16 and 26 minutes after sunset ($\bar{x}$ = 26 min., $n$ = 5) and be away from the nest between 8 and 21 minutes ($\bar{x}$ = 14 min., SD = 5, $n$ = 5). Later in the nesting period, females were detected being away from the nest for up to 43 minutes at a time.

Screech-owls were very specific in the trees that they used for roosting, choosing trees largely based on their diameter. Owls were most likely to roost in trees that were between 48 and 90 cm dbh. However, when they used sites that did not have large trees, they selected patches of habitat that had considerable cover of trees and shrubs >2 m high and little cover below 2 m. We believe that owls selected trees and patches of habitat that provided either cryptic (camouflage) cover (i.e., large diameter trees that were the same colour as the owls) or concealment cover (i.e., dense vegetation) that hid them from potential predators or harassment from songbirds. At least 16% of roost trees were used more than once, with 2 different trees being used 7 times each.

Habitats with the following features can be considered essential for western screech-owls:

1) Roosting: trees with diameters between 48 and 90 cm dbh or patches of habitat with high densities of trees >40 cm dbh, considerable tree and high-shrub cover, and little low-shrub cover.
2) Nesting: cottonwood and paper birch trees that form cavities of sufficient size (i.e., internal cavity ≥19 cm wide).
3) Home Range Occupancy: on average 12 ha of riparian forest habitat within a 65-ha area that includes a mixture of zonal and open forests and early structural stage habitats (e.g., grassland or pasture).

We collected much useful information on the population processes of screech-owls along the Shuswap River. The rate of successful nesting in our research area (11 of 13 nest-seasons; 85%) was similar to that observed in other areas and the number of fledglings per nest (3.25) was higher than that reported for southern California. However, mortality and turnover in the breeding territories was also high. Three of 10 radio-tagged owls died: 2 owls (1 M, 1F) from different territories were killed by predators (likely great horned or barred owls) and 1 female owl was struck and killed on a secondary road. We observed 9 instances of territory turnover in 13 opportunities (69%). The average minimum life span of owls in our study was 1.92 years (SD = 0.72, $n$ = 8), with the longest minimum life span in our study of 3.3 years. Given these parameter estimates, it is unclear whether the population of screech-owls along the Shuswap River is stable.

Conservation Implications

Many of the research and inventory results will help with the recovery of western screech-owl populations in British Columbia. The conservation implications of our work include:

1) Conservation efforts can be focussed within the refined distribution of screech-owls in the Shuswap and northeastern Okanagan regions.
2) Improvements to survey methods will enhance the probability of detecting resident screech-owls.
3) Information on space-use and habitat associations can be used to improve the use of survey data in the estimation of density and population size.
4) Empirical information on the size and location of home ranges can be used to identify other areas that may support screech-owls.
5) Changes in space-use by screech-owls throughout the year can be used to identify areas outside of riparian zones that should receive targeted conservation efforts.
6) Nest cavities and the processes that create them appear to be life-cycle limiting factors for screech-owls. Land managers can use this information to conserve or restore habitats that support these rare habitat features.
7) Screech-owls have very specific requirements for roosting, which appear to be met in a narrow range of habitat conditions. Roost sites must provide cover, either in the form of cryptic (camouflage) or concealment cover.

8) Data-driven predictive habitat models have been developed that can be used for assessing habitat value, predicting changes in habitat value under various management scenarios, and help with the conservation of high-value habitats in other areas.
9) The diet of western screech-owls has been identified. Land management that favours the retention of foraging habitats should be promoted.
10) Essential habitat delineations will help regulatory agencies and forest licensees to refine Section 7 schedules and notices for screech-owls.
11) Effective Wildlife Habitat Areas can be better delineated based upon an improved understanding of the space-use and habitat requirements of screech-owls.
12) The linkage between screech-owls and riparian forests with deciduous components has been strongly characterized. Understanding the reasons that screech-owls need these habitats will promote land management activities that help conserve and restore these identified habitats.

Extension of Project Findings

We delivered an extensive outreach program to landowners along the Shuswap River. Between 2004-2008, we provided over 80 landowners with information on our project. In 2008, we distributed 43 stewardship manuals to people who owned land within home ranges of radio-tracked owls. Landowners were very supportive of the project; 97% of landowners allowed access to their land.

To assess the effectiveness of this extension product and the outreach program as a whole, an independent extension specialist conducted an evaluation of the program. Overall, feedback was excellent. Everyone who was interviewed found the information easy to understand and all of them felt that it was a very worthwhile project in which to have participated. Many of the landowners were already motivated to protect important habitat on their land, but almost all of them felt like they had more knowledge because of the information they had received from the manual. Many landowners were particularly interested in the information about rare species that live in their area, and were excited to talk about the ones that they had seen.

Through our extension efforts, we have facilitated two conservation covenants for significant screech-owl habitats along the Shuswap River. The Land Conservancy has agreed to hold a covenant for one property (approximately 7 ha) that was extensively used by 2 pairs of radio-tagged screech-owls. We have also been working towards a conservation covenant for a much larger section of land owned by BC Hydro that includes over 90 ha of the only old-growth cottonwood riparian forest (essential habitat for screech-owls) in the project area.

Extensive outreach was conducted throughout the project. Presentations on preliminary results of the project were given to 3 Okanagan naturalist clubs, the BC Field Ornithologists annual meeting and at the Federation of BC Naturalists AGM. One scientific paper on the diet of western screech-owls has already been accepted for publication and 3 others are being prepared for submission. Results from the project have also been used to design Wildlife Habitat Areas in BC and in a BC status report on the *macfarlanei* subspecies of screech-owl.

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# Introduction

The *macfarlanei* subspecies of the western screech-owl (*Megascops kennicottii macfarlanei*) is a federally endangered owl that occurs in the dry southern interior of British Columbia from Lillooet to Cranbrook (Cannings and Davis 2007). It is a small brownish-grey owl with large ear-like feather tufts and yellow eyes. The subspecies is listed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2002) and is also resident in Washington, western Montana, Oregon and Idaho. It is estimated that there are only 155-200 pairs in all of British Columbia (Cannings and Davis 2007). Western screech-owls are also an Identified Wildlife species and its habitat requirements are listed in Section 7 notices for the Arrow Boundary, Cascades, Kamloops, and Okanagan Shuswap Forest Districts.

Although much useful natural history information has been collected on western screech-owls, large knowledge gaps still exist about the species' ecology that hampers effective conservation and recovery in Canada (Western Screech Owl Recovery Team 2006). Western screech-owls are territorial non-migratory residents that are closely associated with large, declining deciduous trees that they use for nesting. It is believed that the riparian forests where these trees occur are important to this species (Cannings 2004) but habitat requirements are largely unknown because no research on this subspecies has been conducted in British Columbia. Alteration and loss of riparian cottonwood forests are believed to be the primary factor contributing to the current conservation concern but effective conservation methods are difficult to develop because very limited information is available about the ecology of this species. This handicaps the ability of landowners, regulatory agencies, and forest licensees to effectively integrate habitat considerations for screech-owls into their land management practices. Virtually nothing is known about the vital rates of screech-owls, so assessing the ability of the population to respond to perturbation is also unknown. Furthermore, the distribution and abundance of the species is poorly defined and makes effective targeting of conservation programs difficult.

The purpose of this project was to collect information on the ecology of this species, including essential habitat requirements, so that the effective population recovery can be attained. Effort during the research component of the program was directed towards monitoring screech-owls fitted with radiotransmitters to collect these vital data. By monitoring radiotagged individuals, we were able to determine the aspects of habitat (and at which spatial scales) that screech-owls seem to require, whether it is for foraging, nesting, or roosting. Radiotelemetry was used to collect information on population factors such as natality and mortality rates, which allowed us to assess population factors that may constrain or otherwise affect population recovery. Data from the research study fed directly into recovery actions for this species, such as the Recovery Strategy and Action Plans produced by the Recovery Team, in addition to our extension and outreach program.

Specific Objectives:

1. Identify the features of habitats required by screech-owls for nesting, foraging, and roosting by examining habitat selectivity at a variety of spatial scales.
2. Identify rare ecosystems utilized by screech-owls and determine if they are essential to their survival.
3. Identify population factors (e.g., mortality factors), land use issues, habitat suitability issues and prey base issues that may affect the conservation of screech-owls in the region.
4. Synthesize scientific data into effective habitat conservation, enhancement, and restoration techniques for habitats that are essential or important to screech-owls.
5. Engage First Nations, local landowners and forest licensees in the application of conservation and restoration techniques in identified habitats.
6. Create public awareness regarding the status and issues surrounding screech-owls and other riparian-associated species in the Shuswap Region through education and outreach programs.

## *Report Structure*

The report starts with an overall introduction and then is split into 4 main components: inventory, research (which includes several subsections on capture, handling and radiotelemetry monitoring; spatial organization; habitat relationships; behavioural observations; population characteristics; and conservation implications), extension, and evaluation. The diet of western screech-owls is documented in: “Diet of western screech-owls (*macfarlanei* subspecies) in the interior of British Columbia” in Appendix I by Davis and Cannings (*in press*). This paper has been accepted by the journal “BC Birds”; the manuscript will undergo formatting changes before publication in 2008.

# Inventory

Until recently, the Canadian population of interior western screech-owls, *Megascops kennicottii macfarlanei,* were thought to be limited to areas in the southern interior of British Columbia (Chaundy-Smart 2002). With the passing of the federal Species At Risk Act, survey effort for western screech-owls increased. Recent intensive surveys conducted in the North Okanagan-Shuswap (Davis and Weir 2004), West Kootenay (Beaucher and Dulisse 2004), and East Kootenay regions (Cannings and Davis 2007) indicated that screech-owls may be more widely distributed than originally believed.

Our objective was to conduct surveys for western screech-owls in the Shuswap and North Okanagan areas to provide data that would assist with the conservation of this endangered species. After Davis and Weir (2004) discovered a series of previously undetected territories of western screech-owls during surveys along the Shuswap River in 2004, it was clear that there was a need to further refine our understanding of the distribution of the species in this area, identify linkage corridors between the Shuswap population and other sites known to support western screech-owls, and to identify areas in which to focus conservation efforts for the species.

## *Inventory Area*

The inventory area encompassed 490 km² of valley-bottom habitats to the east and north of Vernon, British Columbia (50° 16' N, 119° 16' W) and included portions of the North Okanagan Highlands, North Okanagan Basin, and Shuswap Highlands ecosections (Demarchi 1995). The inventory area was comprised primarily of the moist-warm and very dry-hot subzones of the Interior Douglas-Fir biogeoclimatic zone (IDFmw1, IDFxh1), but also included grassland (IDFxh1a) and Interior Cedar-Hemlock (ICHmk1, ICHmw2) biogeoclimatic units. Land-use in the inventory area was mixed, but was dominated by land cleared or modified for agricultural and urban developments. In most areas, relatively little of the riparian forests along the major waterways remained intact.

## *Methods*

During 2004 and 2005, we surveyed for screech-owls using call-playback techniques at more-or-less regular intervals of approximately 800 m along roads in close proximity to cottonwood riparian forests >10 ha throughout the inventory area (Resources Inventory Committee 2001). In 2006 to 2008, we refined our site selection to only include areas within or immediately adjacent to riparian habitats. We also surveyed specific sites at which members of the public had reported hearing screech-owl calls.

We conducted call-playback surveys for western screech-owls following Resources Inventory Committee (2001) protocols. Upon arrival at the survey location, we waited 2 minutes before beginning the survey. We played male screech-owl calls (the "bouncing ball" call) to elicit a response from nearby screech-owls. We sometimes also used a female call (Tripp 2002) for call-playback surveys. Calls were broadcast from an MP3 player through a megaphone and played for 1 minute, followed by a 3-4 minute listening period. A second minute of calls were then played followed by another 3-4 minute listening period. This was repeated once more for a total of 14-17 minutes of call playing/listening at each survey site. Upon detection of screech-owls, we immediately discontinued playing the call and recorded the number of owls, estimated distance and direction to the birds, and georeferenced coordinates (UTM, NAD83). Surveys were conducted starting at least a half-hour after sunset when weather conditions were appropriate (e.g., no rain, wind speed <20 km/h; Resources Inventory Committee 2001, Hardy and Morrison 2000).

We conducted surveys at different intensities in the research and inventory areas. After 2005, we conducted fewer surveys in the research area than previous years because we only needed to determine where owls occurred for trapping and did not want to habituate birds to calls to maintain capture efficacy.

We occasionally conducted daytime surveys for roosting owls to identify areas in which a nest might be located. At sunset, we then watched potential nest cavities in the immediate vicinity of the detection for activity to identify the nest.

We conducted additional call-playback surveys specifically for barred owls and great horned owls in the research area in 2006. Both species are known predators of screech-owls (Dark et al. 1998; H. Davis, pers. obs.) and 2 of the radio-tagged screech-owls were possibly killed by larger owls. Great horned owls were surveyed at 16 stations, situated every 600 m along the Shuswap River. Barred owls were surveyed at 26 station, at intervals of ranging from 400 - 800 m. Listening periods for these surveys were 4 minutes in length and repeated 3 times, therefore each station took a minimum of 15 minutes.

## *Results*

We conducted 427 surveys during 109 hours of call-playback over 5 years (Table 1) in 5 main areas (Fig. 1): the Shuswap research area (including Cherry Creek and Bissette Creek), Coldstream and Lavington, Shuswap River between Mabel Lake and Enderby, BX Creek, and Trinity Valley (between BX Creek and the research area). During these surveys, we detected screech-owls 59 times at 45 locations, barred owls 5 times, northern saw-whet owls 5 times and great horned owls 13 times.

**Table 1. Call-playback survey effort in the Shuswap and northeast Okanagan regions of British Columbia, 2004-2008.**

| Year | Number of visits | Number of stations | Survey duration (h) |
|---|---|---|---|
| 2004 | 57 | 36 | 13.55 |
| 2005 | 80 | 72 | 19.43 |
| 2006 | 185 | 112 | 49.43 |
| 2007 | 83 | 46 | 21.38 |
| 2008 | 22 | 20 | 5.17 |
| Total | | | 109 |

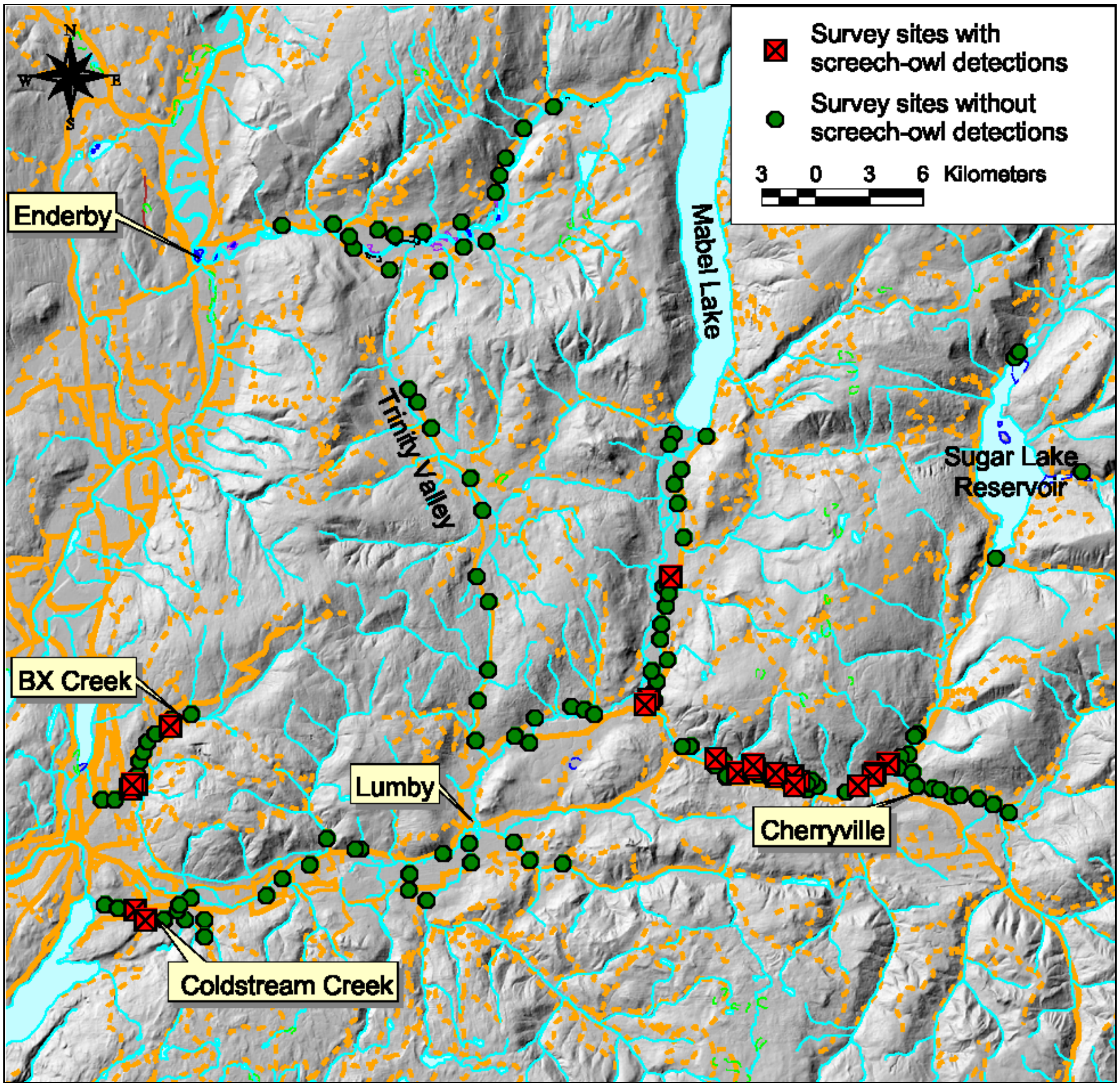


**Figure 1. Survey sites and detections of western screech-owls conducted during 2004-2008 in the Shuswap and northeastern Okanagan regions of British Columbia.**

Most of the screech-owl detections occurred within the research study area, with 28 of 45 detections occurring between Bissette Creek and Cherry Creek (Fig. 1). We detected screech-owls in the IDFmw1 and IDFxh1 biogeoclimatic units only (Table 2). The highest detection probability occurred during March (0.86 detections/hour) and April (0.76 detections/hour; Fig. 2). The average time to first response by screech-owls to was 7.25 minutes (SD = 8.28, $n$ = 59). Screech-owls responded quickest in the month of March ($\bar{x}$ = 4.8 min., SD = 4.97, $n$ = 15 detections).

**Table 2. Survey effort and detections by biogeoclimatic unit during 2004-2008 in the Shuswap and northeastern Okanagan regions of British Columbia.**

| Biogeoclimatic unit | Survey effort (h) | Number of sites | Number of detections |
|---|---|---|---|
| IDFxh1a | 3.0 | 12 | 0 |
| IDFxh1 | 23.8 | 61 | 14 |
| IDFdm1 | 0.3 | 1 | 0 |
| IDFmw1 | 72.8 | 175 | 31 |
| IDFmw2 | 7.2 | 30 | 0 |
| ICHmw2 | 1.9 | 7 | 0 |
| Total | 109.0 | 286 | 45 |

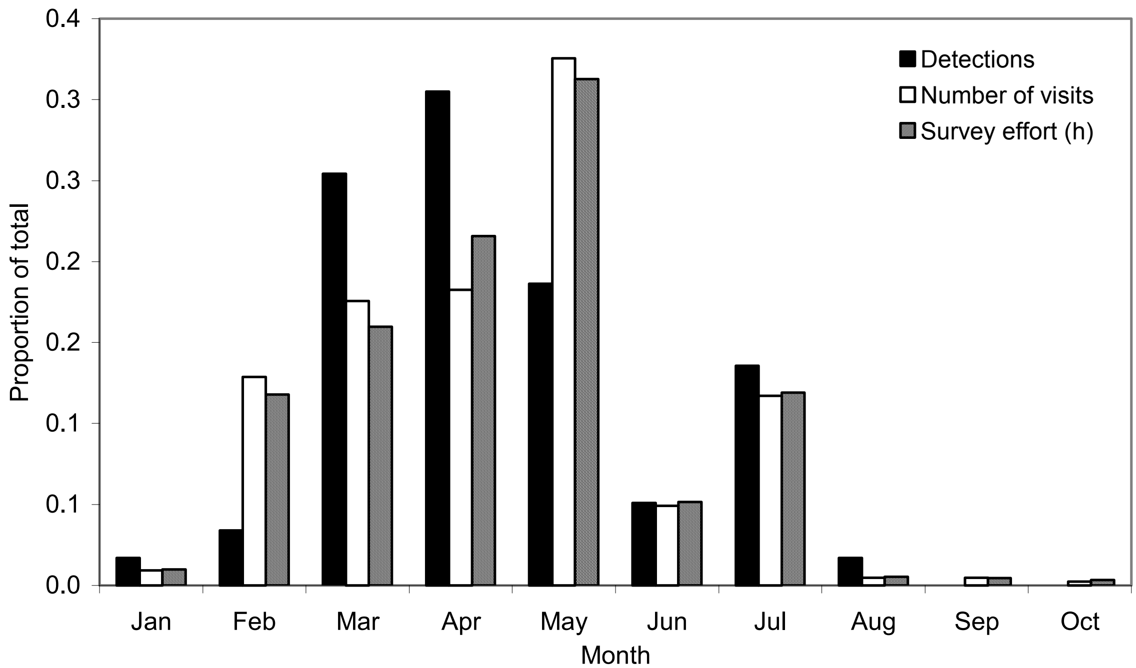


**Figure 2. Timing of survey effort and detections of western screech-owls following standardized protocols during 2004-2008 in the Shuswap and northeastern Okanagan regions of British Columbia.**

In addition to the standardized inventory surveys, we conducted 21 daytime call-playback surveys at 11 sites totalling 13:14 hours between 2005 and 2007 to find male owls roosting near nest sites. These surveys were conducted at sites where we detected owls during call play-back surveys at night. We detected owls 7 times at 4 of the 11 sites. We found a nest at one site that we detected owls, but were unable to do so at the other 3 sites.

Surveys in the research area for great horned owls and barred owls were conducted between 23 July and 14 August 2006. We surveyed for 6:56 hours for barred owls, during which they responded at 2 of the 26 stations surveyed (Fig. 3).

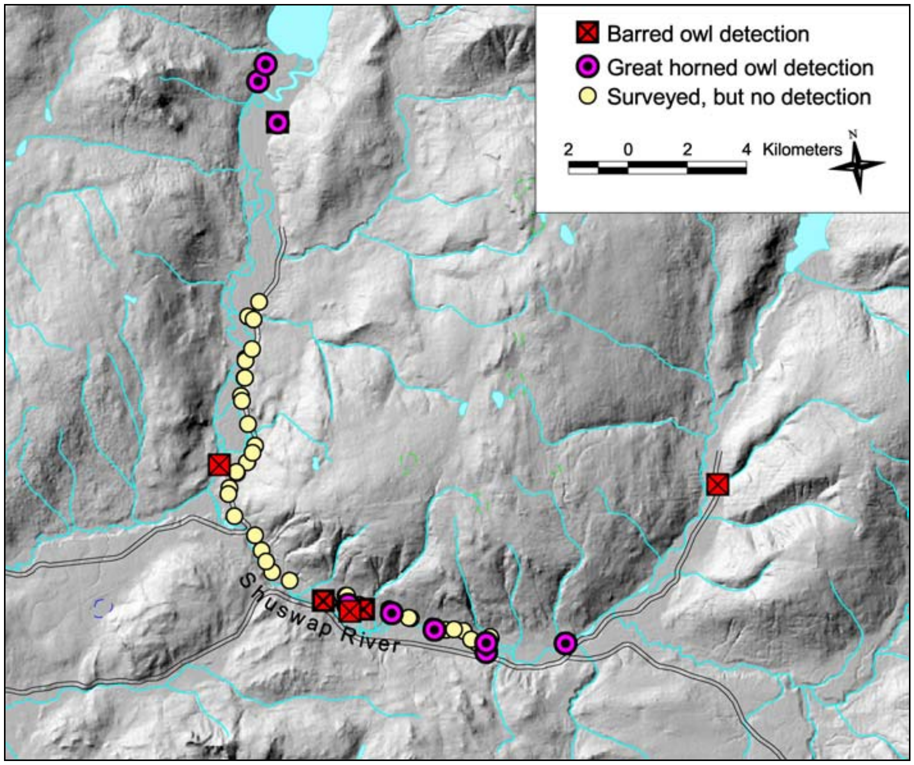


**Figure 3. Detections of barred owls and great horned owls during surveys and capturing efforts along the Shuswap River, British Columbia. We detected both barred and great horned owls at one site (overlapping square and circle symbols).**

These responses were relatively close together and near where a barred owl was captured during screech-owl trapping in 2005. We also incidentally detected barred owls at 3 other locations. We surveyed 5:42 hours for great horned owls at 20 sites with no responses, despite incidentally detecting great horned owls in the research area throughout the year and having them respond during screech-owl surveys.

At BX Creek, northeast of Vernon, screech-owls were documented during a number of surveys. In 2006, we discovered 2 male screech-owls but did not determine if these males had mates or produced offspring because conditions were very poor during the survey periods (loud run-off in creek). Because one of these males called much more and much later than owls with mates in the research area, we felt he did not have a mate. In February and March 2007, we surveyed the same territory 3 times with no response. On the 4th attempt (April 12) we received a response from a male, and the male responded again on April 18th. These responses were different in both intensity and duration than those documented in 2006, which may be indicative that he had found a mate. We conducted a daytime survey April 21 and found the male roosting in a dense patch of redcedar and birch. Unfortunately, we also found a dead screech-owl nearby, later determined by genetic analysis to be a female screech-owl. The area was again surveyed May 29 and a pair of owls was found to be present. This pair may have successfully produced young, as they were located successively in a very small area. We visited repeatedly to try and find the nest cavity but we were unsuccessful. A pair of owls was detected in March 2008 in the same small area.

We also surveyed for screech-owls in the Lavington and Coldstream areas in 2006-2008 (Fig. 1). A breeding pair was previously known to occur on Coldstream Creek that had been surveyed in previous years (J. Hobbs, BC Ministry of Environment, pers. comm.). Our surveys detected a second breeding pair of owls just downstream from the known pair in 2007. Both pairs of owls produced young in 2007 (Vicky Young, BC Conservation Corp, pers. comm.). One survey in 2008 detected individuals at both locations, but we are unsure if pairs at both sites.

## *Discussion*

We observed that the occurrences of western screech-owls to the east and north of Vernon, British Columbia were quite patchy, which is likely related to the distribution and abundance of important habitats that remain in this area. Although considerable stretches of low-elevation creeks occurred within the inventory area, most of the forested habitats surrounding these areas has either been cleared for agriculture or housing or reduced in size such that it cannot support resident owls (i.e., 12 ha within surrounding 64.5 ha, see *Spatial Organization* section). Screech-owls only occurred in areas where these minimum requirements were met: BX Creek, Coldstream Creek, and along the Shuswap River.

The discovery of previously undetected pairs of breeding screech-owls in the Vernon area (BX, Coldstream) was encouraging, in that it showed that this species can persist in areas that were fairly developed, but still rural, given that riparian forest still occurred. It should be noted all 3 pairs that were detected near Vernon lived in and around parks, so where more natural habitat occurred than was available elsewhere along the creeks.

Because of the disparate distribution of suitable habitat along valley-bottom areas, the most likely linkage from the Shuswap population of screech-owls to the Okanagan populations may be through BX Creek. BX owls are likely sufficiently close to screech-owls that live in small drainages on the west side of Okanagan Lake that gene flow could be maintained. Despite extensive surveys through Lumby and Lavington, no screech-owls were detected between the Shuswap population and the Coldstream owls, which prior to extensive human development would likely have supported screech-owls. It is important that these small groupings of owl persist to retain genetic exchange within the population.

## *Surveying Recommendations*

Reliable detections are the goal of every inventory program. We found that our ability to detect screech-owls during call-playback surveys was affected by a number of factors. Many of these were related to the placement of the survey sites relative to the territories of owls, along with the timing of the surveys themselves.

Although we rarely surveyed radio-tagged owls, a number of relationships became evident through our understanding of their space-use patterns and pre-tagging survey results. First, surveys needed to occur within the boundary of the individual's home range for them to respond (Fig. 4). Second, owls did not respond reliably if survey sites were situated near the boundary between 2 adjacent territories. Third, owls sometimes did not respond to calls, irrespective of where within their territory the call was played; whether they were in another part of their territory and could hear the call or just failed to respond is unclear.

Other factors, in addition to these space-use effects, influenced the probability of detecting resident screech-owls. Timing of the survey may be critical to successful detection of resident owls; surveys in March and early April (prior to egg-laying) produced the most responses. This is likely related to the increase in aggressiveness during the mate-selection and pre-breeding period (Herting and Belthoff 1997), which in our area occurs in March and into the first week of April. Also, owls may fly into survey sites, but not vocalize. We noticed on several occasions that individuals of the sex opposite to that of the broadcast call flew into the survey site, but responded only when the same-sex call was played. This result indicates that outside of the non-nesting season (during which females should not be disturbed) utilizing both a male and female call can be beneficial in determining the presence of a breeding pair.

We also observed a reduction in responsiveness by screech-owls during both call-playback surveys and trapping when potential predators (great horned owls and barred owls) were in the area. Additionally, we noted that screech-owls with territories that overlapped those of potential predators reduced their responsiveness to call-playback, compared to individuals in areas where predatory

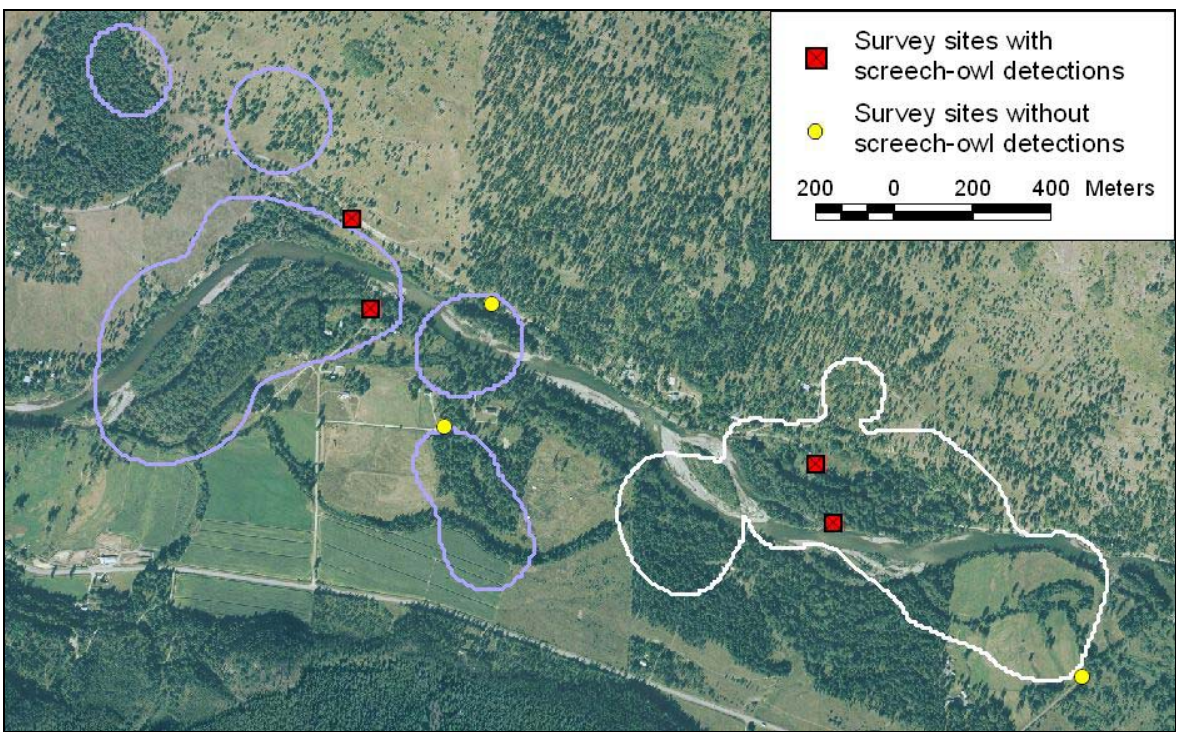


**Figure 4. Effectiveness of survey sites relative to known home ranges of resident screech-owls. Outlines shown for 2 resident males radio-tagged and monitored during 2005.**

owls were not detected. Other researchers have noted that owls change their responsiveness to call-playback surveys in the presence of predatory owls; variability in detection rates of spotted owls in response to the presence of potential predators (barred owls) has been a concern (Olson et al. 2005).

**Potential improvements to existing survey protocols**

Surveying protocols for screech-owls were generally adequate (Hausleitner 2006) but the following actions may enhance the probability of successfully detecting resident owls:

- Surveys using the female call during the last 2 weeks of March can be used to identify breeding pairs because females are very responsive just prior to egg-laying. Female calls should not be used after April 1 because females may be incubating eggs. Observers should document which calls are played so that future analyses can determine the best protocols.
- Ensure that survey sites occur within suitable habitat (e.g., riparian forests) to increase the likelihood that the survey site is within the home range of a resident owl. Owls generally will not respond if survey sites are >100 m away from the edge of their home range, depending upon the intervening habitat.
- Survey locations should be close to trees to provide perching sites from which to respond.
- Do not broadcast calls across open areas (e.g., cultivated fields) because responses by screech-owls may expose them to higher predation risk.
- Immediately discontinue broadcasting once a response is detected.
- Do not resurvey a site known to have resident owls unless additional information is needed about the bird(s) (i.e., whether there is a pair or juveniles present).
- Survey sites can likely effectively sample within 400 m. Given that screech-owl home ranges include at least 867 m of riverfront ($\bar{x}$ = 1198 m; see *Spatial Organization* section), survey locations should be spaced at most 800 m apart along a linear water body. Because rivers are rarely straight, an inter-station interval of 600 m in suitable habitat should ensure that at least one sampling point is within the more heavily used portions of a resident owl's home range.
- Daytime surveys can be conducted to determine roost sites and nest areas of untagged owls. Two-way radios should be used so that one person can broadcast the call at a distance as another observer walks through the stand.
- At sites for which 2 detections occur in close proximity, two-way radios should also be used during night surveys so that personnel can conduct concurrent surveys. This will allow surveyors to determine whether close-proximity detections were the result of two pairs of owls or one pair of owls moving within their home range.

# Capture, Handling and Radiotelemetry Monitoring

## *Project Area*

The research area covered approximately 83 $km^2$ of cottonwood riparian, agricultural, and upland coniferous forest that occurred along the Shuswap River (Fig. 5), approximately 10 km to the east of Lumby, British Columbia (50° 16' N, 118° 15'W). Elevation at river level was 410 m below the Wilsey hydroelectric dam and 480 m above the dam. The area was within the Northern Okanagan Highlands ecosection (Demarchi 1995) and included the moist-warm subzone of the Interior Douglas-Fir biogeoclimatic zones (IDFmw1 variant; British Columbia Ministry of Forests 2004).

Forest ecosystems within the project area were typically dominated by Douglas-fir (*Pseudotsuga menziesii*), with components of ponderosa pine (*Pinus ponderosa*), trembling aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), western redcedar (*Thuja plicata*), and hybrid spruce (*Picea glauca* x *engelmannii*). Black cottonwoods (*Populus balsamifera* ssp. *trichocarpa*) occurred as prominent components of riparian and floodplain ecosystems within the project area.

The understory was diverse. Common snowberry (*Symphoricarpos albus*), tall Oregon-grape (*Mahonia aquifolium*), birch-leaved spirea (*Spiraea betulifolia*), saskatoon (*Amelanchier alnifolia*), red-osier dogwood (*Cornus stolonifera*), thimbleberry (*Rubus parviflorus*), black gooseberry (*Ribes lacustre*) and Douglas maple (*Acer glabrum*) were common shrubs. Twinflower (*Linnaea borealis*), prince's pine (*Chimaphila umbellata*), and pinegrass (*Calamagrostis rubescens*) were the dominant herbs.

Much of the project area has undergone considerable disturbance resulting from human development. The creation of a power project during the late 1920's that involved the installation of two dams in the Shuswap watershed contributed significantly to habitat changes along the Shuswap River. Specific to this project, unnatural flow fluctuations on portions of the river within the research area likely impacted both terrestrial- and aquatic-dependent organisms. Approximately 60% of the riparian forests between Sugar Lake Reservoir and Mabel Lake have been cleared for agricultural activities, in addition to some selective cottonwood harvesting in the late 1970's, however some extensive tracts of late-successional cottonwood riparian forests remain along the Shuswap River.

## *Methods*

### Capture and handling

All capture and handling protocols were approved by the provincial Animal Care Committee (recognized by the Canada Council on Animal Care) and met or exceeded capture and handling guidelines outlined in the protocols for Wildlife Capture and Handling (Resources Inventory Committee 1998a). We hired Capture Specialists (H. van Oort, W. Harrower, R. J. Cannings), who had extensive

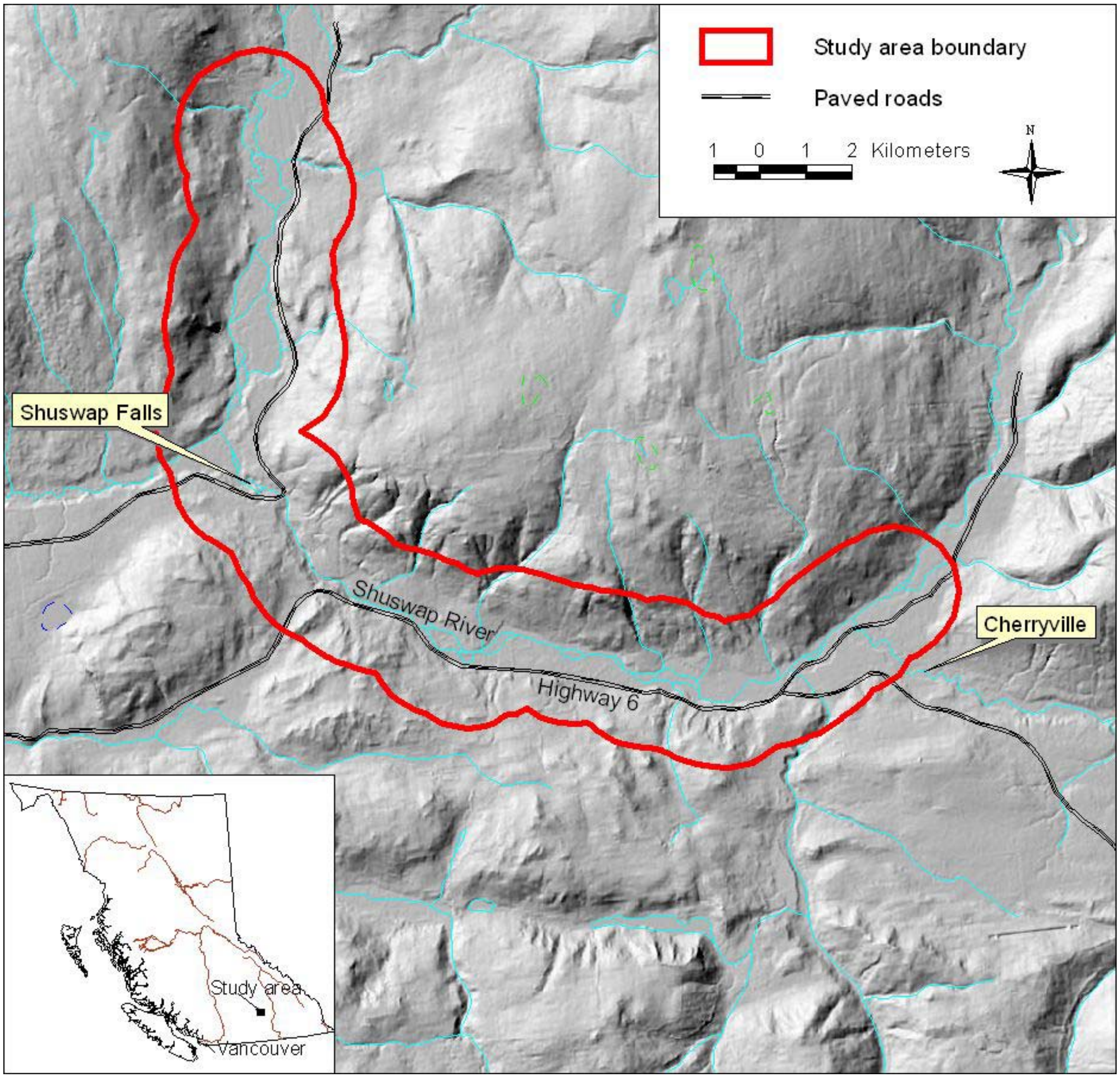


**Figure 5. Western screech-owl research area along the Shuswap River, British Columbia.**

experience capturing, banding and radio-tagging small raptors, to complete the capture and tagging work. Permits for the project were obtained from Industry Canada for the deployed radiofrequencies (licence 4995578) and from the BC Ministry of Environment for capture, banding and tagging (permit PE05-14401).

We attracted owls for capture using call-playback within the territory of resident owls. Audio recordings of the territorial call of the western screech-owl were broadcast from a megaphone located below a mounted decoy western screech-owl (Smith et al. 1983). In 2005, we played calls on a continuous loop under the decoy, but in later years we started the capture session by playing the call for a minute with a break of 3-4 minutes between cycles (i.e., same as call-playback survey). The call was then put on a continuous loop once an owl was attracted to the site.

We used 1 or 2-38 mm mesh mist nets (for medium-sized birds) set up around the decoy to capture owls. Fooled by the recording, the resident owls flew towards the 'intruder' to defend their territories and became entrapped in one of the mist nets. Small bells were clipped onto to the nets to alert us when a net had been hit.

We also attempted to capture owls using bal-chatri and a modified bal-chatri traps (Smith and Walsh 1981) on several occasions. Mist nets or bal-chatri traps were never left open or unattended at any point.

Captured individuals were extracted from the mist nets within seconds of capture. Once the owl was extracted, we immediately began processing it. Captured owls were weighed to determine sex (Pyle 1997, Cannings and Angell 2001). We marked owls with a US Fish and Wildlife Service leg band for identification. If the captured individual was assessed to be in good condition based upon total body mass and subcutaneous fat scores, we affixed Holohil model PD-2 transmitters (weight: 3.8 g, nominal life: 6 months, lifespan range: 5-9 months, dimension [LxWxH]: 23x12x7 mm) to adult owls that had a body mass of at least 150 g. We affixed Holohil model R1-2C (weight: 6.0g, nominal life: 12 months, lifespan range: 6-18 months, dimension [length x diameter]: 32x10 mm) to adult female individuals that had a body mass of at least 215 g. These ratios of transmitter mass:body mass are below 2.5%, which corresponds to a reduction in surplus power of <2% (Caccamise and Hedin 1985). A feather and blood sample were collected for future genetic analyses.

Backpack-mounting a transmitter did not appear to impede the normal movements of the study subject. Straps were adjusted to be snug but comfortable on the owl, and were quickly preened under the contour feathers after release. We attached radiotransmitters using the criss-cross backpack harness described by Smith and Gilbert (1981) for use on screech-owls. This attachment method has been used without incident on several research projects involving both eastern and western screech-owls (J. Belthoff, Boise State University, pers. comm.), which suggests that backpack attachments may be the most appropriate attachment method. Backpack transmitters have been shown to have little long-term effect on the behaviour of most birds of prey (McCrary 1981).

Following handling, owls were briefly placed in a small dark box so that they could acclimate to the new weight before attempting flight (Smith et al. 1983). We released the birds at the capture site after 10-15 minutes in the box. When transmitters neared the end of their battery life, we attempted to recapture owls and replace or remove their transmitter.

### Radiotelemetry monitoring

Screech-owls outfitted with radiotransmitters were monitored year-round for the entire period that their transmitters were functional. We located radio-tagged owls using standard ground telemetry procedures (Resources Inventory Committee 1998b). All ground telemetry work used UTM coordinates from a Global Positioning System and were recorded using North American Datum 1983. Because of the extremely mobile nature of screech-owls, we considered locations to be sufficiently temporally independent for home range and habitat use analyses if they were separated by at least 2 hours.

We often followed telemetry signals and walked in on owls in roost trees. If we could definitively identify the tree used by the owl, we recorded tree species. If the owl could be seen, we also recorded height to the owl. We later returned to these trees to measure the tree diameter, search for expelled pellets and conduct habitat investigations. Owls were often located at roosts before sunset and then monitored to determine when they left the roost for the evening.

We occasionally recorded directional bearings from locations identified by UTM coordinates to owls using an H-antenna. We estimated locations and 95% error polygons from ground telemetry using Locate III software (Nams 2005). We estimated the precision of each location using the 95% error polygons.

Depending on its level of precision, we considered each radiolocation for its suitability for inclusion in habitat analyses at 4 different spatial scales: element (e.g., single tree), patch (150-m² area of habitat), stand (homogenous combination of ecosystem and structural stage), and home range. Precise radiolocations were suitable for inclusion in analyses at fine spatial scales (e.g., element scale), whereas less precise radiolocations were only suitable for coarser-scale analyses (e.g., landscape scale). Very precise radiolocations were appropriate for habitat analyses at the finest scale up to the coarsest scale, while imprecise locations precluded use for analyses at all but the coarsest scales. We classified each radiolocation for its suitability for habitat analyses on the basis of the error associated with the triangulation (Table 3).

## *Results*

### Captures

We captured and radio-tagged 6 male and 5 female owls (Table 4) during 95.1 hours of live-capturing between July 2005 and March 2007. In addition to the tagged owls, we captured, but did not radio-tag, 2 adult females during attempts to remove transmitters in March 2008. We scaled nest trees and banded 7 nestlings in 2006. No banded young were recaptured in subsequent trapping. Mist-netting was the most successful method of capturing owls, producing 17 captures in 74.6 hours of use. Live prey in bal-chatri traps did not result in a single capture in 20.5 hours of use.

**Table 3. Determination of the suitability of radiolocations for habitat analyses at different spatial scales. § denotes scale for which the radiolocation is appropriate for analysis. Radiolocations with error areas > 43,500 m² were not used.**

| | Spatial scale | | | |
|---|---|---|---|---|
| Error area (m²) | Element | Patch | Stand | Home range |
| none | § | § | § | § |
| 1 - 500 | | § | § | § |
| 501 – 1,000 | | | § | § |
| 1,001 – 3,000 | | | § | § |
| 3,001 – 12,000 | | | | § |
| 12,000 – 43,500 | | | | § |

**Table 4. Capture methods and weights of screech-owls captured along the Shuswap River, British Columbia, 2005-2008.**

| Owl ID | Capture method | Date | Body weight | Call playing at time of capture |
|---|---|---|---|---|
| Adult females | | | | |
| B04 | mist net* | 6-Mar-06 | 220 | female |
| B05 | mist net | 5-Apr-06 | 315 | interaction call |
| B05 | mist net | 2-Jun-06 | 229 | interaction call |
| B05 | mist net | 26-Mar-07 | 270 | female |
| B10 | mist net | 31-May-06 | 197 | interaction call |
| B10 | dead | 19-Sep-06 | 255 | n/a |
| B15 | mist net | 15-Mar-07 | 245 | female |
| B18 | mist net | 27-Mar-07 | 204 | female |
| B19 | mist net | 17-Mar-08 | 250 | female |
| B20 | mist net | 17-Mar-08 | 235 | interaction call |
| Adult males | | | | |
| B01 | mist net | 12-Jul-05 | - | male |
| B02 | mist net | 13-Jul-05 | 193 | male |
| B03 | mist net | 15-Jul-05 | 184 | male |
| B03 | noosed | 9-Mar-06 | 207 | n/a |
| B14 | mist net | 5-Jun-06 | 173 | female |
| B16 | mist net | 15-Mar-07 | 190 | interaction call |
| B17 | mist net | 19-Mar-07 | 200 | male |
| Nestlings | | | | |
| B06 | banded at nest cavity | 23-May-06 | 150 | n/a |
| B07 | banded at nest cavity | 23-May-06 | 60 | n/a |
| B08 | banded at nest cavity | 23-May-06 | 160 | n/a |
| B09 | banded at nest cavity | 23-May-06 | 120 | n/a |
| B11 | banded at nest cavity | 3-Jun-06 | 185 | n/a |
| B12 | banded at nest cavity | 3-Jun-06 | 177 | n/a |
| B13 | banded at nest cavity | 3-Jun-06 | 210 | n/a |

* mist net with decoy owl and call-playback

Capture success with mist nets and call-playback was highest through the breeding and fledgling seasons (March-July, Figure 6). We were most successful capturing owls in March when they were very aggressive (prior to laying eggs), capturing 9 owls in 32.3 h of effort. We captured one female on April 5 (2006), she started incubating eggs the next night. Owls were calling spontaneously during set-up on 10 occasions. The average response time was 13 minutes (range: 1-60 minutes, SD = 13, $n$ = 58) at sites where screech-owls reacted to call-playback.

We presented live prey to radio-tagged birds during the day on 3 occasions to test whether live prey could be used successfully as a lure for trapping. None of the birds appeared interested in the mice and did not make any attempts to investigate. Similarly, we attempted to capture radiotagged owls at night using live prey in bal-chatri traps and added the recording of a squeaking mouse under the

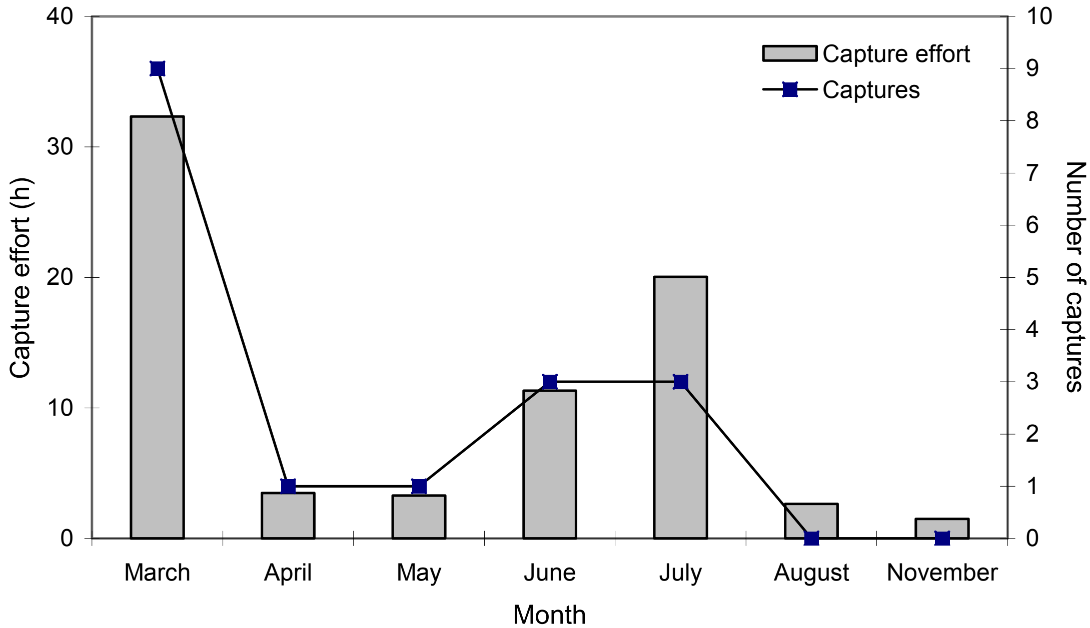


**Figure 6. Monthly captures of western screech-owls and capture effort using mist nets, call-playback and decoys along the Shuswap River, British Columbia, 2005-2008.**

trap to entice them further. This approach elicited interest from 2 female owls that approached the trap on the ground repeatedly. However, they did not attack the trap and get snared in the nooses; we did not observe any hunting dives at the traps with mice. We also constructed a modified bal-chatri that had a clear plexiglass top (Smith and Walsh 1981) but did not have any successful captures with this device likely because frost accumulated on it during cold weather. When we attempted to call-in owls to the bal-chatri trap using call-playback, we interested one female owl, but male owls were only interested in the “intruder” and never focussed on the prey in the trap.

We captured few non-target species in mist nets. We caught one bat, which was easily released, and one flying squirrel that may have been attempting to attack the decoy owl. We also caught one barred owl that was attempting to prey on the decoy screech-owl.

## Handling and tagging

We did not experience any complications during handling as owls were generally very passive. Male screech-owls in this study were smaller (Table 4; $\bar{x}$ = 191 g, SD = 12.0, $n$ = 6) than females ($\bar{x}$ = 242 g, SD = 34.2, $n$ = 10) but both were very similar in size to *macfarlanei* owls in Idaho ($\bar{x}$ = 191.6 g, SD =16.9, $n$ = 74 males, $\bar{x}$ = 235.5 g, SD = 27.3, $n$ =105 females; Cannings and Angell 2001).

We deployed several different transmitter designs and attachment methods, but only the PD-2 transmitter on a backpack-type attachment worked well (Table 5). We found that backpacks were difficult to construct and fit correctly; a slightly different design may improve fit and decrease handling time.

**Table 5. Longevity of transmitters used on western screech-owls along the Shuswap River, British Columbia, 2005-2008.**

| Owl ID | Transmitter type (Holohil model #) | Expected operational life (months) | Actual operational life (months) |
|---|---|---|---|
| B02 | PD-2 | 5-9 | 10.07 |
| B03 | PD-2 | 5-9 | 8.13 |
| B05 | PD-2 | 5-9 | 10.03 |
| B15 | PD-2 | 5-9 | 4.50 |
| B16 | PD-2 | 5-9 | 10.23 |
| B17 | PD-2 | 5-9 | 5.13 |
| B18 | PD-2 | 5-9 | 10.00 |
| B05 | RI-2C | 6-18 | 1.80 |
| B05 | RI-2C | 6-18 | 7.27 |

We deployed 3 R1-2C transmitters on female owls, but due to the early failure of 2 of these transmitters we discontinued using them in 2007; all individuals caught in 2007 were outfitted with the smaller PD-2 transmitters. We affixed 1 transmitter using a tail-mounted attachment, but the owl removed the transmitter within 3 days. We discontinued this method because screech-owl tail feathers did not appear to be sufficiently robust to support tail-mounted transmitters.

Backpack radio-transmitters did not appear to negatively affect owls, as evidenced by increases in body mass of several birds while tagged. One adult female weighed 197 g when captured 31 May 2006. At her death (struck by vehicle) 111 days later (19 September 2006), she weighed 255 g; a 29% increase in weight in 3.5 months. Additionally, an adult female weighed 229 g when fledging young, but her weight increased by 18% to 270 g when she was re-captured in March 2007.

### Radiotelemetry monitoring

We collected 704 radiolocations of 11 tagged owls during 2688 radio-days of monitoring between July 2005 and January 2008 (Fig. 7). Of these radiolocations, 659 were suitable for home-range scale habitat analyses, 580 of these were suitable for stand level analyses, 499 for patch level analyses and 316 identified the tree the owl was utilizing and thus were suitable for element scale analyses. We collected 472 radiolocations when owls were roosting, whereas 134 were of owls hunting or unknown behaviour (i.e., night-time radiolocations). Screech-owls were radio-monitored between 4 and 573 radio-days ($\bar{x}$ = 244 radio-days, SD = 170, $n$ = 11).

## *Discussion*

Eliciting aggressive responses is necessary when using call playback, decoys and mist nets to capture screech-owls. We experimented with many different screech-owl calls to increase the aggressiveness of the response and our capture efficiency but found that owls were captured most frequently when the call of the same sex or calls of an excited pair of owls “talking” to each other (1999, Paso Robles, California, from www.owling.com) were played. Only once was an owl caught with the call of the opposite sex. We made many attempts to improve our capture success, such as attaching strings to move the decoy, which did not seem to elicit much additional aggression.

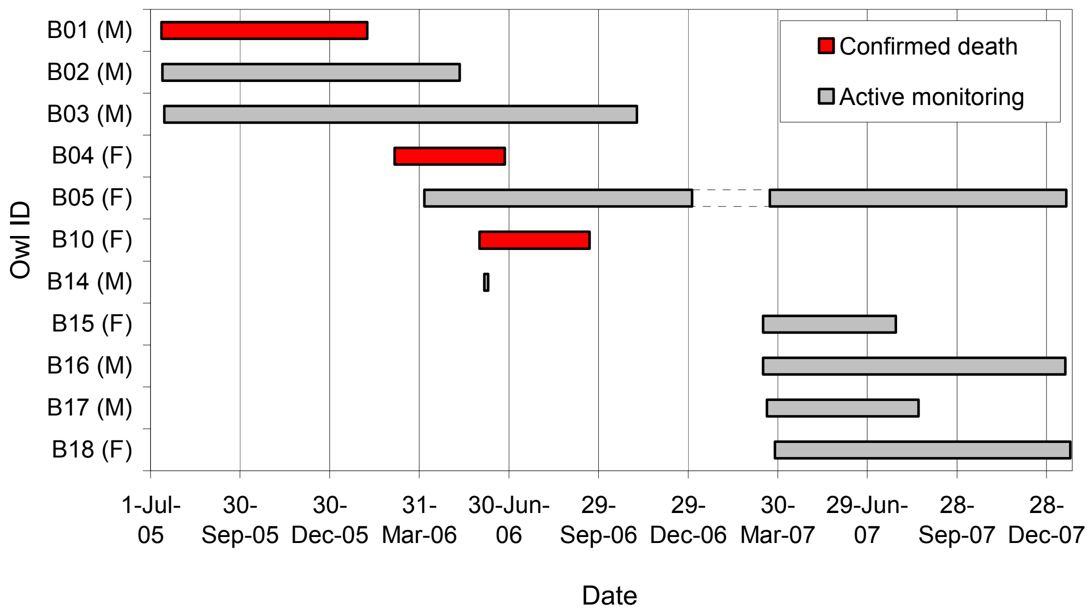


**Figure 7. Tracking history of 11 radio-tagged western screech-owls monitored along the Shuswap River, British Columbia, 2005-2008.**

We noticed a substantial difference in ease of capture between male and female screech-owls; females were more aggressive than males and were more prone to attack. During the breeding season, males call extensively to attract females to their territory, after which the male moves to the potential nest site and calls more to attract the female to the nest cavity (Feusier 1989). Perhaps lone males were less aggressive than females because they are smaller and, without a mate to defend, there is no benefit to engaging in potentially deadly conflict. Indeed, we were unable to change the behaviour of lone males to come to the decoy female and observed that playing female calls caused the males to call loudly from nest sites during the pre-breeding period.

Aggression levels are dependent on hormone levels (Herting and Belthoff 1997), which fluctuate through the year and timing appeared to have considerable affect on the capture success that we observed. Capture success for naïve (i.e., previously uncaptured) owls was highest in March, which corresponds to increased hormone levels associated with breeding (Herting and Belthoff 1997). Capture success of naïve owls increased during the fledging and post-fledging periods (first week of June and into July) when the adults were aggressive again. It appeared that the propensity to attack the decoy declined after this point and did not increase again until the following breeding season.

Capture success was affected by other factors in addition to timing. The location of the capture apparatus within the home range seemed to affect the likelihood of success. Differences of <100 m among capture sites appeared to affect the aggressiveness exhibited by breeding pairs; success appeared to be greater as we live-trapped closer to the nest site. We also noted that capture success was low on moonlit nights, during which the owls appeared to see the nets. In these instances, we found that moving the nets into the shadows of trees helped reduce this effect. Placing the net between suitable trees or sites in which the owl could perch while building up to an attack seemed to increase the likelihood of capture. Using more than one mist net did not appear to be necessary, as one mist net with the decoy owl next to appeared to be sufficient when capturing owls.

We observed 2 different types of responses by owls to the decoy owl and calls. Some owls immediately rushed to the trap site and attacked; 4 owls were captured in less than 10 minutes from the start of playing calls. Other owls seemed to build up to an attack by conducting “fly-by’s” above the decoy owl several times. Leaving the capture apparatus operational for >1 hour did not tend to improve capture success; if the owls were flying about calling and not flying directly over the net and decoy, they never attacked and we learned to end the session after an hour. The maximum time to first response that resulted in an owl capture was 37 minutes.

Banding birds was useful for identification upon death and recaptures. Feathers and blood were easily obtained for future DNA analyses. Feathers were sometimes retrieved from handling bags.

We attempted to recapture owls to change or remove transmitters, but found that recapturing individuals was difficult. As Smith and Walsh (1981) observed, owls were wary of the trapping apparatus in which they were caught before. We observed one female the night following her capture in a mist net, while we tried to capture her mate, the second night she was obviously avoiding the mist net. However, we caught one female 3 times using mist nets and call-playback, and her mate twice.

We recommend that future research projects use transmitters that last longer than those we used because information need to be collected on owls through the critical period of January-March of each year. This is the period during which we documented 1 mortality and observed considerable territory turnover (see *Survivorship and territory turnover* section).

# Spatial Organization

Western screech-owls are territorial animals that defend a defined space from conspecifics throughout the year (Cannings and Angell 2001). Much of our understanding of the spatial organization and space-use patterns of western screech-owls has been gleaned from natural history and call-playback observations of vocalizing owls. It is from these observations that researchers have determined that screech-owls can occur in densities of up to 14 pairs in 6.4 km of river (Feusier 1989) and speculated that a screech-owl pair can occupy up to 58 ha centred along large creeks (Idaho; G. Hayward, University of Wyoming, pers. comm.). However, data from vocalizing owls or incidental observations of the species does not provide unbiased indications of space use or movements.

Western screech-owls have long been known to be closely associated with riparian forest habitats in most places the species occurs (Cannings and Angell 2001), with researchers assuming that home ranges are centred on these habitats (Hayward and Garton 1988). Indeed, western screech-owls have been used as an indicator of the health of riparian ecosystems (Chaundy-Smart 2002). However, because of the lack of unbiased space-use data, the requirements of screech-owls for this habitat is unknown and previous work has been unable to determine if these habitats are required for resident owls to occupy an area within the landscape. This shortcoming has hampered efforts that need this vital data to ensure effective conservation.

Unfortunately, developing effective conservation programs targeted at occupied sites is difficult when the actual areas used by resident screech-owls is unknown. Our objective was to quantify the home ranges of radio-tagged owls within our study area and characterize the composition of their home ranges. This data is critical to be able to predict potential densities and distributions of the species throughout its range in British Columbia. It is also provides insights into the areas outside of known habitat associations for which land management specific for the species should occur.

## *Methods*

For home range analysis, we used only those radiolocations for which the 95% error polygon was ≤ 4.35 ha. This criterion was selected because it was equivalent to approximately 5% of the average minimum area used by tagged screech-owls (as of 15 November 2005), which we considered to be an acceptable level of precision.

We estimated the size and location of the home range of each resident screech-owl for which we gathered sufficient data. For screech-owls with 30 or more radiolocations, we estimated home ranges using the 95% isopleth of the utilisation distribution (UD) generated from the fixed kernel method with the smoothing parameter selected by least-squares cross-validation (Worton 1989, Seaman et al. 1999). For screech-owls with repeated observations at one location (e.g., nest site, roost tree), we estimated the UD with the fixed kernel for a dataset without repeated observations. Using the value of the smoothing parameter generated from this technique, we re-ran the fixed kernel on the complete dataset. We used the Animal Movement extension to ArcView (Hooge and Eichenlaub 1999) for all home range calculations.

We calculated aggregate and seasonal home ranges for each screech-owl. We pooled locations across years for each screech-owl for the calculation of their aggregate home range, including individuals for which we collected radiolocations for ≥10 months. We estimated breeding (i.e., egg-laying to fledging) and non-breeding seasonal home ranges from data collected within one season for each screech-owl.

We examined spatial overlap of the home ranges among screech-owls using a coefficient of overlap (Walls and Kenward 2001). This measure allowed us to assess the overlap between 2 home ranges with a single dyad measurement:

$$\text{Coefficient of overlap} = 2 \times (\text{overlap}_1 \times \text{area}_1)/(\text{area}_1 + \text{area}_2)$$

where the home range $\text{area}_x$ of $\text{screech-owl}_x$ has a coefficient of $\text{overlap}_x$.

Inter-nest distances were measured between nests. In one case where different nests were used in one territory over two years (209 m apart) we averaged the distance between the nests in the neighbouring territories to the two nests.

We used several sources of spatial data to evaluate spatial relationships among owls and their habitat. We overlaid the aggregate 95% UD home ranges on draft (not ground-truthed) terrestrial ecosystem maps of the project area (Grods and Uunila 2008) to determine the composition of the home ranges of resident screech-owls. We measured distances to the edge of the Shuswap River using Terrain Resource Inventory Management data (Ministry of Sustainable Resource Management 2005). We also quantified where within the home range owls situated nest sites by calculating a UD based on all non-nesting radiolocations and identifying the isopleth of the UD in which the nest occurred (Fig. 8). The value of the UD score represented the probability of an owl using that portion of its home range; nests with low UD scores were closer to the core of the home range, whereas those with UD scores closer to 95% were situated near the periphery.

## *Results*

We collected 704 radiolocations of 11 radio-tagged screech-owls between 12 Jul 2006 and 18 Jan 2008, of which 659 were suitably precise for inclusion for home range analysis (i.e., error polygons < 4.35 ha).

We estimated aggregate home ranges for 5 owls (3 M, 2 F; Figs. 9 - 11). Aggregate 95% fixed kernel estimates of home ranges averaged 64.5 ha ($SD = 10.6$, $n = 5$). Aggregate home ranges of males were very similar in size to those of females ($\bar{x}_{Male} = 62.5$ ha, $SD = 6.8$, $n = 3$; $\bar{x}_{Female} = 67.6$ ha, $SD = 18.0$, $n = 2$).

Owls used considerably smaller areas during the breeding season ($\bar{x} = 20.4$ ha, $SD = 15.3$, $n = 7$) than the non-breeding season ($\bar{x} = 88.6$ ha, $SD = 44.5$, $n = 6$).

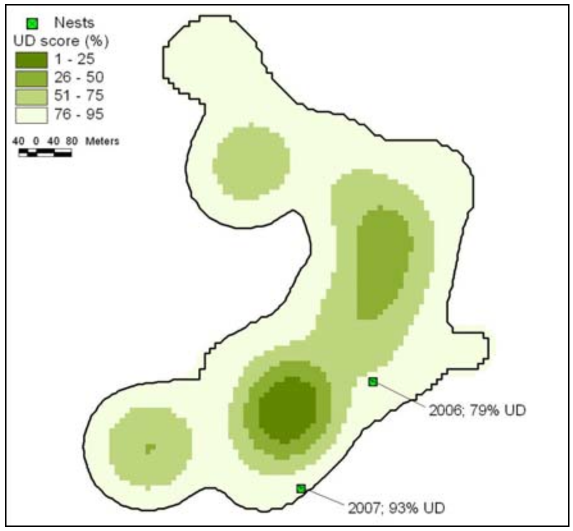


**Figure 8. Method for identifying the UD score of the nest within the utilization distribution (UD; home range) derived from non-nesting radiolocations of tagged screech-owls along the Shuswap River, British Columbia. This owl (B05) had 2 nests (2006, 2007) that were located in the 79% and 93% isopleth of her non-nesting UD.**

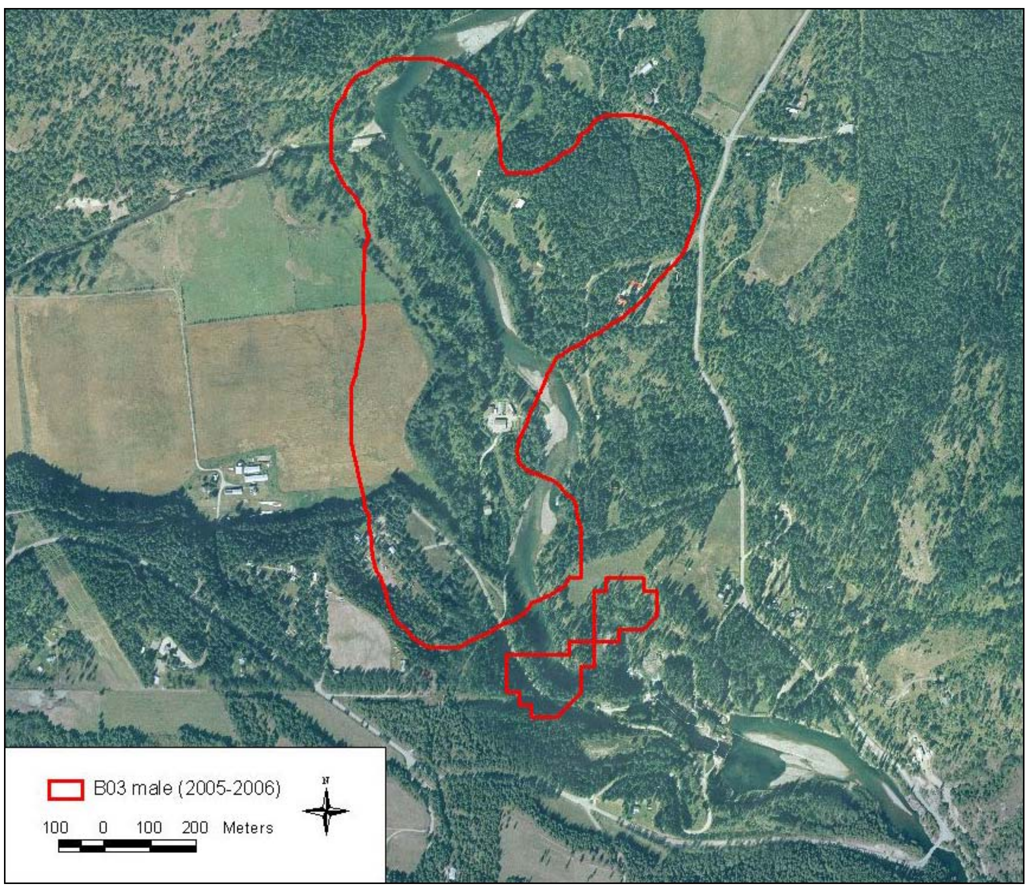


**Figure 9. Aggregate home range of adult male B03, based on 112 radiolocations collected between Jun 2005 and Nov 2006 along the Shuswap River, British Columbia. Another adult male (B17, insufficient data) occupied this area during 2007. Both males had mates that were radio-tagged but insufficient data was collected to determine aggregate home range sizes.**

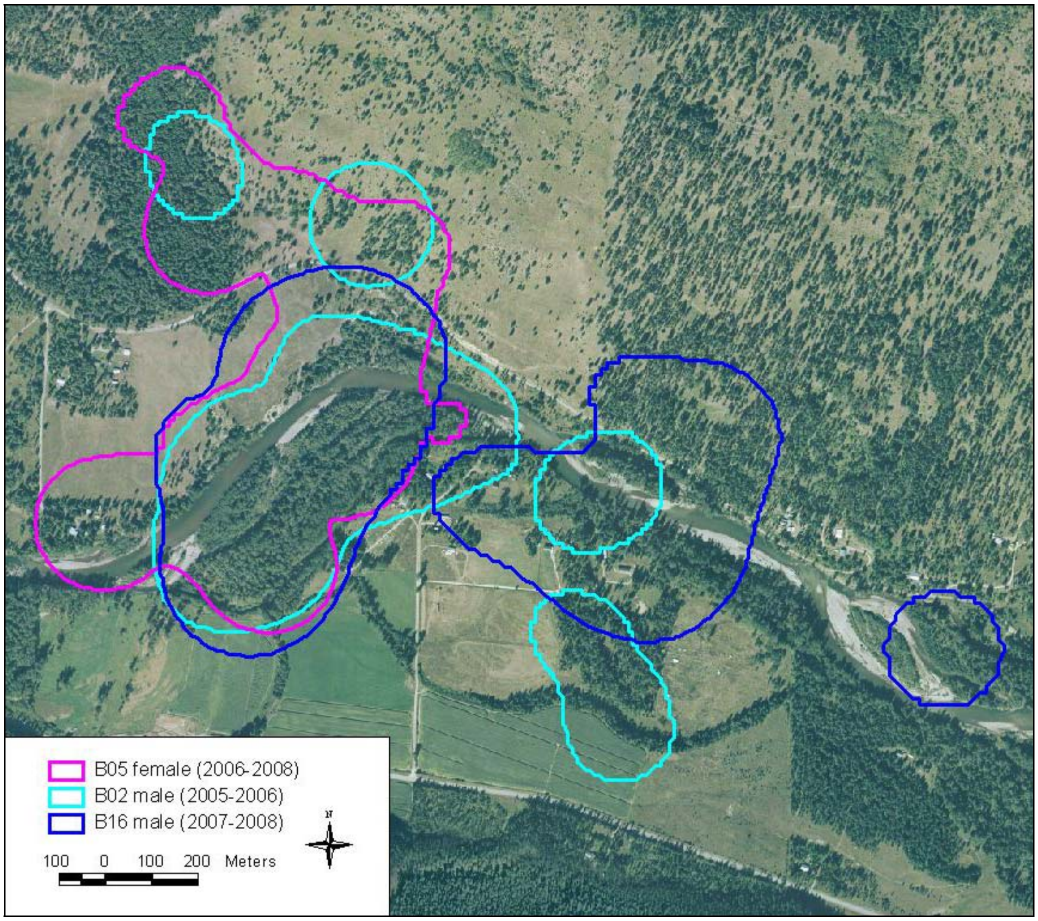


**Figure 10. Aggregate home ranges of an adult female (B05) and 2 adult male (B02, B16) western screech-owls monitored between Jul 2005 and Jan 2008 along the Shuswap River, British Columbia. B02 was presumed to be dead when B16 was captured in Mar 2007.**

### Home range overlap

Overlap of home ranges varied among and within individuals. Overlap only occurred within male-female breeding pairs and in different years among home ranges of owls through replacement of individuals. We did not detect overlap of owls that were not part of a pair (i.e., no overlap with adjacent home ranges). Overlap within pairs during the breeding season averaged 71% (SD = 8, $n$ = 3); however, overlap reduced to 43% (SD = 10, $n$ = 2) during the non-breeding season. Individual screech-owls tended to segregate their use of space throughout the year; overlap between the breeding and non-breeding home range of individual owls averaged 35% (SD = 22, $n$ = 4).

### Inter-nest distance

Inter-nest distance ranged from 1164 m to 7076 m ($\bar{x}$ = 3314 m, SD = 2330, $n$ = 4). Inter-nest distances have been found as close as 300 m in the Pacific Northwest (Cannings and Angell 2001), and as much as 205 to 8475 m in southern Idaho ($\bar{x}$ = 3054 m ± 481 SE; Rains 1998). Three nests in our study were 1164 and 1605 m apart, which may be a more typical inter-nest distance in areas with a continuous distribution of cottonwood riparian habitats.

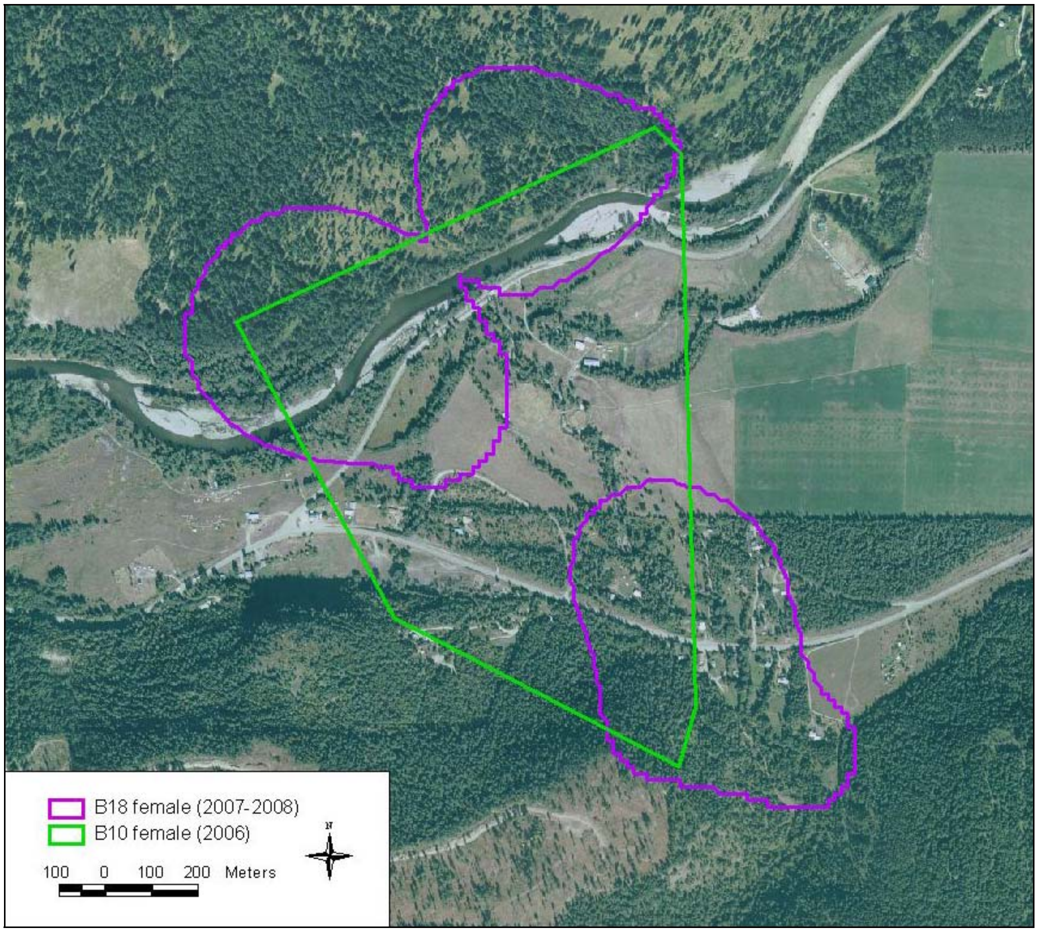


**Figure 11. Aggregate home ranges of reproductive females B10 in 2006 (minimum convex polygon) and B18 in 2007-2008 along the Shuswap River near Cherryville, British Columbia.**

### Home range composition: habitats within the home range

The home ranges of the tagged owls were comprised of many different ecosystems and structural stages. Based upon 1:20,000 scale draft terrestrial ecosystem mapping (Grods and Uunila 2008), 5 screech-owls included between 22 and 52 stands within their home ranges ($\bar{x}$ = 33 stands, SD = 11). Although the composition varied among individuals, on average home ranges generally included 11.9 ha of riparian forest (i.e., IDFmw1/05 [Lloyd et al. 1990]; SD = 4.4, *n* = 5; Fig. 12). Mature and old forest structural stages comprised, on average, 10.4 ha of an aggregate home range (SD = 6.2, *n* = 5; Fig. 13). All of the home ranges overlapped portions of the Shuswap River; home ranges included at least 867 m of riverfront ($\bar{x}$ = 1198 m, SD = 250, *n* = 5).

### Proximity to nests and rivers

We estimated the distance to nest for 686 radiolocations of 10 screech-owls. Not surprisingly, both male and female owls, on average, used sites closer to the nest during the breeding season (egg-laying through to post-fledging; $\bar{x}_{Male}$ = 188 m, SD = 43, *n* = 5 owls; $\bar{x}_{Female}$ = 132 m, SD = 56, *n* = 5 owls) than non-breeding season ($\bar{x}_{Male}$ = 458 m, SD = 124, *n* = 5 owls; $\bar{x}_{Female}$ = 599 m, SD = 225, *n* = 4

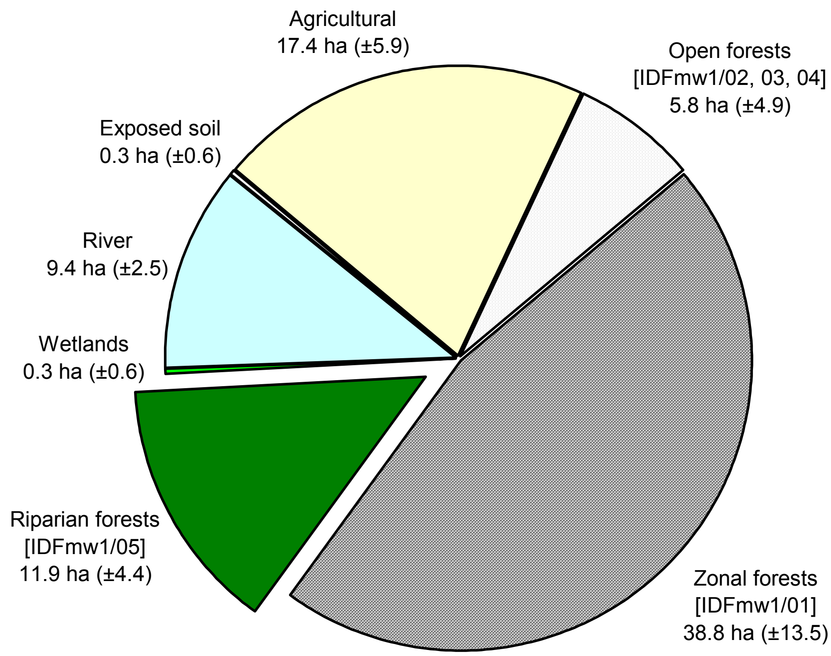


**Figure 12. Mean area (±SD) of ecosystems occurring within an average aggregate home range of western screech-owls tagged along the Shuswap River, British Columbia, 2005-2008. *N* = 5 owls.**

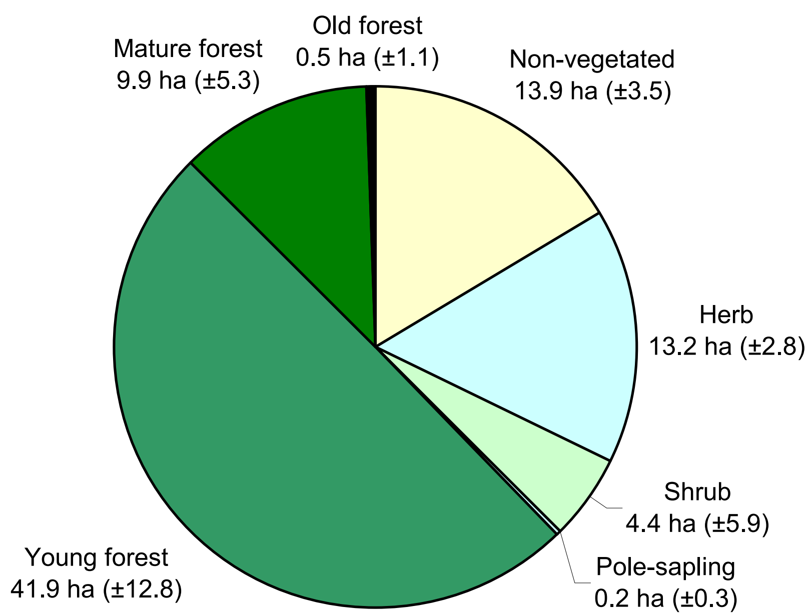


**Figure 13. Mean area (±SD) of structural stages occurring within an average aggregate home range of western screech-owls tagged along the Shuswap River, British Columbia, 2005-2008. *N* = 5 owls.**

owls). Most radiolocations during the breeding season were within 50 m of the nest, whereas most from the non-breeding season were >450 m away from the nest (Fig. 14).

Nests were not situated in either the geographic centre or core area of the home range (Fig. 8). The mean score for the utilization distribution of the home range at the nests was 54% (SD = 24, *n* = 9 owls), indicating that nests occurred outside of the 50% isopleth, which is often considered the core area of a home range.

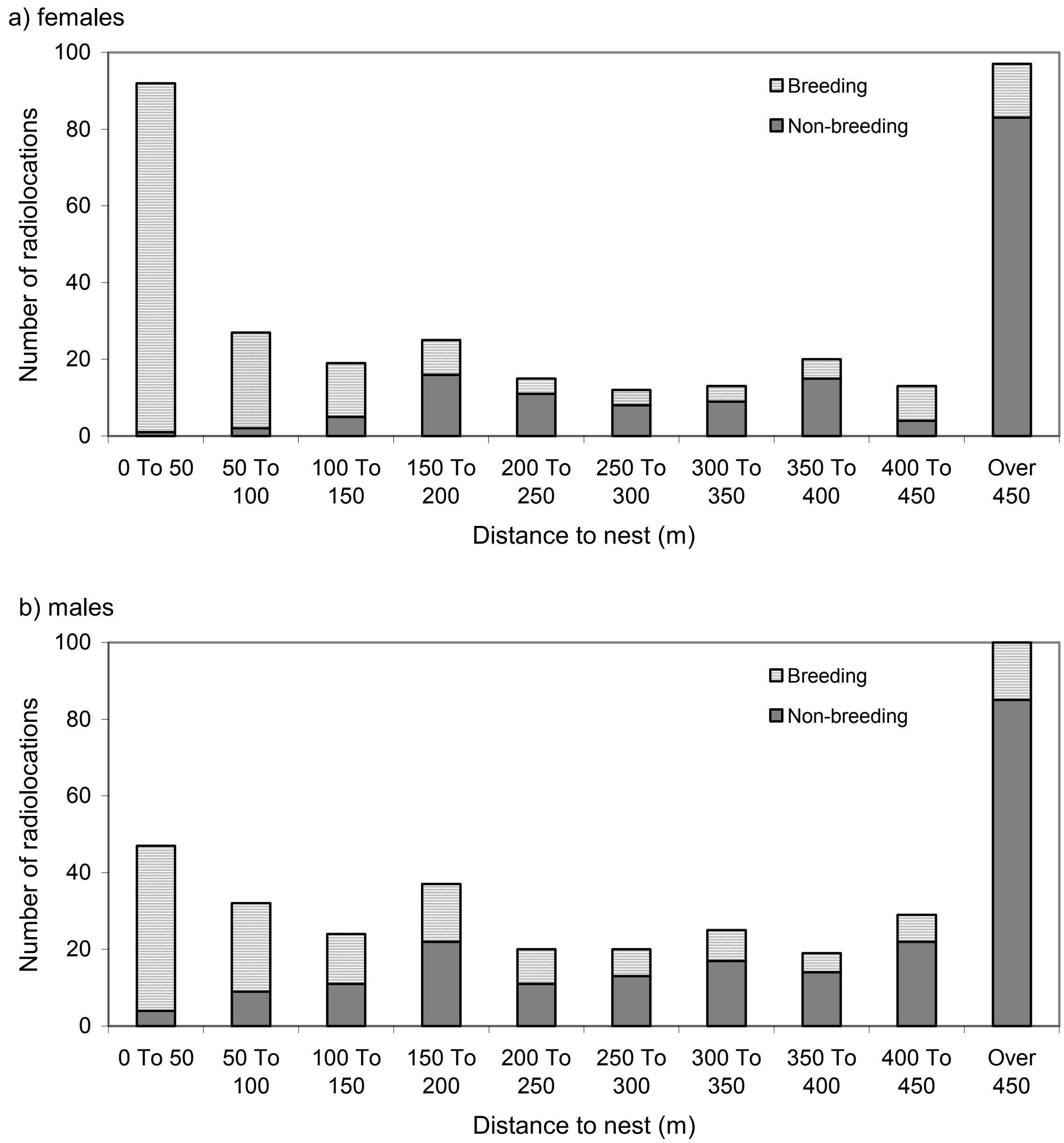


**Figure 14. Relationship between season and proximity to nest for a) female and b) male radio-tagged western screech-owl along the Shuswap River, British Columbia, 2005-2008. Breeding season includes egg-laying through to post-fledging periods.**

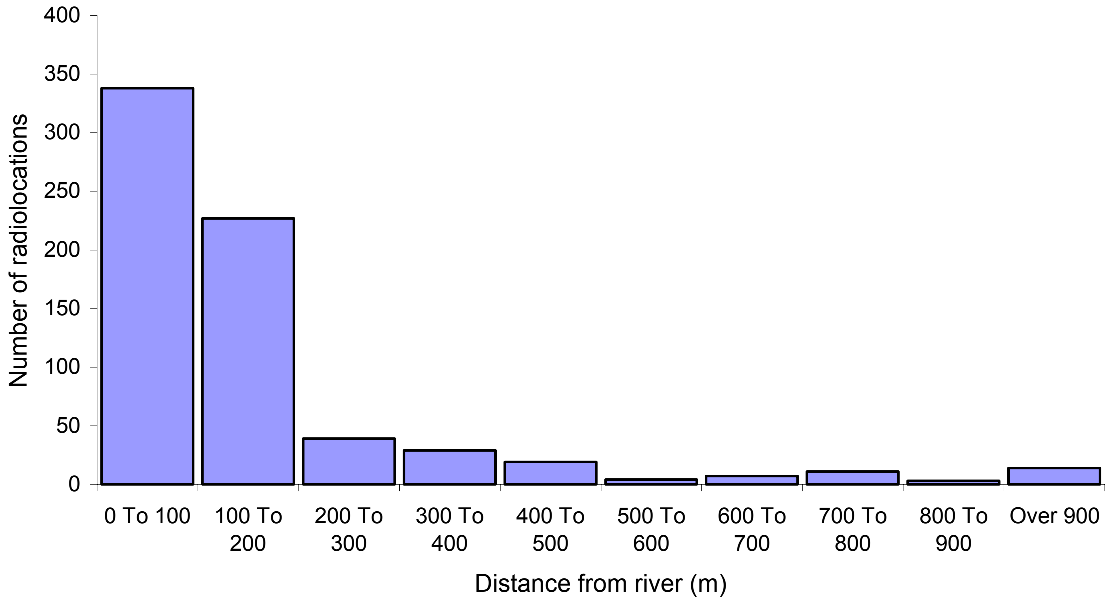


**Figure 15. Distribution of radiolocations of radio-tagged western screech-owls in relation to distance to the Shuswap River, 2005-2008. *N* = 704 radiolocations of 11 owls.**

The mean proximity to the river for females ($\bar{x}$ = 112 m, SD = 26, $n$ = 5 owls) was not substantially different than for males ($\bar{x}$ = 99 m, SD = 21, $n$ = 5 owls). However, during the non-breeding season, the average distance of females from the river ($\bar{x}$ = 346 m, SD = 230, $n$ = 4 owls) was farther than the males ($\bar{x}$ = 131 m, SD = 42, $n$ = 5 owls). Ninety-five percent of all radiolocations that we collected were within 620 m of the Shuswap River (Fig. 15).

## *Discussion*

Our results showed that western screech-owls had large home ranges that, although each included considerable stretches of river, incorporated a wide variety of ecosystems. The use of their home ranges throughout the year varied considerably, with much apparent spatial segregation between portions of the home range used during the breeding period relative to the remainder of the year. These observations have considerable implications for effective density estimation and survey protocols.

Previous work has focussed on surveys or inventories conducted during the nesting season, when owls are most responsive to call-playback (Cannings and Angell 2001). However, space-use by western screech-owls during this period was at its most constrained. Our data also indicated that the area used by screech-owls during the remainder of the year was almost 4 times that used during the breeding season and included considerably different ecosystems. Thus, it is quite likely that previous estimates of the size of screech-owl home ranges have been low.

There are several likely causations for the shift in space use from breeding to non-breeding periods. Because owls spent >2 months at nests, it is likely that prey became depleted in the nest area. Perhaps the shift in space-use that we observed was related to foraging efficiency. Also, it is possible that prey was not spread evenly throughout the home range and prey concentrations fluctuated in different habitats at different times of year. Inter-species competition from 4 other owl species that we documented within the study area may also have occurred within the breeding home range, so a shift to other areas when the owls were not constrained to the nest would reduce this competition.

Resource partitioning may also help explain the reduction in overlap of space-use among breeding pairs during non-breeding periods. We observed that the male and female of a pair would use considerably different areas during the non-breeding period, roosting on opposite sides of the territory for much of November though January. This may be another strategy to decrease competition within a pair for limited food resources, in addition to the reduction in dietary overlap among sexes that we observed (Davis and Cannings *in press*).

Home ranges were centred on riparian habitats in close proximity to the Shuswap River, however they were not centred around the nest. Riparian habitats occur most widely on fluvial river systems where frequent inundation and consistent sub-surface moisture (Lloyd et al. 1990) allow for the establishment and development of large deciduous trees such as black cottonwoods. Because of their decay characteristics (Jamieson et al. 2001), these large deciduous trees are one of the few species that develops cavities of sufficient size to house nests (see *Habitat Relationships* section). Because males seem to establish their territories around nest opportunities and these opportunities are most common in large old deciduous trees (Jamieson et al. 2001), it is not surprising that a considerable amount of riparian habitat is needed within the home range.

The inferences that we could draw about the factors that affected where screech-owls occurred within the landscape were limited by the extent of ecosystem mapping that was available. Ecosystem mapping was completed for 38 $km^2$ of the 195 $km^2$ of the IDFmw1 that occurred within 2.5 km of our research area land. Because the mapping was completed for areas immediately adjacent to the Shuswap River, it was not a representative sample of ecosystems within the IDFmw1 variant. The mapping likely overestimated the relative abundance of the IDFmw1/05 ecosystem because it was focussed along the river, where this ecosystem was most likely to occur. Despite this bias, screech-owls included substantially more of the IDFmw1/05 ecosystem in their home ranges than was expected from the mapping ($\bar{x}$ = 14.9% within home ranges, compared to 6.0% overestimated from the mapping). Thus, we can conclude with reasonable confidence that screech-owls select for home ranges largely on the ability of an area to supply on average 12 ha of cottonwood riparian forest within a 65-ha home range.

# Habitat Relationships

## *Introduction*

Screech-owls rely on habitat to fulfil their day-to-day resource requirements for roosting, foraging, and nesting. Although screech-owls may be selective in the habitats that they use to meet these needs, the only consistent habitat observation is their broad-scale association with forested riparian habitats throughout their range (Cannings and Angell 2001).

Screech-owls are a secondary cavity nester (Cannings and Angell 2001) and a supply of suitable nest cavities are needed to support breeding. Screech-owls have been reported to use primarily large deciduous trees for nesting, including cottonwoods (*Populus* spp.), bigleaf maple (*Acer macrophyllum*), paper birch (*Betula papyrifera*), water birch (*B. occidentalis*) and trembling aspen (Cannings and Angell 2001, Beaucher and Dulisse 2004, Canning and Davis 2007). It is believed that screech-owls rely upon primary cavity nesters, such as northern flickers and pileated woodpeckers, to excavate cavities suitable for use as nests, although some occur in natural branch-hole cavities (Cannings and Angell 2001).

Habitats used by screech-owls for foraging are poorly identified. Screech-owls are sit-and-wait predators, being that they dive from perches (Cannings and Angell 2001) and catch prey either on the ground, or in the case of aquatic insects and fish, in shallow water. The diet of screech-owls in our project area included small mammals, birds, fish and insects (Davis and Cannings *in press*). It is likely that foraging habitat for screech-owls is related to the provision of suitable prey and availability of perches, balanced with the limitation of structural complexity.

It is speculated that western screech-owls need roosting habitats to supply several key features to be used successfully. An effective roost has an amenable microenvironment that keeps the owl within its thermoneutral zone (Abeloe and Hardy 1997, Cannings and Angell 2001). Roosts must provide security from both avian and mammalian predators (Hayward and Garton 1988; Cannings and Angell 2001) and successful roosting habitats may have higher levels of catchable prey than other habitats (Rodriguez-Estralla and Careaga 2003).

Although life requisites that owls need to have fulfilled by roost sites have been identified, our understanding of which habitat features can be used successfully is limited. Screech-owls use both branches and cavities in trees for roosting (Cannings and Angell 2001). Hayward and Garton (1984) found that screech-owls used deciduous trees for roosts only during the summer months; during winter, owls used only coniferous trees. Canning and Angell (2001) suggest that cavities may be important as roost sites during winter because they provide a better microenvironment than branch roosts.

Our objectives were to describe habitat features used by western screech-owls for roosting, nesting, and hunting at several spatial scales. Few studies, however have quantified selectivity and none that we could find have developed models that could be used to predict the relative value of different habitats for screech-owls. Our ultimate purpose is to develop data-driven models that predict the value of trees, patches, and stands for western screech-owls so that conservation programs can identify and target habitats at each scale that are important for the maintenance of screech-owl populations.

## *Methods*

We examined the habitat relationships of screech-owls at several spatial scales. These scales were nested and ranged from fine-scale to coarse-scale. *Elements* were single structural features of habitat such as a single nest or roost tree. *Patches* were small areas with unique soil, vegetation, or site characteristics and, for western screech-owls, likely range in area up to 150 m². An example of a patch is a small clump of 5-10 trees within an otherwise open stand. *Stands* were composed of patches and vary from 1.5 ha to hundreds of hectares. Stands were generally derived from the site series classification of the biogeoclimatic ecosystem classification system (Pojar et al. 1987) and were further differentiated according to more specific site conditions (thus defining more homogeneous site units) and structural developmental stages (thus defining more homogeneous vegetation structure).

We explored fine-scale habitat selection by radio-tagged screech-owls along the Shuswap River, British Columbia by examining the selection of elements, patches, and stands. Our objectives were to 1) identify the fine-scale habitat features that screech-owls exploit, 2) develop parsimonious models that predict the probability of selecting identified habitat features, and 3) assess the specificity that screech-owls have for each feature. To achieve this, we asked several questions:

1) are screech-owls selective for elements, patches, or stands?
2) if so, what features affect the probability of selection?
3) how strong is the relationship between selection and these habitat features?

Understanding the linkages between screech-owls, their behaviours, and the supply of identified habitats will allow us to predict the effects that habitat alteration may have on the ability of habitats to support sustainable populations of screech-owls.

### Experimental design

We used similar designs at the element, patch, and stand scales to examine the effects that various factors had on the probability of selection by screech-owls. At the element scale, we compared the tree used by a screech-owl to simultaneously unused trees found within the same patch. At the patch scale, we compared a patch of habitat used by a screech-owl (e.g., a clump of sapling conifers) to a simultaneously unused patch within the same stand. We also compared the stand selected by a screech-owl to simultaneously unused stands elsewhere within its home range. We considered a radiolocation to be the measured currency of use (i.e., an index of time spent at a specific element or patch; Buskirk and Millspaugh 2006).

We used the scale of examination to identify the boundaries of "choice sets" (Buskirk and Millspaugh 2006) for each selection event. That is, we identified features that were available to each individual within the scale of examination. We considered use of a specific element (e.g., roost tree) to have occurred as selection of one of the numerous elements available within a patch. Likewise, selection of a patch occurred when individuals selected from a choice of patches within a stand.

We were constrained by sample sizes in the level of habitat examinations that we could perform. Roosting was the only behaviour for which we had enough data to examine selectivity at the element and patch scales. At least 10 observations are needed to be able to conduct selection analyses (Peduzzi et al. 1996) and, because of the limited number of nests that were identified, we could not conduct element or patch selectivity analyses for nesting. Also, the difficulty in collecting sufficiently precise hunting radiolocations precluded us from conducting selectivity analyses at the element and patch spatial scales for foraging. We did, however, provide descriptive statistics of the habitats that screech-owls used for these behaviours at these scales.

**Analysis**

We completed separate analyses of the factors that affected selection by radio-tagged screech-owls at the 3 spatial scales. We considered selection as a binary process and modelled the process as a logistic function. Because we used temporal stratification to identify used and unused elements, patches, and stands, the derived function was a resource selection probability function (RSPF, Manly et al. 2002).

As outlined in Tables 6 – 8, we developed different sets of candidate models to evaluate hypothesized relationships between habitat factors and selection at each spatial scale. We used information from previous studies of screech-owl ecology and suspected ecological relationships to develop *a priori* models that we tested using information-theoretic inference (Burnham and Anderson 1998), in which several competing hypotheses (models) were simultaneously confronted with radiotelemetry data (Johnson and Omland 2004). We assessed multicollinearity among variables at each scale by ordinary least-squares regression; we determined that those combinations of variables with $r^2 \geq 0.4$ were sufficiently correlated to exclude them from the same model (Ballinger 2004).

**Hypothesis (model) development**

Past research on fine-scale selection of habitat by screech-owls has identified few environmental variables that may affect which habitats are selected by owls for roosting at element and patch scale and for habitat selection at the stand scale (Tables 6 - 8). Many of the models that we examined were based on observations from elsewhere, especially from Hayward and Garton's (1998) study of roosting screech-owls in southern Idaho. Several models that were based on previously published literature included correlated variables; to examine these models, we excluded the variable of each correlated pair that we believed to have the least amount of ecological relevance to the selection process. Many models, however, were unique hypotheses that we thought might explain selection better than other previously identified models.

Some models included 2 variables that interacted; using this approach we were able to model the effect of one factor on the probability of use being mediated by (or compensatory on) another. For example, model R-9 (Table 6) includes the variable interaction “Length of crowns of deciduous trees depending upon phenology”. Our interpretation of this interaction is that screech-owls will be more likely to use a deciduous tree with a long crown during the leaf-on period than either 1) the same tree during leaf-off period, or 2) a different deciduous tree with a short crown during the leaf-on period. In this instance, the variables functioned collectively to influence selection.

### Hypothesis (model) evaluation

We used an information-theoretic approach to identify the most parsimonious models (Burnham and Anderson 1998) that predicted selection by radio-tagged screech-owls at each spatial scale. Information-theoretic inference allowed us to compare the support by the data among several hypothetical models (including a null model that predicted no selection) and determine the probability of each model in the candidate set being closest to the underlying process that affected selection (i.e., selection decisions by the animal). Information-theoretic (IT) inference differs from conventional frequentist inference in that IT inference estimates the likelihood of the estimated parameter (i.e., resource selection probability function) given the data that was collected, whereas frequentist inference estimates the likelihood of the data given the estimated parameter. Since the data always has a likelihood of 100%, IT methods provide more valuable inference about the process that generated the data (i.e., selection by the animal).

**Table 6. Set of 18 candidate models used to examine selection of elements within patches by radio-tagged western screech-owls for roosting along the Shuswap River, British Columbia, 2005-2008.**

| Model ID | Number of variables | Probability of use of tree for roosting related to: |
|---|---|---|
| R-1 | 2 | Deciduous during leaf-on, coniferous otherwise |
| R-2 | 2 | Crown condition |
| R-3 | 1 | Diameter |
| R-4 | 7 | Coniferous tree species |
| R-5 | 1 | Length of tree crown |
| R-6 | 1 | Height of tree |
| R-7 | 7 | Tree form depending upon diameter |
| R-8 | 1 | Similarity between colour and pattern of tree bark and plumage |
| R-9 | 1 | Length of crowns of deciduous trees depending upon phenology |
| R-10 | 1 | Crypticness afforded by bark depending upon phenology |
| R-11 | 2 | Size of crown adjusted for phenology |
| R-12 | 1 | Presence of potential nests |
| R-13 | 2 | Crypticness afforded by bark during leaf-off, crown length during leaf-on |
| R-14 | 2 | Diameter class (20-40 cm dbh, >40 cm dbh) |
| R-15 | 1 | Status of tree – live or dead |
| R-16 | 2 | Quadratic relationship with diameter |
| R-17 | 2 | Length of crown adjusted for phenology and depending upon patch cover and length of coniferous crown depending upon patch cover |
| R-null | 0 | Nothing (no selectivity) |

**Table 7. Set of 18 candidate models used to examine selection of patches within stands by radio-tagged western screech-owls for roosting along the Shuswap River, British Columbia, 2005-2008.**

| Model ID | Number of variables | Probability of use of patch related to: |
|---|---|---|
| P-1 | 1 | Cover of trees and shrubs |
| P-2 | 1 | Tree cover |
| P-3 | 1 | Shrub cover |
| P-4 | 1 | Tree density |
| P-5 | 1 | Density of trees >40 cm dbh |
| P-6 | 1 | Density of deciduous trees |
| P-7 | 1 | Shrub cover depending on amount of tree cover |
| P-8 | 1 | Proximity to Shuswap River |
| P-9 | 1 | Proximity to edge of stand |
| P-10 | 1 | Slope |
| P-11 | 2 | Density of conifers during winter and density of all trees during summer |
| P-12 | 2 | Tree and high-shrub cover, and low-shrub cover |
| P-13 | 2 | Cover of trees and shrubs and proximity to nest during nesting period for males |
| P-14 | 3 | Density of trees >40 cm dbh, proximity to edge, and cover of trees and shrubs |
| P-15 | 2 | Mean dbh of trees and cover of trees and shrubs |
| P-16 | 2 | Density of trees >40 cm dbh and cover of trees and shrubs |
| P-17 | 3 | Density of trees >40 cm dbh, tree and high-shrub cover, and low-shrub cover |
| P-null | 0 | Nothing (no selectivity) |

**Table 8. Set of 11 candidate models used to examine selection of stands within home ranges by radio-tagged western screech-owls for roosting along the Shuswap River, British Columbia, 2005-2008.**

| Model ID | Number of variables | Probability of use of stand related to: |
|---|---|---|
| S-1 | 4 | Structural stage |
| S-2 | 8 | Ecosystems |
| S-3 | 1 | Stand area |
| S-4 | 6 | Broad stand categories |
| S-5 | 3 | Stand composition |
| S-6 | 2 | Riparian ecosystems |
| S-7 | 1 | Mature riparian forests |
| S-8 | 3 | Mature riparian forest agricultural areas zonal forests |
| S-9 | 3 | Stand composition based upon phenology |
| S-10 | 4 | Structural stage |
| S-null | 0 | Nothing (no selectivity) |

We dealt with the longitudinal nature of repeated observations on a fixed number of radio-tagged screech-owls by employing generalized estimating equations to generate a population-averaged model (Hu et al. 1998). Because generalized estimating equations are not likelihood-based, we used a modification to the Akaike Information Criterion to produce a quasi-likelihood information criterion ($QIC_u$) to identify the most parsimonious model (Pan 2001). We assumed that correlation among data points occurred within individuals, which necessitated the use of exchangeable correlation (Ballinger 2004) as our working correlation structure. We calculated the $QIC_u$ score for each model and ranked the relative support for each model by comparing the scores among competing models. We then identified the "best" model from this candidate set by selecting the model with the lowest $QIC_u$ score. We assessed whether selection occurred by comparing the $QIC_u$ scores of the models in the candidate set to a null model that predicted no selection. We considered selection to have occurred if the null model was not within the 95% confidence set of best models.

We used Akaike weights ($w_i$) to quantify strength of evidence for candidate models (Burnham and Anderson 1998). The 95% confidence set of best models was identified using the fewest top models where $\sum w_i$ was ≥0.95. We used multi-model inference to estimate model-averaged parameters and unconditional 95% confidence intervals for each of the variables in the production of a best predictive model (Burnham and Anderson 1998). Odds ratios >1 indicated increasing probability of use with increasing values of the variable, whereas an odds ratio <1 indicated decreasing probability of use.

This inferential process allowed us to determine if selection occurred, and if so, to estimate the changes in probability of use of an element, patch, or stand based upon increases or decreases of identified habitat features.

### Model performance

Because our modelling approach for each scale of analysis employed a used-unused design, we evaluated performance of the each model by estimating the area under its receiver-operating characteristic (ROC) curve (Hosmer and Lemeshow 2000). The ROC curve uses 2 measures of model evaluation to produce an overall index of model performance: model sensitivity and specificity. *Sensitivity* is the probability of a used site being correctly predicted by the model, whereas *specificity* is the probability of an unused site being correctly predicted by the model. We can measure the probability of an unused site being incorrectly predicted as being used (i.e., error) if we consider the metric of [1 – specificity]. The ROC curve assesses the predictive capabilities of a model by plotting sensitivity against 1- specificity over cut-off probabilities ranging from 0 and 1. The area under this curve provides a measure of discrimination of the model. That is, it helps us quantify the likelihood predicted by the model of a site used by an owl was higher than non-use. Following the guidance provided by Hosmer and Lemeshow (2000:160), areas under the ROC curve have the following discriminatory powers: ≤0.5 (none), 0.5-0.7 (poor), 0.7-0.8 (acceptable), 0.8-0.9 (excellent), and >0.9 (outstanding).

### Habitat assessment

We measured habitat components at each spatial scale using 2 sources of data, depending upon the scale of investigation.

#### <u>Patch and Element Scales</u>

We assessed habitat at the patch and element spatial scales by conducting habitat evaluations at a sample of radiolocations with error polygons ≤ 500 m². These plots represented the fine-scale features used by screech-owls. We collected habitat information throughout the year, but timing of data collection was dependent upon the season in which the radiolocation was collected. That is, we collected habitat information at plots during the leaf-on season for radiolocations obtained during leaf-on periods, and vice-versa. This allowed us to compare vegetation cover values that were representative of the phenological period during which the owl used the site. We collected habitat information at sites used by radiotagged owls during winter as soon after radiolocation as possible to ensure that snow levels remained unchanged.

We conducted the habitat evaluations in 150-m² plots at suitably precise radiolocations of screech-owls within the study area. We selected this size of plot because we believed that it adequately reflected the values of fine-scale patches of habitat that could be exploited by screech-owls. Sampling within each plot followed methods for vegetation sampling as outlined in Describing Terrestrial Ecosystems in the Field (British Columbia Ministry of Environment, Lands and Parks & British Columbia Ministry of Forests 1998) to quantify the vegetation and structural characteristics of a 150-m² plot centred around the radiolocation. We used ground inspection methods for site description, mineral soil characteristics, humus form, coarse fragment content, and ecosystem description. We conducted ocular cover estimates for the A (tree), B1 (high shrub; 2-10 m), B2 (low shrub; 0.15-2 m), B (all shrub), C (herbaceous), and D (moss) vegetation-layers. We also estimated cover for each tree species in the A layer. We used Tree Attributes for Wildlife techniques (British Columbia Ministry of Environment, Lands and Parks & British Columbia Ministry of Forests 1998: section 6) to assess all trees ≥7.5 cm dbh within the 150-m² plot. Measurements included tree species, diameter-at-breast-height (cm), remaining bark at dbh (%), and height (m). We assigned a crown class designation to all standing live trees and measured the height to live crown (m). We recorded the condition of the tree crown in relation to a normal live crown, estimated the retention of bark on the tree, and classified the texture (i.e., soundness) of the wood for each tree in the plot.

*<u>Stand Scale</u>*

We used spatial data to determine the values of habitat and non-habitat variables associated with each radiolocation within the home range of each screech-owl. We used a draft ecosystem map of the study area (Grods and Uunila 2008) to identify the stand in which each radiolocation occurred, using the combination of ecosystem and structural stage information as the basic mapped unit. Ecosystem polygons were delineated on the basis of relatively homogenous moisture and nutrient regimes, structural stages, site modifiers, terrain and soil components, and site attributes (British Columbia Ministry of Environment, Lands and Parks and British Columbia Ministry of Forests 1998). These polygons were assigned 1 of 6 structural stages: sparsely vegetated (generally < 5 years old), herb-shrub (5-20 years), pole-sapling (20-40 years), young forest (40-80 years), mature forest (80-250 years), and old forest (>250 years). Polygons ranged between 0.3 and 16.3 ha.

Complex polygons were common in the ecosystem map data, therefore, for each observation (i.e., single radiolocation or randomly located point in a stand), we estimated its composition by assigning proportions equal to the decile (Resources Inventory Committee 1998c) of each ecosystem association that occurred in the polygon. Additionally, to further capture the uncertainty associated with imprecise radiolocations, we assigned an area-based weight for error polygons that encompassed >1 polygon. For example, consider a 400-m² error polygon that included 300 m² of a polygon comprised of 80% riparian forest and 20% agricultural field, and 100 m² of another polygon comprised of 50% riparian forest and 50% open forest. The resultant composition of this observation would be 0.725 of an observation in the riparian forest, 0.15 of an observation in the agricultural field, and 0.125 of an observation in the open forest. The structural stage composition for an observation was similarly estimated.

## *Results*

### Nesting

We identified 6 nests during the research study; 5 nests used by radio-tagged owls while being monitored and 1 nest that was likely used by an owl immediately before we tagged it. We documented the use of 5 of the nests in 2006 and 3 of the nests in 2007. In 2007, 2 of the 5 nests that were used by radio-tagged owls in 2006 were re-used by different pairs of owls. The 1 female that was radio-tagged during both years used a different nest in 2007, selecting a new tree 209 m from her previous nest. Two of the nest sites from 2006 were not used in 2007, although one of them had a pair of owls near it in March.

All of the nests were in cavities in large-diameter deciduous trees. Five nests were in large-diameter cottonwood trees ($\bar{x}$ = 81 cm dbh, range 43-111 cm) and one was in a large paper birch (70 cm dbh). Nest cavities ranged between 8 m and 25.5 m above ground ($\bar{x}$ = 14.2 m, SD = 6.5) in trees averaging 33.5 m (SD = 11.9) in total height. Five of the 6 nests were in live trees. Cavities were created through natural decay processes (branch hole cavities) and by primary cavity nesters. The birch nest had 2 openings into the cavity.

We were able to take measurements of 3 of 6 nest cavities; for safety reasons we were unable to measure 3 others. Nest entrances averaged 9.3 cm (SD = 1.15, $n$ = 3) in height and 12.6 cm (SD = 3.1, $n$ = 3) in width. Cavity depth averaged 41.5 cm (SD = 10.6, $n$ = 2) and width averaged 25.8 cm (SD = 7.3, $n$ = 3). The distance between the cavity entrance and the back of the cavity averaged 37.2 cm (SD = 12.0, $n$ = 3).

### Roosting

### Roost descriptions

We identified the species of tree that was used by the radio-tagged owl 298 times, with western redcedar trees used most frequently (166 times; 56% of roosts). Other frequently used species of trees included paper birch (40 times; 13%), Douglas-fir (27 times; 9%), hybrid spruce (26 times; 9%), and black cottonwood (23 times; 8%). We documented owls roosting < 4 times each in ponderosa pine, lodgepole pine (*Pinus contorta*), and western larch (*Larix occidentalis*) trees. Shrubs were also infrequently used; beaked hazelnut (*Corylus cornuta*), willow (*Salix* spp.), Douglas maple, and alder (*Alnus* spp.) shrubs were each used < 4 times. Screech-owls mostly selected coniferous trees for roosting throughout the year; deciduous trees and shrubs were used more frequently in late summer (August and September; Fig. 16). We did not observe a substantial difference in the frequency at which males and females selected coniferous or deciduous trees for roosting (Table 9).

Screech-owls roosted predominantly on small branches and situated themselves immediately adjacent to the bole of the tree within the tree crown, particularly in western redcedars. We only documented 4 cases (in 3 trees) of roosting occurring inside a tree cavity. Occasionally, owls would select roosts with complex structure to provide security. Some roosts had considerable vegetation cover at sites that did not afford crypticness (e.g., beaked hazelnut shrubs). One roost that was used

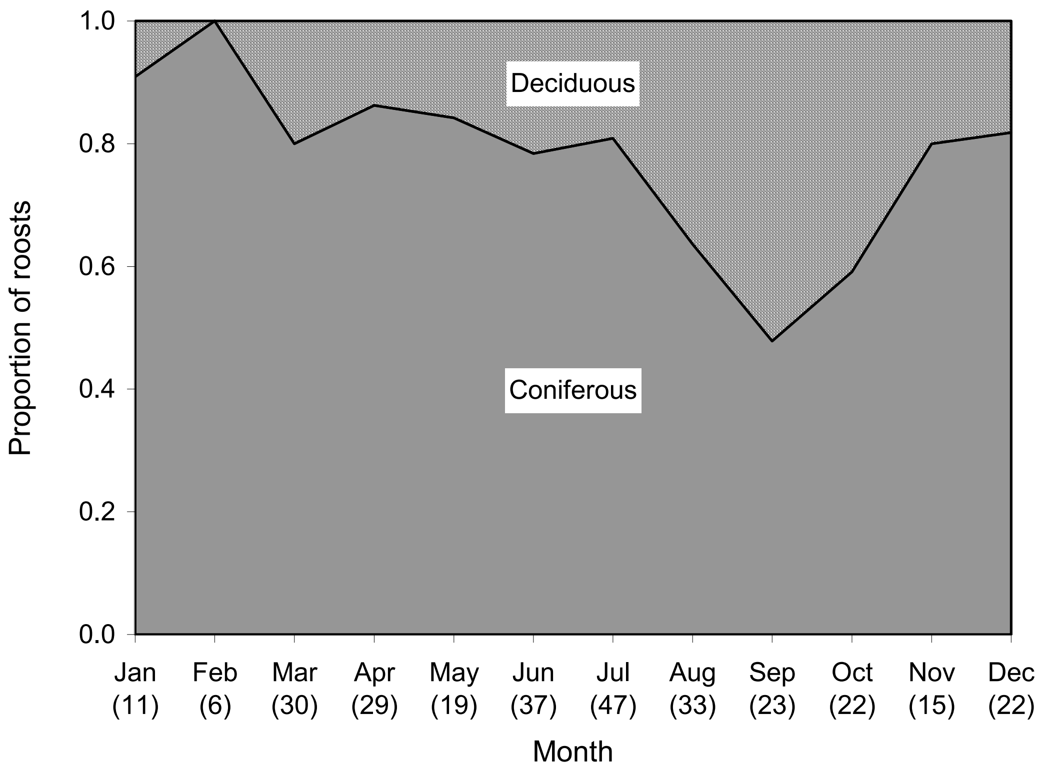


**Figure 16. Changes in the relative use of coniferous and deciduous trees (and shrubs) by radio-tagged western screech-owls used for roosting throughout the year, Shuswap River, British Columbia, 2005-2008. Number of roosts identified each month listed in brackets. N = 294 roosts.**

**Table 9. Frequency of use of coniferous and deciduous tree species as roosts by radio-tagged western screech-owls along the Shuswap River, British Columbia, 2005-2008.**

| Tree type | Males | Females | Total |
|---|---|---|---|
| Coniferous | 137 | 90 | 227 |
| Deciduous | 35 | 36 | 71 |
| Total | 172 | 126 | 298 |

at least 7 times by a female owl occurred in a paper birch with a broken top and flap of bark that provided a roost site. A large cottonwood branch leaning up against a tree with a complex bunch of cedar branches caught in it allowed another owl to tuck up under the branches creating a secure, well-protected roost. Snow on a roof created by leaves fallen on small side branches of a large tree was utilized by a male owl.

We measured diameter-at-breast-height of 201 roost trees; the average dbh was 33 cm (SD = 17). Ponderosa pines and black cottonwoods were the largest diameter trees used for roosting (Table 10). The dbh of roost trees did not vary considerably between sexes ($\bar{x}_{Female}$ = 34 cm, SD = 19, $n$ = 87; $\bar{x}_{Male}$ = 31 cm, SD = 16, $n$ = 114).

The height of roosts ranged between 2 and 24 m above ground level; the average height was 7.0 m (SD = 4.0, $n$ = 231). Roost heights were substantially lower during the nesting period ($\bar{x}$ = 5.7 m, SD = 2.6, $n$ = 121) compared to other periods in the year ($\bar{x}$ = 8.4 m, SD = 4.8, $n$ = 110).

### Selection of trees for roosting

We measured the attributes of 89 trees that were used by radio-tagged screech-owls for roosting and compared them to 1087 simultaneously unused trees within the same patch (Table 11).

Radio-tagged screech-owls showed extremely high levels of selectivity for trees used for roosting, with the best model scoring ≥108 $QIC_u$ units better than the null model (i.e., no selection). The 95% confidence set of best models included 2 models, both of which predicted probability of use based upon tree diameter (Table 12; Appendix II-1). The model most-supported by the data predicted

**Table 10. Mean diameter-at-breast-height of trees and shrubs used by radio-tagged western screech-owls for roosting along the Shuswap River, British Columbia between 2005 and 2008. *N* = 201 roost sites.**

| | dbh (cm) | | |
|---|---|---|---|
| Species | $\bar{x}$ | SD | $n$ |
| ponderosa pine | 45 | 27 | 3 |
| black cottonwood | 40 | 21 | 20 |
| western redcedar | 33 | 19 | 108 |
| paper birch | 32 | 12 | 27 |
| Douglas-fir | 32 | 11 | 19 |
| western larch | 31 | | 1 |
| hybrid spruce | 26 | 8 | 19 |
| lodgepole pine | 20 | | 1 |
| willow | 18 | | 1 |
| Douglas maple | 10 | | 1 |
| beaked hazelnut | 6 | | 1 |

**Table 11. Descriptive statistics for roosts and unused trees within the same patch used by radio-tagged western screech-owls along the Shuswap River, British Columbia, 2005-2008. Statistics were not stratified by time or individual owl, as was done for the selection analysis. *N* = 89 roost trees, 1087 unused trees.**

| | Roosts | | Unused trees | |
|---|---|---|---|---|
| Variable | $\bar{x}$ | SD | $\bar{x}$ | SD |
| Diameter-at-breast-height (cm) | 37 | 19 | 20 | 14 |
| Tree height (m) | 20 | 8 | 13 | 6 |
| Height to live crown (m) | 6 | 5 | 6 | 4 |
| Total length of tree crown (m) | 13 | 7 | 7 | 5 |

**Table 12. Ninety-five percent confidence set of models to explain selection of trees within patches for roosting by radio-tagged western screech-owls along the Shuswap River, British Columbia, 2005-2008.**

| Model ID | Probability of use of patch for roosting within stand related to: | $K^a$ | $QIC_u{}^b$ | $\Delta_i{}^c$ | $w_i{}^d$ | Area under ROC curve |
|---|---|---|---|---|---|---|
| R-16 | Quadratic relationship with diameter | 4 | 523.888 | 0 | 0.743 | 0.82 |
| R-14 | Diameter class (20-40 cm dbh, >40 cm dbh) | 4 | 526.010 | 2.123 | 0.257 | 0.79 |

probability of use based upon a quadratic relationship with tree diameter (model R-16). The other model in the 95% confidence set predicted probability of use based upon 2 categorical variables: whether the tree diameter was between 20 and 40 cm dbh or >40 cm dbh (model R-14). The best model had excellent discriminatory power (ROC curve area = 0.82) and was 2.9 times more likely to be closest to the true underlying selection process than the next-best model.

The parameterization of the best model indicated a strong positive relationship between probability of use and first-order tree diameter (i.e., dbh; OR = 1.317, 95% CI: 1.224 – 1.418) and a weak negative relationship with second-order tree diameter (i.e., dbh$^2$; OR = 0.998, 95% CI: 0.997 – 0.998). The best model predicted that screech-owls were >15 times more likely to roost in a 70-cm dbh tree than a 20-cm dbh tree. However, it also predicted that the probability of a screech-owl selecting a 100-cm dbh tree was 62% of that for selecting a 70-cm dbh tree (Fig. 17).

### Selection of patches for roosting

We conducted habitat evaluations at 88 patches used by screech-owls for roosting and compared these sites to 88 simultaneously unused patches within the same stand (Appendix II-2).

Screech-owls showed strong selectivity for the patches in which they roosted, with the best model scoring >31 $QIC_u$ units better than the null (no-selection) model. The best model in the candidate set predicted the probability of use based upon the density of trees >40 cm dbh, cover of trees and shrubs >2 m high, and cover of shrubs <2 m high. The ROC curve area for the best model was 0.75, suggesting that this model had an acceptable level of discriminatory power. None of the other 17 candidate models were plausible explanations for the selection that we observed (i.e., $\Delta_i$ > 10 $QIC_u$units; Appendix II-3).

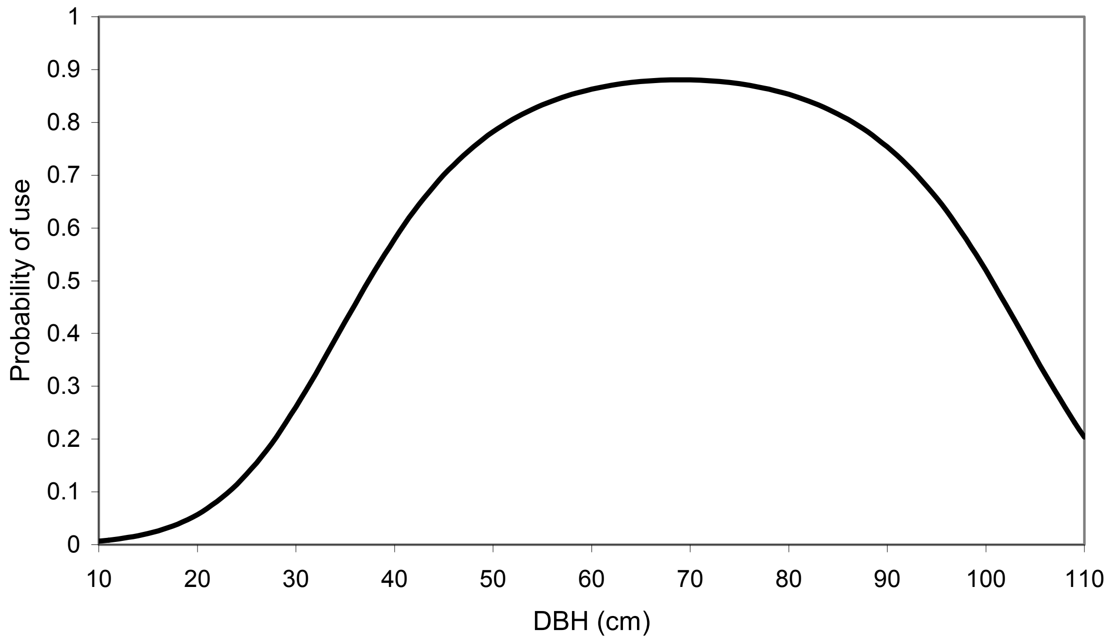


**Figure 17. Predicted relationship between diameter-at-breast-height (dbh) and probability of a screech-owl selecting a tree for roosting along the Shuswap River, British Columbia, 2005-2008.**

The best model predicted that the probability of a patch being selected by screech-owls for roosting was positively related to the density of trees >40 cm dbh and the cover of trees and shrubs >2 m high; the probability of use was negatively related to the amount of cover of low shrubs (<2 m high) (Table 13). It should be noted that tree and high-shrub cover were not substantially correlated with low-shrub cover. The best model predicted that a 150-m² patch with 2 trees >40 cm dbh, 70% tree and high-shrub cover, and no low-shrub cover was 2.9 times more likely to be used for roosting than a patch with no trees >40 cm dbh, 10% tree and high-shrub cover, and 10% low-shrub cover (Fig. 18). Based upon this parameterization, a 150-m² patch with no trees >40 cm dbh, 70% tree and high-shrub cover, and no low-shrub cover was 5.7 times more likely to be used for roosting than one with 1 tree >40 cm dbh, 10% tree and high-shrub cover, and 60% low-shrub cover.

*Post-hoc analysis*

We conducted a post-hoc analysis on 3 patch-scale models that we constructed based upon the means of the variables that we measured at the plots. We tested one model (P-ph1) that included all non-correlated variables for which the average value at the used patches was >50% more than that at the unused patches: high-shrub cover, density of paper birch, density of hybrid spruce, density of all conifers, and density of trees >40 cm dbh. The second model (P-ph2) included variables for which the unused patches had values that were >35% more than the used patches: low-shrub cover, and density of alder. We also tested a third post

**Table 13. Multi-model parameterization of factors affecting selection of patches used for roosting by radio-tagged screech-owls along the Shuswap River, British Columbia, 2005-2008. An odds ratio >1 indicates increasing probability of use with increasing values of the variable; ratios <1 indicate an inverse relationship.**

| Variable | Model-averaged estimate | Unconditional SE | Odds ratio (95% CI) | Relationship |
|---|---|---|---|---|
| Intercept | -0.723 | 0.273 | | |
| Density of trees >40 cm dbh (stems/ha) | 0.009 | 0.002 | 1.009 (1.005 – 1.014) | Positive |
| Cover of trees and high shrubs (>2 m) | 0.014 | 0.005 | 1.014 (1.005 – 1.024) | Positive |
| Cover of low shrubs (<2 m) | -0.037 | 0.011 | 0.963 (0.942 – 0.985) | Negative |

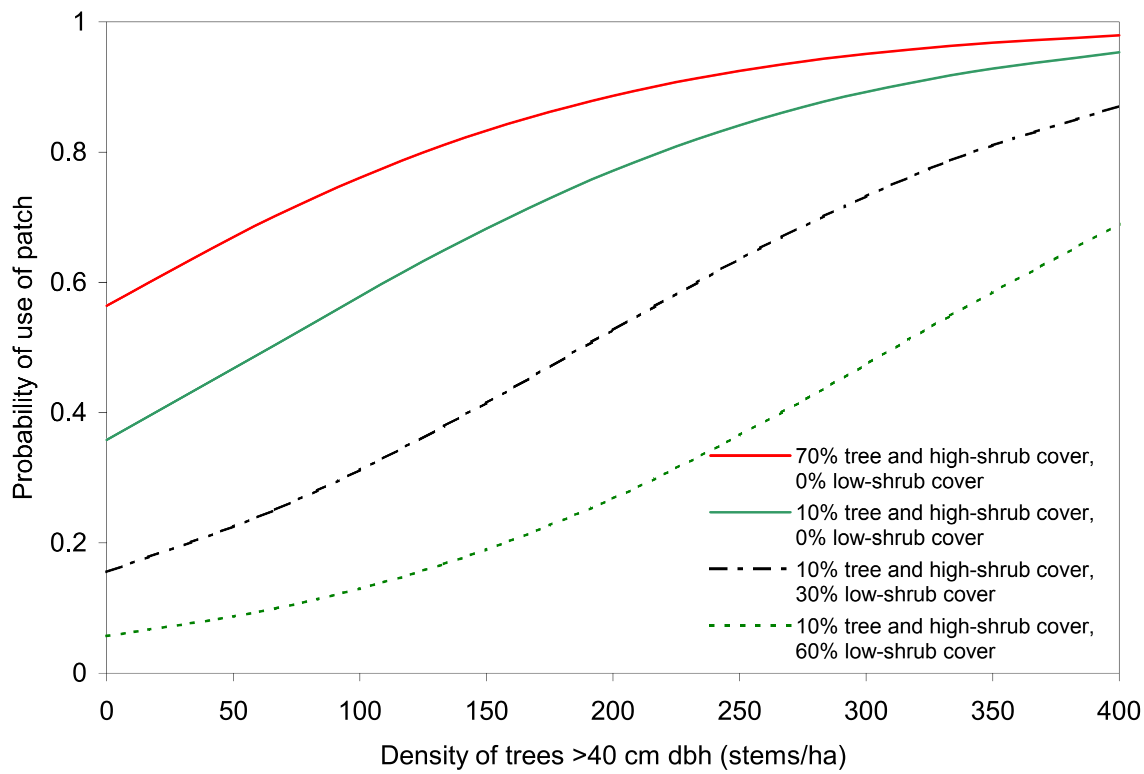


**Figure 18. Predicted relationship between density of trees >40 cm dbh, cover of trees and shrubs >2 m high, and cover of shrubs <2 m high and the probability of use of a patch for roosting by radio-tagged screech-owls along the Shuswap River, British Columbia, 2005-2008. Not all values on each line were possible, particularly for high densities of large trees and low values of tree and high-shrub cover.**

hoc model (P-ph3) that included all variables included in both of these post hoc models.

The post-hoc analysis indicated that the model P-ph3 was the best model of any of the a priori and post-hoc models that we evaluated (Appendix II-4). This model scored >12.5 $QIC_u$ units better than the next-best post-hoc model (P-ph1) and >23.5 $QIC_u$ units better than the best a priori model (P-17). Parameterization of this best model suggested that the probability of use of a patch for roosting was positively associated with high-shrub cover, density of trees >40 cm dbh, and density of hybrid spruce trees (i.e., lower 95% confidence limit of OR >1). It also suggested that the probability of use by screech-owls was negatively related to low-shrub cover and the density of alders (i.e., upper 95% confidence limit of OR <1). The relationship between density of paper birch and density of conifers was uncertain (i.e., 95% confidence interval of OR spanned 1).

### Selection of stands within the home range

Screech-owls used a wide variety of ecosystems in their day-to-day activities. It appeared that owls used different ecosystems and structural stages for different activities, roosting most frequently in riparian forests and hunting near open water, in open forests, and in sparse/non-vegetated areas (Figs. 19 - 20).

Screech-owls showed selectivity for the stands that they used within their respective home ranges, with the best model scoring >166 $QIC_u$ units better than the null (no-selection) model. The best model in the candidate set predicted the probability of use based on whether the stand was mature riparian forest (i.e., mature- or old-forest structural stage of the IDFmw1/05 site series). Although this model was much more likely to be closest to the true underlying selection function than any other model in the candidate set, the ROC curve area for this model was 0.56, suggesting that it had poor discriminatory power. None of the other 9 candidate models were plausible explanations for the selection that we observed (i.e., $\Delta_i$ > 6 QICu units; Appendix II-5).

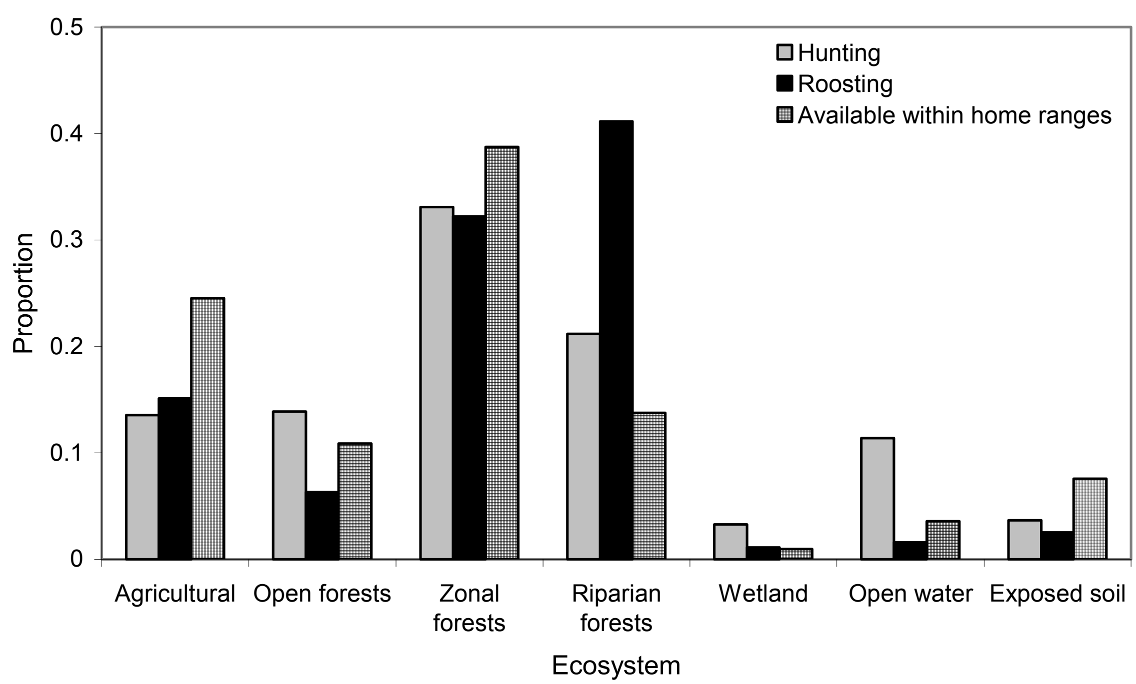


**Figure 19. Prevalence of use of ecosystems by radio-tagged western screech-owls, compared to those within their home ranges along the Shuswap River, British Columbia, 2005-2008. Statistics were not stratified by time or individual owl, as was done for the selection analysis. *N* = 80 hunting, 407 roosting radiolocations.**

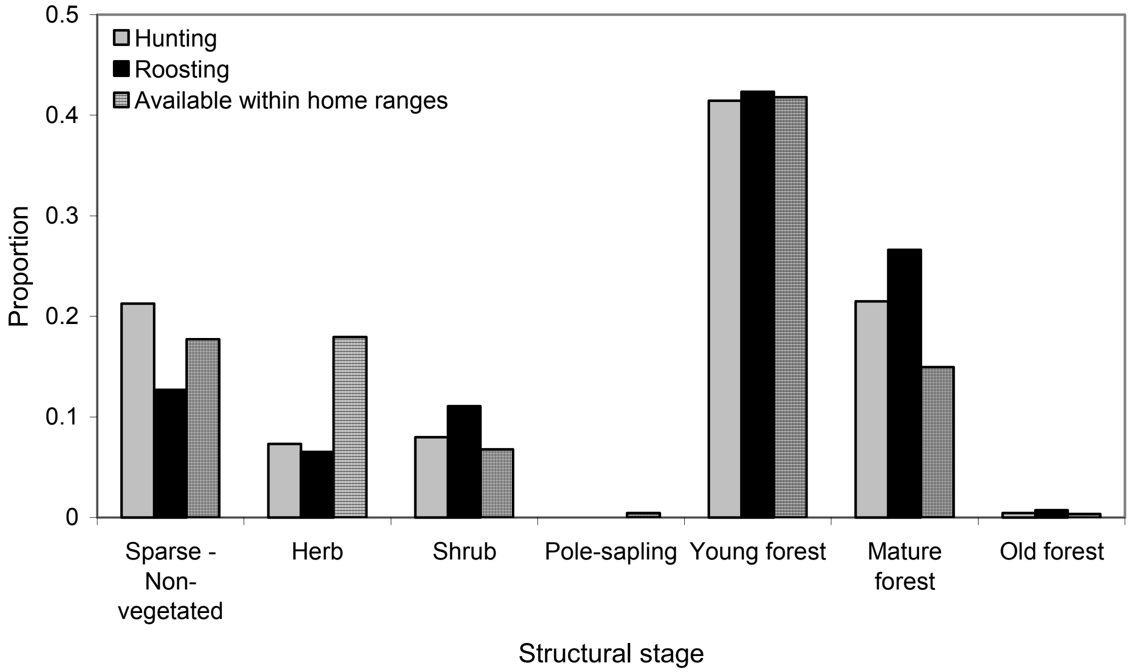


**Figure 20. Prevalence of use of structural stages by radio-tagged western screech-owls compared to those within their home ranges along the Shuswap River, British Columbia, 2005-2008. Statistics were not stratified by time or individual owl, as was done for the selection analysis. *N* = 80 hunting, 407 roosting radiolocations.**

The best model predicted that the probability of a stand being selected by screech-owls for roosting was positively related to the stand being mature riparian forest; the estimated odds ratio for this relationship was 4.869 (95% CI: 4.078 - 5.813). The predicted probability of use of mature riparian stands was 16% compared to 4% for other stands. However, given its poor performance, little confidence should be afforded to this estimate.

## *Discussion*

Generally, we found that screech-owls used a variety of habitat features at several spatial scales when roosting, nesting, and foraging and selection was very strong for roosting habitat at fine spatial scales. The exact features that they selected depended upon the resource requirement being fulfilled (e.g., roosting or nesting) and the scale of investigation. Selection analysis produced useful predictive models that will help delineate essential habitat for screech-owls throughout their range in British Columbia.

### Nesting

In many respects, the black cottonwood and paper birch trees that screech-owls used for nesting along the Shuswap River were similar to those reported elsewhere. Screech-owls in our study nested in cavities in large deciduous trees, as they do elsewhere in their range (Cannings and Angell 2001), including cottonwood and trembling aspen trees in the Kootenay region of British Columbia (Beaucher and Dulisse 2004, Hausleitner and Dulisse 2007). The diameters of trees used in our study area ($\bar{x}$ = 79.3 cm) were similar to that found in the southern Okanagan region (55 – 116 cm dbh; Cannings 1997), but much larger than 2 nests in the Kootenay region (40 cm each; Hausleitner and Dulisse 2007).

Trees used by screech-owls for nesting were extremely uncommon in our study area (Fig. 21). We measured 1087 trees at random plots, of which 34 were dead or declining black cottonwood or paper birch trees (i.e., had the potential for internal decay needed for cavity creation). Of these few trees, only 7 were larger than the smallest nest tree that we recorded. Furthermore, only 4 (<0.4%) of these trees were taller than the minimum nest height that we observed (i.e., >8 m). Our observations support the hypothesis that trees with potential nest cavities tend to be taller and have larger diameters than trees that do not have cavities (Sedgwick and Knopf 1986).

The formation of cavities suitable for nesting is likely a relatively rare event and the supply of these important habitat elements is probably very low. In west-central Alberta, Bonar (2000) conducted an extensive search to locate large “natural” cavities (i.e., cavities not created by a pileated woodpecker [*Dryocopus pileatus*] but having similar entrance sizes). He assessed large coniferous snags and large, living and dead trembling aspen and balsam poplar (a subspecies of *P. balsamifera*) stems. He found that these large natural cavities were very rare; only 15 natural cavities were found in 6,298 trees >25 cm dbh. Because of this rarity, the retention of existing screech-owl nests is probably critical, as indicated by the reuse of nests by individuals and successive territory holders. Screech-owls readily use nest boxes (Cannings and Angell 2001), but natural cavities may be preferred.

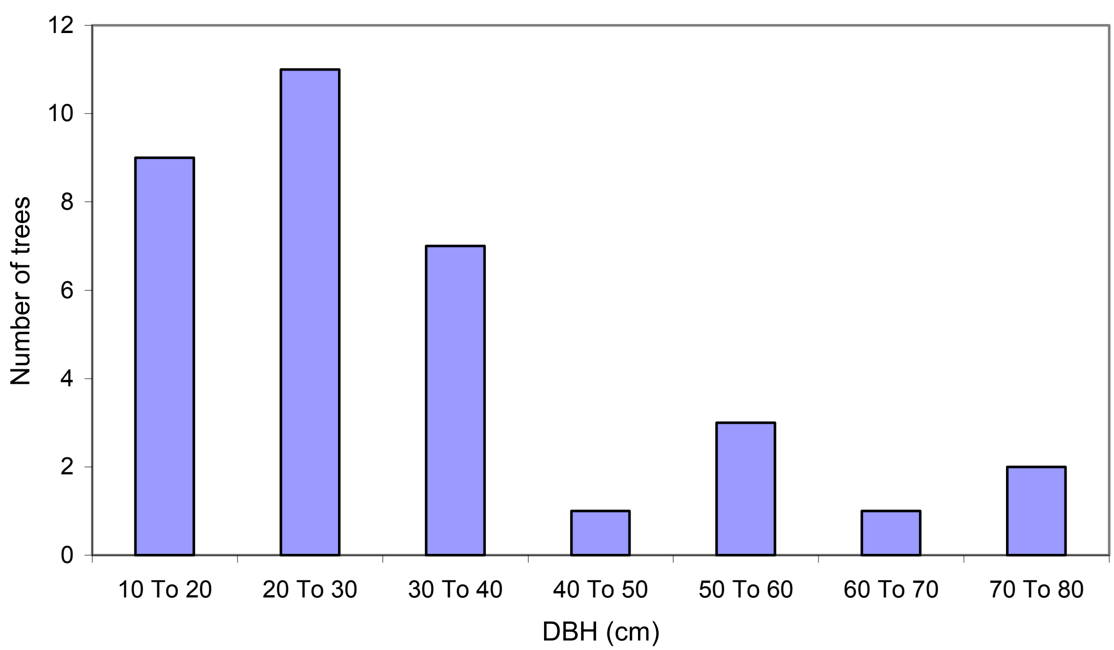


**Figure 21. Distribution of diameter-at-breast-height (dbh) of declining black cottonwood and paper birch trees at random sites along the Shuswap River, British Columbia. *N* = 36 trees at 88 sites.**

The composition of the habitat around and adjacent to nests was likely very important for cover, perches, and roosts. We observed both males and females landing in trees adjacent to nests before flying to the nest entrance. Sometimes females came out of the nest to meet the male with a prey delivery in these adjacent trees. Males often roosted in nearby trees, primarily redcedar trees.

The supply of deciduous trees for nesting sites is necessary for successful breeding by screech-owls. Mature black cottonwoods, and to a lesser extent paper birch and aspens, must be available within the home ranges of individual animals. Recruitment of these tree species is critical to the long-term supply of nest cavities, and thus health of screech-owl populations. The creation of suitable cavities may be assisted by inoculating suitable trees with pathogens to increase the speed at which cavities form (Manning 2007). If these techniques are shown to work, it may be worthwhile to introduce pathogens into a sample of deciduous trees in the Shuswap to increase the number of suitable nest trees for screech-owls.

### Roosting

Screech-owls showed considerable plasticity in the habitat features that they used for diurnal roosts. As had been observed by other researchers, we documented owls using both coniferous and deciduous trees and shrubs as roosts, and the relative frequency with which they used these 2 categories of trees changed with phenological development (Hayward and Garton 1984). The height at which they roosted also changed throughout the year. Although screech-owls used an assortment of sizes and species of trees and shrubs, the relative value of these structures for roosting varied considerably.

Screech-owls were very specific in the trees that they used for roosting, choosing trees largely based on their diameter. The fact that the relationship between probability of use and diameter was non-linear (i.e., quadratic) suggests that tree diameter in itself may not directly confer an advantage as a roost for screech-owls. As diameter is not likely a resource that is directly used by the animal (*sensu* Morrison 2001), the strong relationship that we observed may be related to the amount of cryptic cover afforded by the tree bole.

Screech-owls generally roost on small branches next to the bole of the tree (Hayward and Garton 1984, this study) and cryptic colouration has been identified as being important when screech-owls select roosts (Canning and Angell 2001). Screech-owls are probably less visible next to large diameter boles than small-diameter, especially if their plumage is similar to the colour of the bark of the tree. Large diameter trees with bark that is grey and striated (e.g., black cottonwood or western redcedar) may offer better cryptic cover than trees with other bark patterns (e.g., trembling aspen, which is whitish).

Interestingly, the predicted probability of use declined as trees grew to be >69 cm dbh. Perhaps, as the diameter increased, low branches for perching became uncommon, so that, although the cryptic cover was good, no opportunities existed for owls to perch at the desired height on the bole. Alternatively, this relationship may be better explained if other features such as tree species or crown length were incorporated into the model.

Our results indicated that large trees were not necessary for a patch to be used for roosting. Patches of habitat that had considerable cover of trees and shrubs >2 m high and little cover below 2 m were predicted to be useful as roosting habitat. Indeed, our model predicted that the absence of large trees could be compensated by a relative increase in the cover of trees and high shrubs, and decrease in the cover of low shrubs. For example, a patch with no trees >40 cm dbh but 80% cover of trees and high shrubs and no low-shrub cover <2 m high had the same probability of use as a patch with 1 tree >40 cm dbh, 60% cover of trees and shrubs >2 m high and 10% cover of low shrubs.

Thus, in the absence of cryptic tree-bole cover, it seemed that screech-owls selected patches of habitat that provided concealment cover. Although diameter appeared to play an important role in the selection of trees that owls used for roosting, the structure of the patch in the immediate vicinity of the roost tree also strong affected the selection of roosting habitat. On many occasions when screech-owls roosted in small-diameter trees, the cover associated with the crowns of these trees was very dense and provided substantial visual opacity. It should be noted that our results were phenology-dependent. That is, the predicted value of a patch of trees changed value throughout the year as deciduous plants developed, maintained, and shed leaves.

Our observation of the relationship between probability of use and large trees and cover of the various vegetation layers is supported by other research. Rodriguez-Estralla and Careaga (2003) noted that screech-owl detections in Baja California, Mexico were positively associated with cover of trees > 5m and shrubs >1 m and negatively associated with shrubs <1 m high. Hayward and Garton (1988) reported that screech-owls used areas with high amounts of deciduous tree cover, moderate high-shrub cover, and minimal low-shrub cover. These observations from Mexico and Idaho further support the hypothesis that cover, either in the form of cryptic cover or visual obscurity, is needed by screech-owls when roosting.

We documented no substantial use of cavities for roosting, even during winter, as predicted by Cannings and Angell (2001). Perhaps because, as identified by Hayward and Garton (1984), cavity roosts made screech-owls more susceptible to mammalian predators than branch roosts, from which owls could escape more easily. Hayward and Garton (1984) go on to speculate that cavities may only be used for roosting when adequate concealment cover is not available. In our study area, with its abundance of western redcedar trees with dense crowns and large diameter trees, it is likely that trees provided sufficient concealment cover such that cavities were not needed. Perhaps in the South Okanagan, where use of cavities is more common (Cannings and Angell 2001), trees that provide concealment or cryptic cover are rare.

### Selection of stands

We observed little predictable selection for stands within the home range by screech-owls. Although mature riparian forests were selected quite frequently, the best model in our candidate set had poor discriminatory power, which suggests that other factors that we did not measure were better indicators of the value of a stand. Future work should attempt to address the stand-scale selection of western screech-owls. This may be achieved by sampling at sufficient intensity to estimate the mean values of various structural features upon which screech-owls select habitat at this scale.

**Identification of essential habitat**

Using the scale-based predictive models, and with the assumption that habitats with a probability of use of >75% are essential habitats, habitats with the following features can be considered essential for western screech-owls:

*Element scale*

Essential roosting trees for western screech-owls are those with diameters between 48 and 90 cm dbh.

It is likely that essential nesting habitat for western screech-owls include trees that form cavities of sufficient size to hold a clutch (i.e., internal cavity greater than 26 cm wide).

*Patch scale*

See Table 14 for values of density of trees >40 cm dbh, tree and high-shrub cover, and low-shrub cover that produce essential patches of roosting habitat.

*Stand scale*

Because of the poor performance of the best model in the stand-scale analysis, we were unable to identify essential habitat for screech-owls at this scale.

**Table 14. Maximum low-shrub cover values (%) that can produce "essential" roosting habitat at the patch-scale for western screech-owls. For example, a patch of habitat with 200 stems/ha of trees >40 cm dbh and tree and high-shrub cover of 50% would be essential roosting habitat only if the low-shrub cover was ≤10% (shaded cell). Cells without values do not produce essential habitat, regardless of low-shrub cover.**

| | | Tree and high-shrub (>2 m) cover (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 |
| Density of trees >40 cm dbh (stems/ha) | ≤67 | | | | | | | | |
| | 133 | | | | | | | 0 | 0 |
| | 200 | | 0 | 0 | 0 | 10 | 10 | 10 | 20 |
| | 267 | 10 | 10 | 20 | 20 | 20 | 30 | 30 | 30 |
| | 333 | 20 | 30 | 30 | 40 | 40 | 40 | 50 | 50 |
| | 400 | 40 | 40 | 50 | 50 | 60 | 60 | 60 | 70 |

# Behavioural Observations

Below, we report on anecdotal behavioural observations that were collected during surveys, capturing, and radiotelemetry monitoring.

**Vocalizations**

- Lone males called a great deal in the pre-nesting season. During this period, lone males moved about their territory broadcasting loudly, likely to attract females. They often used a fast version of the bouncing ball call that did not speed up (i.e., become more closely spaced) and drop off at the end for minutes at a time; it sounded like the bouncing ball call being played on a skipping CD player. This call was described by Feusier (1989) as the "drum" call. Males may make this call to attract females to the territory, then to a potential nest cavity. When males were unpaired and performing this kind of call, it was not possible to catch them using call-playback because their response was to move to the nest cavity and call from this location.
- Males seemed to use the bouncing ball call from near the nest to alert the female to prey deliveries. Perhaps this is why females, once they had laid eggs and after the young had fledged, often produced begging calls (bark or chirp and begging whinny, Cannings and Angell 2001) in response to our broadcast of the male bouncing ball call.
- After the fledging period, we rarely detected owls calling spontaneously until the next breeding season.
- When attempting to catch owls, we found that owls initially responded with the bouncing ball call and sometimes switched to the double trill (*see* Cannings and Angell 2001). It seemed that the double trill call signalled a decrease in aggression. In these situations, we discovered that aggressiveness increased when we changed the call that we were broadcasting.

**Copulatory behaviour**

We observed several instances in which 2 owls flew into the same tree and seemingly copulated in the midst of aggressive displays in response to call-playback and decoys. In these cases, we heard chirping vocalizations and wing flapping. Copulations may have been used to strengthen the pair-bond or as reassurance. A similar incidence of a pair copulating after responding to call-playback was reported by McQueen (1972).

**Nesting behaviour**

We documented timing of egg incubation (Table 15), rates of prey deliveries by males to females at the nest, hatching dates, and fledging dates. Incubation and hatching periods appeared to be similar to that reported elsewhere (Cannings and Angell 2001). We did not observe tagged owls attempting a second brood in a season.

**Table 15. Incubation, hatching and fledging dates of screech-owls along the Shuswap River, British Columbia, 2006-2008.**

| Owl(s) | Behaviour | Dates |
|---|---|---|
| B03 & B04 | Start of incubation | Prior to March 30, 2006 |
| | Egg hatching | Prior to May 3, 2006 |
| | Fledging | June 6, 2006 |
| B05 | Start of incubation | April 5, 2006 |
| B10 | Fledging | Prior to June 8, 2006 |
| B14 | Fledging | June 6-8, 2006 |
| B15 & B17 | Start of incubation | April 2-4, 2007 |
| | Fledging | June 8-11, 2007 |
| B05 & B16 | Start of incubation | April 6-9, 2007 |
| | Fledging | June 8-11, 2007 |
| B18 | Start of incubation | April 9-12, 2007 |
| | Fledging | June 20-23, 2007 |

- Fledging occurred 65-74 days after start of incubation ($\bar{x}$ = 69 days, *n* = 4).
- The only occasion for which we documented the use of a new nest in a territory was of a female (B05) we followed through two nesting seasons. B05 used a different cottonwood tree for nesting when she had a new mate.
- During the week prior to fledging, nestlings were observed peeking out of the nest cavity during the day.
- Not all nestlings fledged on the same night, one group of nestlings fledged over at least 2 nights.
- It can be very difficult to find screech-owl nests without radio-tagged animals. We found no whitewash or pellets around nest trees.
- Later in the nesting season, males brought prey more frequently as the nestlings developed, which can make detection of the nest site easier.
- Nestlings were quite large when they left the nest. One brood had 3 individuals that weighed 120-160 g and one that weighed only 60 g on May 23 (Table 4), which was 14 days before they fledged (June 6). Surprisingly the small nestling fledged. A different brood of 3 nestlings averaged 191 g on June 3 and likely fledged soon after. The first brood were 57% of adult mass compared to the average weight of all adult screech-owls in this study, while the second brood were 89%; greater than that observed by Sumner (1928; 75%).
- Adult pairs and young stay near the nest for the first couple of weeks once the young have fledged. Fledglings were often seen roosting in the same tree. A few weeks after fledging the group moves farther from the nest area.

### Roosting

- At least 16% of roost trees were used more than once, with 2 different trees being used 7 times each. Re-use of roosts not only occurred by the same owls, but by owls of the opposite sex and owls of the same sex that had overtaken the territory. Several roosts were used by new territory members on the exact same day, but different year, as the previous territory member.
- Roosting owls rarely reacted to the presence of researchers, although some adults were more easily agitated immediately after young fledged.
- When agitated, owls would occasionally respond with bill snaps.

- Male-female pairs often roosted in close proximity to one another prior to egg-laying, often roosting a few metres apart in separate trees or sometimes in the same tree, although at times individuals were hundreds of metres apart.
- One male (B03) that we monitored during the entire breeding season had mean distance from roosts to nest during the incubation period of 79 m (SD = 128, $n$ = 10), whereas during the nestling period this measure was 56 m (SD = 40, $n$ = 10). A second male (B17) replaced B03 in 2007 and used the same nest. B17 roosted, on average, 107 m away from the nest during the nesting period (SD = 165, $n$ = 18; Fig. 22). Roosting behaviour of male owls in relation to the nest site has been of interest in other studies (e.g., Sproat 1997).
- Females roosted adjacent to nests just prior to fledging.

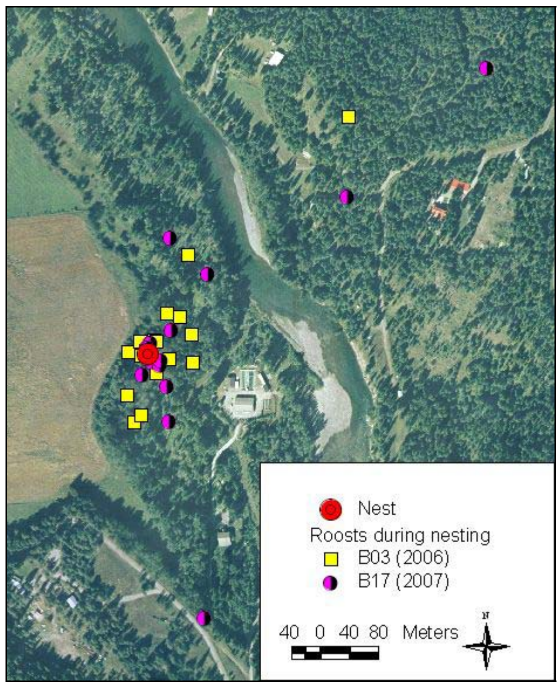


**Figure 22. Distribution of roosts of adult males relative to the nest during the nesting period along the Shuswap River, British Columbia, 2006 and 2007.**

### Time to first activity

- Owls were observed leaving roosts between 35 minutes before sunset and 73 minutes after sunset ($\bar{x}$ = 20 minutes after sunset, SD = 17, $n$ = 63). Only 6 times did we record them leaving their roosts prior to sunset.
- We determined that observers needed to be close to roost trees when attempting to collect roost departure times because the owls were quite active in the tree prior to flying away. This caused the radio signal to fluctuate greatly in strength. From a distance the telemetry signal sounded like the bird had started moving for the evening when in fact it had not.

- The current survey methodology (Hausleitner 2006) recommends starting owl surveys a half hour after sunset, which seems appropriate from our data.

**Hunting behaviour**

Owls were located before sunset to follow their first movements in the evening upon leaving the roost. Visibility was still reasonable at this time so we could safely follow owls. We hoped that by following the owls leaving daytime roosts it would increase the chance that they were hunting, assuming they would be hungry at this time.

- We conducted 43:58 hours of continuous monitoring of owls at nests to determine nest attentiveness and feeding rates. After females started incubating eggs, they were observed to leave the nest between 16 and 26 minutes after sunset ($\bar{x}$ = 26 min., *n* = 5) and be away from the nest between 8 and 21 minutes ($\bar{x}$ = 14 min., SD = 5, *n* = 5). Later in the nesting period, females were detected being away from the nest for up to 43 minutes at a time.
- Males did not go directly to the nest after sunset, but instead left their roosts and went hunting. During the incubation phase, males were observed to visit the nest (likely to feed the female) on average 58 minutes after leaving their roost trees ($\bar{x}$ = 58 min., SD = 19, *n* = 6). Males often ranged far from the nests while hunting and at times we lost their signal. We do not believe they went out of their known territories.
- Late in the incubation phase, females sometimes waited until well after sunset to leave the nest for the first time (>1.5 hours).
- Visitations by adults to the nest can be very frequent, likely when delivering insects to nestlings. On June 5, 2006 we monitored a male and female pair at their nest site. Over the course of 1:57 hours the female brought prey to the nest 8 times; she was away from the nest for a total of 1:52 hours and at the nest making prey deliveries for 5 minutes in total. Five hunting trips away from the nest lasted less than 6 minutes each. At the same time the male was likely hunting different kinds of prey because he visited the nest only once, 43 minutes after leaving his roost.
- One fledgling was observed catching and eating a mouse as early as 6 weeks after fledging.
- There was some evidence of daytime hunting by both males and females while adults were feeding fledglings. We displaced an adult female that was on the ground eating a bird at 11:32. Owls rarely moved from their roosts during the day during the rest of the year.
- Three habitat features appeared to be important for screech-owls when they were hunting: dead trees, steep slopes, and river edges. On numerous occasions after sunset, we observed owls perched in snags on the edges of small openings in open forests. This foraging method is consistent with that reported in the literature (Abbruzzese and Ritchison 1997, Cannings and Angell 2001). Somewhat different, however, was the observation that steep slopes were often used as well, perhaps because visibility of the ground, and thus prey, may be greater below/next to hunting perches than on flat

ground. Thirdly, river edges appeared to be important hunting areas; many times we detected owls perching in trees along the river channel at night. This is not surprising, as we detected some aquatic species in the diet of screech-owls in our study area (Davis and Cannings *in press*).

# Population Characteristics

## *Introduction*

Understanding the population characteristics of screech-owl populations is essential to recovery of the species in British Columbia. Unfortunately, very little is known about vital birth and death rates, so it is difficult to predict the ability of populations of this species to recover, especially at the periphery of its range. Indeed, in the most recent review of the status of the species in Canada, it was noted that population size and trends of screech-owls are virtually impossible to estimate (Chaundy-Smart 2002).

Probably the best vital rate information is available for breeding productivity. Based upon observations as known nest sites, it is believed that screech-owls likely begin breeding annually at 1 year of age, with 1 clutch of 2-7 eggs produced each successful breeding season ($\bar{x}$ = 3.48 eggs/clutch; Cannings and Angell 2001). It is unclear if pairs breed every year, although 89% of nests observed in southern Idaho produced fledglings (Rains 1998).

Data on survivorship, however, is limited. Reported survivorship of adult screech-owls is generally low, with the average lifespan of breeding adults being less than 2 years (Cannings and Angell 2001). Survival rates during juvenile dispersal may be similarly low; of the closely related eastern screech-owl, only 1 in 3 juveniles survive dispersal and successfully establish a territory (Belthoff and Ritchison 1989). Causes of mortality include starvation (Cannings and Angell 2001), accidents (von Bloeker and Rudd 1937), being struck by vehicles (Hawbecker 1938), and predation by other owl species, although rates of mortality are not well-documented. Of particular significance to the possible decline of western screech-owls in British Columbia may be the increasing rates of predation by an invasive species, the barred owl (*Strix varia*), much like spotted owls (*S. occidentalis*; Dark et al. 1998).

Our objective was to collect vital rate data for western screech-owls by following radio-tagged owls and documenting nesting rates, productivity, year-to-year survivorship, and causes of mortality. This data will provide better insight into the factors that affect natality and survival of screech-owls in British Columbia, which is needed to help restore populations.

## *Methods*

Using the information collected during radiotelemetry monitoring, we provided descriptive statistics on several population parameters.

We monitored 5 breeding territories along the Shuswap River with radiotelemetry and surveys. During livetrapping activities in 2005, we recorded the number of fledglings that accompanied adults, whereas we documented fledglings that were seen with radiotagged adults in 2006 and 2007.

We documented all sources of mortality that owls experienced while radiotagged, although we did not have a sufficient sample size to effectively characterize population parameters (e.g., Heisey and Fuller 1985).

We assessed the rate of change in territory holders within occupied habitat throughout the study area. We did this by confirming that a new individual of the same sex occurred in a territory previously occupied by an owl that had died or disappeared. For example, if a male was tagged during 2006 and a different male was caught the following year in the same territory, we determined that territory turnover had occurred. No radio-tagged adults moved to other territories while they were monitored, so we felt this was a reasonable assumption.

We determined the minimum life span of resident screech-owls from capture and radiotelemetry data. We assumed that resident screech-owls were born on May 1 of the year before they were captured. We made this assumption because all of the owls that we tagged were actively breeding adults and screech-owls are reported to breed at one year of age (Cannings and Angell 2001). Date of death was recorded as the date that the owl died while being monitored or assumed to be the day after its last radiolocation if the transmitter battery failed. Minimum life span estimates were conservative because owls could have been older than one year when first captured and lived longer than the end of telemetry monitoring.

## *Results*

### Natality

Productivity of the 5 territories varied considerably among years (Table 16). We identified at least 5 fledglings from 3 broods in 2005, although this was an underestimate because we observed fledglings only during trapping. We did not assess 2 of the 5 territories in 2005. In 2006 and 2007, the 5 territories averaged 3.25 fledglings/year. A radio-tagged female (B05) fledged 3 young in each of 2 consecutive years. Two other territories had different adult females radio-tagged in 2006 and 2007 and both successfully produced 3 or 4 young.

### Survivorship and territory turnover

Three of 10 radio-tagged owls died while being monitored (Fig. 7; B14 was not included because dropped transmitter at 4 days), all of which occurred during 2006. Two owls (1 M, 1F) from different territories were killed by predators (likely great horned or barred owls). One other female owl was struck and killed on Sugar Lake Road, a secondary road with relatively little traffic. A necropsy revealed that

**Table 16. Fledgling productivity in 5 breeding territories along the Shuswap River, British Columbia, 2005-2007.**

| Territory | 2005 | 2006 | 2007 |
|---|---|---|---|
| A | - | 3 | 3 |
| B | - | 4 | none |
| C | 3 | 3* | none |
| D | ≥1 | 3 | 3 |
| E | ≥1 | 4 | 3 |
| Total | | 17 | 9 |

* remains of 1 dead individual found during banding of nestlings

the female's stomach contained 2 freshly killed deer mice (*Peromyscus maniculatus*).

We did not document survivorship of young. However, we encountered one case of a cannibalism of siblings in the nest. During our nest survey on 3 June 2006, we found part of a nestling's wing and a screech-owl foot was found in a pellet in the nest. Although fledglings were not radio-tagged, we were able to determine the outcome of 1 fledgling that was born in 2006. This individual was found by landowners on 25 July with an injured wing, unable to fly. We took the owl for rehabilitation at the South Okanagan Rehabilitation Centre for Owls (SORCO), but its wing did not heal well enough for release back into the wild.

Turnover rates among breeding territories were very high. We observed 9 instances of territory turnover in 13 opportunities between years (69%). Five of 7 females and 4 of 6 males were replaced between years (71% and 66% respectively). The average minimum life span of owls in our study was 1.92 years (SD = 0.72, $n$ = 8), with the longest minimum life span of 3.3 years (female B05).

## *Discussion*

Generally, the productivity of screech-owls in our study area was high. The rate of successful nesting in our research area (11 of 13 nest-seasons; 85%) was similar to that observed in some areas (89% in southern Idaho; Rains 1998) and the number of fledglings per nest (3.25) was higher than that reported for southern California (2.15; Feusier 1989). It is likely that our nestling rate was higher than our fledgling rate because some nestlings did not fledge. Also, observations in 2005 were anecdotal; the live-trapping occurred late in the fledging period so it is possible some young did not survive or were not seen during trapping. Although productivity was high among breeding territories, so too was mortality.

Screech-owls died from a number of biotic and abiotic factors. Mortalities of 2 radio-tagged owls appeared to have resulted from predation by larger raptors (likely great horned or barred owls), which are believed to be a major source of mortality for screech-owls (Elliot 2006). Because screech-owls called extensively through February and March, they may be more conspicuous and vulnerable to predation at this time. Most of the turnover of territories that we observed occurred in these months, highlighting the need for future studies to span this time of year and better identify the mortality factors during this period. In addition, raccoons were seen on a number of occasions in the research area, including climbing trees in the vicinity of nests.

However, intraspecific competition may also be a source of mortality within screech-owl populations. The response of owls, especially females, that we observed while live-trapping indicated that females were prepared to attack other females. This suggests that competition for the best territories could be occurring within the population. We found one dead female within a territory that was later determined to be occupied by a nesting pair. Either the female died and was quickly replaced, was attacked by the other female, or died by other means. A necropsy indicated that the dead owl had no major injuries as would be expected from an attack by a larger owl (H. Schwantje, BC Environment, pers. comm.). Our radiotelemetry data suggested that excursions by resident paired owls into adjacent territories were rare; it is likely that unpaired owls are more prone to initiating competition for territories.

Small owls were at risk from abiotic threats as well. Road mortality has been observed in other areas (Hawbecker 1938, Western Screech Owl Recovery Team 2006), and perhaps the use of the edge of openings as foraging areas puts screech-owls at greater risk. As further support to the risk associated with using open areas, 1 saw-whet owl was killed on a barbed wire fence in the study area, which is a known source of mortality for small owls (Hawbecker 1938), including screech-owls (von Bloeker and Rudd 1937).

The rate of territory turnover that we observed appeared very high but may be typical. In coastal screech-owl (*kennicottii* subspecies) populations, turnover of territories from one year to the next based on vocal recordings may be 29–64% (Tripp 2004) or 28–50% (Tripp and Otter 2006). Using similar vocal discrimination techniques, Galeotti and Sacchi (2001) found turnover rates for the European Scops owl (*Otus scops*) to be 55-78%. It is unclear whether the observed amount of turnover within territories in our study area was indicative of an unstable high mortality rate or simply a normal population process.

Our estimate of average life span was the absolute minimum time an owl could have been alive while we followed it. Owls may have been older than 1 year when we caught them: one pair of owls was replaced by a new male and female that were not offspring from the previous years' nest (the nestlings were banded and neither the male nor female were marked). Either both birds were from other territories or were older than 1 year. Survivorship of owls in the Shuswap was greater than that found in southern Idaho (Cannings and Angell 2001) where the mean survivorship of males was found to be 1.83 years and females 1.73 years. Both are much less than is possible in the wild (12 years, Clapp et al. 1983).

It is unclear whether the population of screech-owls along the Shuswap River is stable. The consistently high productivity of nests within the study area suggested that production of offspring was high, but recruitment into the population may be low. Given the relationships that we discerned regarding the apparent need to include 12 ha of riparian forest habitat within a 65 ha territory, it appears that this feature probably limits where screech-owls can occur within the landscape. Thus, the relative paucity of potential territories within the landscape likely affects the recruitment of young owls into the population.

Information on the age-specific fecundity of screech-owls has not been collected, so it is unclear as to whether the high rate of turnover that we observed enhanced or hindered productivity within the population. If first-time breeders have small clutch sizes and clutch sizes increase as adults age, the high turnover rate would likely reduce the productivity within the population. Conversely, if the opposite were true, the productivity would be enhanced with increased territory turnover. However, given the small sample sizes that we observed, the relative productivity of the study population is unidentified. It is also unclear as to whether the rate of recruitment of young birds was sufficient to offset the high rate of mortality that we observed among adults.

# Conservation Implications

Many of the results of our research and inventory project will help with the recovery of western screech-owl populations in British Columbia. Data from this project can be used to improve land-management by landowners, government agencies, and forest licensees in support of the conservation of screech-owls and their habitat. Below, we detail specific conservation implications from our work:

**1) Conservation efforts can be focussed within the refined distribution of screech-owls in the Shuswap and northeastern Okanagan regions.**

Our work has delineated the occurrences of screech-owls in the northern portion of their range in British Columbia. This will allow for more-focussed conservation efforts in areas that support screech-owls in this area: the Shuswap River between Cherryville and Mabel Lake, lower Coldstream Creek, and BX Creek.

**2) Improvements to survey methods will enhance the probability of detecting resident screech-owls.**

Our data showed that survey stations needed to occur within the home range of resident owls to ensure a high likelihood of detection during call-playback surveys. Surveys should also be conducted primarily during the pre-breeding period in March and early April so that screech-owls are at their peak aggressiveness. Thus, surveys should occur during early spring within, not peripheral, to quality screech-owl habitats, which are typically late-successional riparian forests.

**3) Information on space-use and habitat associations can be used to improve the use of survey data in the estimation of density and population size.**

The density of screech-owls can be predicted more reliably from survey data by applying our understanding of the space-use requirements of screech-owls to detections or known occurrences.

**4) Empirical information on the size and location of home ranges can be used to identify other areas that may support screech-owls.**

Screech-owls occurred in our study area in locations where on average 11.9 ha of riparian-forest ecosystems and 1198 m of river frontage occurred within 64.5 ha of a potential home range (i.e., 18% riparian forest). Other sites that meet these requirements should be surveyed within the Interior Douglas-Fir biogeoclimatic zone.

**5) Changes in space-use by screech-owls throughout the year can be used to identify areas outside of riparian zones that should receive targeted conservation efforts.**

Space-use was different than previously assumed in that screech-owls use very different habitats outside of the breeding period. These areas are important for providing prey and roosts during non-breeding periods and need to be considered when applying conservation measures to sites known to support screech-owls.

**6) Nest cavities and the processes that create them appear to be life-cycle limiting factors for screech-owls. Land managers can use this information to conserve or restore habitats that support these rare habitat features.**

Nests only occurred in large-diameter declining black cottonwood and paper birch trees that formed cavities ≥19 cm diameter. These cavities only occurred in trees that were ≥43 cm diameter-at-breast-height, ≥17 m tall, and only found in riparian forest ecosystems. As these features are rare and recruitment is likely uncommon, activities that promote the retention and recruitment of these trees will assist in the restoration of vital screech-owl habitat.

Recruitment of cottonwoods is a complex process. Cottonwoods reproduce well by seed or vegetatively only on moist exposed soil or gravel bars (Jamieson et al. 2001) and they do not regenerate well in shaded sites, such as under conifers. Thus, open, moist recruitment sites, such as those created along rivers by high water flows, are essential to the recruitment of this species. Allowing these geomorphological processes to occur is essential for regeneration and recruitment of hardwoods stands that will eventually provide nesting habitat for screech-owls.

The need to retain hardwood species in natural and rural areas may also apply to small riparian systems within urbanized areas that still support small screech-owl populations. There are currently 1 or 2 nesting pairs of screech-owls dotted along creeks and rivers through the Okanagan Valley. The current trend to limbing or removing large deciduous trees (potential nest sites) from these riparian areas over human safety concerns could have implications for the persistence of western screech-owls in these areas.

**7) Screech-owls have very specific requirements for roosting, which appear to be met in a narrow range of habitat conditions. Roost sites must provide cover, either in the form of cryptic (camouflage) or concealment cover.**

A synthesis of our results suggest that ideal patches of roosting habitat for screech-owls include at least 1 large diameter tree (i.e., >40 cm dbh), surrounded by considerable cover of trees and shrubs >2 m high, and little cover below 2 m. Habitat management that conserves or restores these important habitat features will assist in the recovery of screech-owl populations.

**8) Data-driven predictive habitat models have been developed that can be used for assessing habitat value, predicting changes in habitat value under various management scenarios, and help with the conservation of high-value habitats in other areas.**

The predictive habitat models that we developed had good or excellent discriminatory power and so should be applicable in other areas, even those with very different vegetation associations. For example, most screech-owl records in British Columbia occur in the dry forests and grassland ecosystems of the South Okanagan in the very dry-hot Interior Douglas-Fir and very dry-hot Bunchgrass biogeoclimatic subzones (Cannings and Davis 2007). Although this area is considerably different in vegetation structure than our study area (IDFmw), our predictive model could be used to identify areas that provide sufficient cover for roosting.

**9) The diet of western screech-owls has been identified. Land management that favours the retention of foraging habitats for screech-owls should be promoted.**

Screech-owls had a diverse diet that included small mammals, birds, fish and insects. Female owls tended to eat mammals more than males, and males ate insects than females. Activities that increase the abundance of these prey items in close proximity to perching sites (e.g., snags on edge of field) should be promoted.

**10) Essential habitat delineations will help regulatory agencies and forest licensees to refine Section 7 schedules and notices for screech-owls.**

Regulatory agencies and forest licensees can use the delineations of essential habitat in modifications to Section 7 schedules and notices under the *Forest Planning and Practices Regulation*. The specific features of nesting and roosting habitats that should be conserved during forest management planning have been clearly identified.

**11) Effective Wildlife Habitat Areas can be better delineated based upon an improved understanding of the space-use and habitat requirements of screech-owls.**

Screech-owls appear to need at least 12 ha of their home range to be riparian forest, which seems to be best accomplished through the inclusion of >867 m of river frontage. Wildlife Habitat Areas should also include foraging and non-breeding season habitats. Foraging habitats are typically open forests and sparsely treed hillsides. Non-breeding season habitats are typically zonal forests that provide adequate roosting opportunities. The best protection of screech-owl habitat would be to delineate an entire corridor following an occupied riparian area, extending >600 m to either side of the riparian area.

**12) The linkage between screech-owls and riparian forests with deciduous components has been strongly characterized. Understanding the reasons that screech-owls need these habitats will promote land management activities that help conserve and restore these identified habitats.**

Many of the habitat features upon which screech-owls appeared to base habitat decisions were found primarily in late-successional riparian forests. Riparian stands not only provide essential habitat for western screech-owls, but they are important to many other bird and mammal species such as other owl species, bald eagles, ospreys, great blue herons, pileated woodpeckers, cavity nesting ducks, bats, flying squirrels, marten and beavers.

Cottonwoods were an essential component of the riparian forests in our study area, but the supply of these features was low. Controlling the flow levels of rivers by dams affects the processes by which these tree species regenerate and are recruited. In areas outside of the Shuswap, hydroelectric development floods riparian areas to create reservoirs. Cottonwood stands are much reduced in size under such circumstances (Jamieson et al. 2001).

# Extension

The extension component of our project provided a crucial link between research information and the application of science-based recovery of species at risk. Specifically, our programme used the information collected during the research study and synthesized it into effective habitat conservation approaches. Because most of the land in the project area was privately owned, our extension programme was also an opportunity to promote conservation covenants as a long-term strategy to maintain habitat for screech-owls.

## *Objectives*

Specific objectives of the extension component included:

1) Synthesize scientific data into effective habitat conservation, enhancement, and restoration techniques for habitats that are essential or important to screech-owls,
2) Engage local landowners, First Nations, and forest licensees in the application of conservation and restoration techniques in identified habitats, and
3) Create public awareness regarding the status and issues surrounding screech-owls and other riparian-associated species in the Shuswap Region through education and outreach programs.

All 3 years of the program included a strong extension and stewardship component that engaged local landowners, First Nations, and forest licensees. Throughout the course of the study we gave presentations on the ecology and importance of screech-owls in riparian ecosystems to a variety of audiences.

## *Methods*

Key products that were developed as part of our extension component included:

1) Information brochures on screech-owl ecology and conservation that were distributed during fieldwork and at open houses.
2) Project information posters used at community events.
3) Stewardship support manuals that included information on the habitat needs of western screech-owls and nest box plans, information on conservation covenants, plans for identified habitat conservation and restoration techniques for landowners and forest licensees.
4) Peer-reviewed scientific publications detailing the findings of the research study.

We assisted other projects that were conducted in the research area by sharing some of the landowner ownership and contact information. This included the Whitevalley Community Resource Centre's sensitive ecosystem inventory mapping and a BCRP-funded bat inventory. Communications were maintained with the *macfarlanei* Screech-Owl Recovery Team throughout the life of the project. Funding agencies were prominently recognized in all extension products and programs (Appendix III).

## *Results*

Results of our project are being utilized effectively. This is in large part because communications from our project have been targeted at local landowners, all levels of government (including First Nations, the federal recovery team and provincial government employees), forest licensees, naturalists, other professional biologists, and multiple land conservation organizations. Feedback from these groups has been overwhelmingly positive.

### Landowners

We have been in contact with the landowners throughout the course of the project. See previous reports for details on all of the mail-outs and events attended in previous years (Davis and Weir 2004; 2006; 2007). Landowner support throughout the project was exceptional; we were granted access to 97% of the land the tagged screech-owls utilized.

In March 2008 we held a wrap-up presentation for landowners and the public in Lumby, BC. We invited 40 people/families and representatives of local organizations by mailed invitation and email. We placed announcements in both the Lumby Valley Times and Morning Star newspapers (see Appendix III). The meeting was attended by members of the North Okanagan Parks and Natural Areas Trust to talk to any landowners interested in placing conservation covenants on their lands.

At the conclusion of the study, we disseminated 43 stewardship manuals to landowners that had owls use their land at some point. Most stewardship manuals were hand-delivered and thus we spoke to many of the landowners about the results of the project when we dropped off the manuals. Copies were also distributed, by request, to the local BC Environment office, the North Okanagan Parks and Natural Areas Trust and the Environmental Farm Plan Program. Stewardship Support Manuals included the following sections:

- A colour cover page with logos of funding agencies.
- A personally addressed letter giving details about the pair of birds that use the landowners land (e.g., nest success, home range sizes), what they would find in the stewardship manual and a thank you for their cooperation and support.
- A colour orthophoto printout of the landowner’s neighbourhood with the owls’ home range outlined.
- <u>Screech-owls and Their Habitats</u>: results from the research project on home range size and composition, diet, nest and roost tree habitats. This section included photos of what good screech-owl habitat looks like and detailed plans on how to build a screech-owl nest box.
- <u>Conservation Covenants</u>: 3 Land Trust Alliance of BC brochures about covenants (Your Land: Conservation Options; Preserving Natural and Cultural Features of Land with a Conservation Covenant; Tax Benefits of Your Conservation Donation).

- Other Wildlife Species: information on the status of rare wildlife species, who to report sightings of rare species to, and:
    - BC Conservation Data Centre reporting forms
    - Badger Wildlife in BC at Risk brochure
    - Western toad fact sheet
    - Western painted turtle fact sheet
    - Rubber boa fact sheet
    - Western skink fact sheet
    - Northwestern alligator lizard fact sheet
- A CD of owl calls so that landowners can identify owls by their calls. It included calls from screech-owls (male and female) and other owl species that occurred in the project area.
- Larger farms also received a brochure about the Environmental Farm Plan program.

In 2006, we discovered 2 previously undetected screech-owls in the BX Creek area of Vernon (due to community contacts). We initiated a landowner contact program in the area that was carried out by the Allan Brooks Nature Centre (ABNC). We provided ABNC with a redesigned screech-owl fact sheet that was sent, along with a personalized cover letter, to 44 landowners with properties bordering BX Creek. The intention was to make property owners aware of the owls' presence in the area, how to identify the call of the species and how they could conserve screech-owl habitat. ABNC followed up with a phone call to each letter recipient.

**Government**

First Nations: This project was initiated with the assistance of the Spallumcheen Indian Band. Artemis Wildlife Consultants has carried out screech-owl surveys for both the Spallumcheen and Okanagan Indian Bands and has thus communicated our research results to these bands. We displayed our screech-owl poster at 2 Species At Risk community forums for the Spallumcheen Indian Band (attendees included council members).

Local Government: We made sure city planners, local Ministry of Environment employees and the Regional District of the North Okanagan were aware of the presence of screech-owls in Coldstream and BX Creeks. A councillor from the city of Vernon was shown the BX Creek location, along with the president of the Allan Brooks Nature Centre.

Provincial Government: We provided the BC Ministry of Environment Conservation Corp with locations of areas that needed to be surveyed for screech-owls based on our reconnaissance work and findings. Some new owls were found based on the information we provided. In 2007, we provided the BC Ministry of Environment with the latest information on screech-owl home range sizes and composition for use in designing Wildlife Habitat Areas and for a Canadian Intermountain Joint Venture initiative.

Federal recovery team: The *macfarlanei* recovery team was updated regularly through the course of the research and year-end reports were sent out to members. We invited members to a 2-day field trip in the research area in July 2007 (Photograph 1). Attendees:

Orville Dyer (Screech-owl Recovery Team chair, BC Environment)
Ted Antifeau (BC Environment)
John Surgenor (BC Environment)
Dick Cannings (Cannings Holm Consulting)
Scott Allen (BC Hydro's Bridge Coastal Restoration Program)
Andrew MacDonald (BC Hydro's Bridge Coastal Restoration Program)

Attendees were shown roost and nest trees, owls with transmitters, proposed wildlife habitat areas (WHAs), home ranges, and lands for potential conservation covenants.

We also attended joint meetings between different species at risk recovery teams working on grassland-related species (both plant and animal).

**Photograph 1. Members of the screech-owl recovery team at a screech-owl nest, July 2007.**

### Forest Licensees

Our research has provided the information needed by forest licensees to ensure that Section 7 results and strategies for western screech-owls in the Southern Interior region are measurable or verifiable. Throughout the course of the project, we have provided forest licensees within the project area with updates and year-end reports detailing the results of the study. However, during the course of the inventory and research study, it became apparent that screech-owls were very rare on crown land and were minimally affected by operations of forest licensees in our study area. Subsequently, the focus of the extension activities for licensees became more directed towards ensuring that results of the study were forwarded so that they could incorporate results into their Section 7 schedules of the Sustainable Forest Management Plans. To this end, copies of this final report will be distributed to all forest licensees with operations in low-elevation forests in the Interior Douglas-Fir biogeoclimatic zone. Targeted forest licensees that will be receiving this final report include:

- Tolko Industries,
- Gorman Brothers,
- Weyerhaeuser Canada,

- Pope and Talbot, and
- BC Timber Sales.

We identified 2 candidate Wildlife Habitat Areas (WHAs) for screech-owls in the research area. WHAs are a conservation process under the BC Government's Identified Wildlife Management Strategy whereby important habitats for wildlife species on Crown Land are identified and in which specified forest and range management activities occur that help to maintain the function of the habitat for the species. The 2 areas that we identified occurred within home ranges of tagged owls and included areas in which we documented owls roosting. Unfortunately, none of the nests that we identified occurred on Crown Land, so no nests could be included within the Wildlife Habitat Areas. We submitted these proposals in December 2006 but BC Ministry of Environment has so far failed to establish the WHAs.

### Naturalists

Presentations about screech-owls were given at:

- The BC Field Ornithologists Annual Conference,
- The Society for Northwestern Vertebrate Biology annual meeting (scientific poster)
- North Okanagan Naturalist Club,
- Central Okanagan Naturalist Club,
- South Okanagan Naturalists Club, and
- Federation of BC Naturalists AGM.

Funding agencies were recognized at all public presentations. We took a photojournalist (A. Michael Bezener, One Wild Earth Photography) into the field to take photos of our work and the owls, he plans on submitting articles about the project to a number of magazines. These photos have been used at presentations.

### Professional biologists

We have been in contact with many professional biologists who are surveying for western screech-owls. We have undertaken to mentor younger biologists by giving presentations about our research at an ecology course at Thompson Rivers University and we provided work experience for two Lumby grade 10 students interested in becoming biologists.

We have endeavoured to conduct our research in a rigorous fashion that will assist in publishing our findings:

- A scientific publication on the diet of screech-owls has been accepted for publication in the journal "British Columbia Birds". Citation: Davis, H. and R. J. Cannings. *In press*. Diet of western screech-owls in the interior of British Columbia. British Columbia Birds. 18:000-000.
- Three manuscripts are currently being prepared for submission to peer-reviewed scientific journals for publication:
    - Home ranges and spatial organization of western screech-owls in British Columbia. Target journal: The Condor.

    - Factors affecting selection of roost sites by western screech-owls: implications for conservation. Target journal: Biological Conservation.
    - Population characteristics of western screech-owls in southern British Columbia. Target journal: Northwestern Naturalist.
- Data from the research study was included in a new BC status report on western screech-owls (*macfarlanei* subspecies; Cannings and Davis 2007). Funding agencies were recognized for their contribution towards the results that were utilized in the report.
- We assisted with screech-owl habitat modelling by the Grassland Conservation Council for their priority grasslands initiative.
- We submitted sightings of species at risk found within the research area over the last 3 years to the BC Conservation Data Centre.
- We took Irene Manley (Columbia Basin Fish and Wildlife Compensation Program) out to view habitats used by owls in our study and provided instruction on capturing screech-owls for the second *macfarlanei* screech-owl research project in BC, to take place in the Kootenays. We successfully caught 2 owls in the nights she assisted with trapping.

**Land conservation**

We have discussed the option of placing conservation covenants on important pieces of land in the research area with private landowners. We have a working relationship with both NOPNAT and the Okanagan branches of The Nature Conservancy of Canada (NCC) and The Land Conservancy (TLC). However, much of the research area is within the Agricultural Land Reserve (ALR) and it can be extremely difficult to get approval from the Agricultural Land Commission for covenants on lands in the ALR as habitat protection is not an agricultural use.

We have been working towards conservation of a large piece of intact cottonwood riparian land owned by BC Hydro in the heart of the research area. The Bridge Coastal Restoration Program Office is working with the BC Hydro Properties Division to identify BC Hydro-owned lands on the Middle Shuswap that we have identified as key habitat for western screech-owls. Combined with information compiled from other BCRP-funded projects in the area (e.g., the Shuswap Bat Project) BC Hydro’s goal is to identify and secure key habitats owned by BC Hydro by designating the properties as conservation lands. BCRP is investigating if conservation covenants could achieve this goal. A balance will need to be struck between the goals of conservation, and recognizing what restrictions are required for BC Hydro to conduct its generation business. The Land Conservancy has agreed to pursue the protection of this land with BC Hydro and have received approval for funding from BCRP in 2008/09 to assist with the development of a strategy to carry out this initiative.

The Land Conservancy has also agreed to hold a covenant in cooperation with NOPNAT for one of the landowners in the research area whose land has been used extensively by a pair of screech-owls that were followed in the research study. TLC applied for funding from the Habitat Stewardship Program to carry out the establishment of this covenant, HSP has approved funding in principal as of April 24, 2008.

Because of our contacts, a third property in the research area has been the subject of discussions between a landowner and land conservation organizations. This property is just in the beginning phase of negotiations. The land is similar to the BC Hydro owned land in that it is a large cottonwood riparian forest with high habitat values, especially salmon habitat. We will continue to be a part of coordinating this endeavour.


**Photograph 2. Field visit to potential covenant area between the Nature Conservancy of Canada, the North Okanagan Parks and Natural Areas Trust and BCRP representatives, 2006.**

Having landowners who are interested in establishing conservation covenants has highlighted a number of issues that need to be resolved if agencies wish to see more private landowners pursue covenants. Overall, land trusts do not have the personnel capacity to deal with establishing covenants. Also, covenants are costly ($10-15,000) with very little incentive to landowners, especially if they do not have high income levels.

Some of the riparian areas of the Shuswap are somewhat protected by the Official Community Plan for electoral areas “D” and “E” of the Regional District of the North Okanagan. There are provisions for “protection of the natural environment” as well as “protection from hazardous conditions” in the floodplains of the Shuswap River.

# Stewardship Extension Evaluation

To evaluate the effectiveness of our extension programs, a portion of this program was dedicated to evaluating project outcomes.

### Objectives

The general objectives were to assess:

1) Changes in behaviour and perceptions of landowners resulting from the stewardship and outreach program,
2) The effectiveness of Best Management Practices for retaining habitat structures,
3) Feedback on the various aspects of the program by end-users to adapt and enhance the efficacy of restoration actions.

### Methods

To extend the results of the research project to landowners that manage screech-owl habitat on their property, we provided 43 landowners in the project area with an information package containing details on how best to conserve screech-owls and their habitats, conservation covenants, and other species at risk that live in the area (see *Extension* section). To assess the effectiveness of this extension product and the outreach program as a whole, an independent extension specialist (Susan Leech) conducted an evaluation of the program. Landowners were contacted via telephone after they received the information package. Thirty-two of the 43 landowners were contacted; of these, 14 were interviewed in depth about the effectiveness of the information package and their experience with the project in general. Landowners were asked a series of questions to evaluate what they learned from the package and what they will do differently as a result. A detailed summary of the feedback received from landowners is included in Appendix IV. Some key results from the evaluation are highlighted below.

### Key Results

- Overall, the feedback on the manual was excellent. Everyone who was interviewed found the information easy to understand and all of them felt that it was a very worthwhile project in which to have participated.
- Many of the landowners were already motivated to protect important habitat on their land, but almost all of them (with the exception of one who felt that he already knew all the information) felt like they had more knowledge because of the information they had received from the manual.
- Many landowners were particularly interested in the information about rare species that live in their area, and were excited to talk about the ones that they had seen.
- Landowners who received the information in the binders were much more likely to have read, or at least reviewed, the information. None of the people contacted who had received a CD (0/4) had looked at it, while all of the people who had received a binder (10/10) had at least looked at the material.

### Recommendations

An extension program that involves personal contact between researchers and landowners is a very effective tool for increasing interest and knowledge in local wildlife and habitat issues amongst landowners. Future research projects that take place on private land should follow our stewardship model.

It seems there is a great desire to learn more about rare wildlife species. Landowners were often not aware of the important or at-risk species that might occur in their neighbourhood and they had a desire for this information. Small, local education programs would help achieve protection of species at risk and their habitats and assist with gathering sightings of rare species. We have brought this to the attention of the Whitevalley Community Resource Centre in case they would like to pursue such an education program.

Providing information on a CD proved to be an ineffective delivery method and should be avoided in the future. We provided some stewardship manuals on CD, partly because we felt there might be some negative reaction to the amount of paper used in the printed version. This was apparently not the case.

Conducting an evaluation was helpful in gathering information on the intentions of some landowners. Those that expressed interest in covenants and protecting river frontage will receive further information or contact from a local land trust organization (NOPNAT) that may be able to assist.

# Acknowledgements

We gratefully acknowledge financial support from the Bridge-Coastal Restoration Program of BC Hydro, the Government of Canada Habitat Stewardship Program for Species at Risk, and the Forest Science Program of the Forest Investment Account. Additional funding during previous years was provided by the World Wildlife Fund and Environment Canada through the Endangered Species Recovery Fund, Tolko Industries Ltd. and the BC Ministry of Environment.

The Spallumcheen Indian Band was instrumental in the discovery of these screech-owls and we thank them for their support of the research project.

Many thanks to Whitevalley Community Resource Centre for their support and assistance.

Thanks to Harry van Oort and Bill Harrower for their dedication to trapping until the wee hours and climbing nest trees! Incredible photos of screech-owls were taken by A. Michael Bezener (One Wild Earth Photography), which he allowed us to use in our presentations to the public. We thank assistants Ryan Noble and Apryl Hahn for helping to collect the field data. Tania Tripp provided recordings of owl calls. Don Doyle loaned us his stuffed owl for trapping for the duration of the project.

Many thanks to Dick Cannings for answering many questions, conducting the pellet analysis and reviewing a draft of the final report.

Susan Leech carried out the evaluation of the landowner stewardship program. Thanks for a quick, well-done job.

Scott Allen and Andrew MacDonald were supportive of this project through the Bridge Coastal Restoration Program, but also in facilitating the work in general.

The results and recommendations presented in this document do not necessarily represent official positions of sponsors or funding agencies.

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# Appendix I: Diet of western screech-owls in the interior of British Columbia

The following paper has been accepted for publication in *British Columbia Birds*. The only changes will be to formatting. The paper should be published in Volume 18, 2008.

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**DIET OF WESTERN SCREECH-OWLS IN THE INTERIOR OF BRITISH COLUMBIA**

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*Abstract*—During 2006 and 2007, we radio-located Western Screech-Owls (Megascops kennicottii macfarlanei) at roost sites along the Shuswap River, British Columbia, Canada. Between March and November, we collected regurgitated pellets at these roosts and analysed them for content. Screech-owls had a diverse diet that included small mammals, birds, fish and insects. Female owls included more mammals in their diet than males, and males included more insects than females. We speculate that differential niche utilization may reduce intersexual competition for food resources within this endangered species.

*Key Words*: Western Screech-Owl, *Megascops kennicottii macfarlanei*, diet, intersexual competition, niche separation.

## Introduction

The interior Western Screech-Owl (*Megascops kennicottii macfarlanei*) is an endangered species (COSEWIC 2002) that occurs in lowland areas of south-central British Columbia. Screech-owls have a varied diet; beetles, crickets and grasshoppers, snails, fish, birds, voles, mice, shrews, pocket gophers, and bats have been found in the diet of screech-owls in previous studies (Munro 1929; Earhart and Johnson 1970; Smith and Wilson 1971; Marks and Marks 1981; Rains 1997; Cannings and Angell 2001). Understanding the composition of the diet of Western Screech-Owls can be useful for conservation programs because it will aid in identification of habitat factors that may affect abundance and distribution of food resources for this endangered species.

## Methods

We captured and radio-tagged screech-owls as part of a study on the general ecology of the species. We used radiotelemetry to locate owls at daytime roosts and returned to these sites at a later date to search for regurgitated pellets and prey remains. Samples were collected, frozen and analysed later for contents.

We separated each raw pellet using fine forceps and spread the contents under a dissecting microscope. Using the key of Nagorsen (2002) and reference collections, we identified individual prey items to species where possible, and to genus or other taxonomic levels when this could not be accomplished.

We occasionally collected multiple pellets at a single site and grouped these pellets into a single sample. Because pellets found at a single roost site could be of multiple ages or from untagged owls, the provenance of the pellet or confidence in the dates of use may be reduced. We did not assign date or sex of owl to pellets that were collected > 2 weeks after the roost site was identified or for pellets collected from sites used by both male and female radio-tagged owls.

For each pellet sample, we recorded the prey species present and the minimum number of individuals of each prey species. We then grouped prey species into 4 broad taxonomic groups: insects, fish and molluscs, birds, and mammals. Fish and molluscs were combined because of low sample sizes and presumed ecological similarities. We compared the diet composition between sexes by assessing the frequency of occurrence of each of the 4 taxonomic groups in the pellets. We used Chi-square goodness-of-fit test and Bonferroni-adjusted $Z$-tests to compare the frequency that each group occurred in the pellets collected from each sex. We set the acceptable Type I error rate at 0.05.

## Results

Number of pellets collected varied throughout the year. Pellets were easiest to find prior to nesting, which occurred in April. Pellets were often very difficult to locate because of their small size (most < 2 cm long) and cryptic colouration. Pellets were only found between March and November of 2006 and 2007; despite considerable search effort we did not find pellets at roosts during winter. We collected and analysed 75 samples of regurgitated pellets, with some samples containing multiple pellets. Individual pellets often contained multiple prey items.

We identified 219 prey items in the 75 samples, for an average of 2.9 prey items per sample (SD = 2.8). The largest number of prey items in one sample was 16 found in 3.5 pellets, which were mostly beetles (14 of 16 items). Beetles were the most common prey item (100 or 45.7%) followed by *Microtus* species as a group (46; 21%). Most of the *Microtus* species samples were likely *M. pennsylvanicus*, but species identification could not be made on all *Microtus* samples; no other *Microtus* species were identified. Not all prey items could be identified to the species level, since most specimens were badly broken with missing teeth or bones, some of which were critical to species identification.

The frequency of occurrence of 4 taxonomic groups was significantly different ($\chi^2 = 7.88$, df = 3, $P = 0.049$; Table 1) between the diets of males and females (Figure 1). Males consumed significantly more insects than did females, whereas females consumed more mammals than did males (Bonferroni-adjusted *Z*-tests, $P < 0.05$).

**Table 1. Frequency of occurrence of prey items found in pellets collected from Western Screech-Owls along the Shuswap River, British Columbia, 2006 and 2007. The number of items of a category found in a single sample is not indicated. *N* = 75 pellet samples.**

| | Sex of owl | | | |
|---|---|---|---|---|
| | Female | Male | Unknown | Total |
| Insects | | | | |
| Beetle (Coleoptera: most or all Carabidae) | 14 | 21 | 2 | 37 |
| Cricket/grasshopper (Orthoptera) | 2 | 2 | 0 | 4 |
| Undifferentiated insects | 2 | 4 | 0 | 6 |
| Molluscs | | | | |
| Snail | 0 | 1 | 0 | 1 |
| Fish | | | | |
| | 0 | 4 | 0 | 4 |
| Birds | | | | |
| Ruffed Grouse (Bonasa umbellus) | 4 | 1 | 0 | 5 |
| Killdeer (Charadrius vociferus) | 1 | 0 | 0 | 1 |
| American Robin (Turdus migratorius) | 1 | 0 | 0 | 1 |
| Cedar Waxwing (Bombycilla cedorum) | 0 | 1 | 0 | 1 |
| Undifferentiated bird | 4 | 5 | 1 | 10 |
| Egg shell | 0 | 1 | 0 | 1 |
| Mammals | | | | |
| Shrew (Sorex spp.) | 6 | 0 | 1 | 7 |
| Bat (Chiroptera) | 0 | 0 | 1 | 1 |
| Red Squirrel (Tamiasciurus hudsonicus) | 1 | 0 | 0 | 1 |
| Northern Pocket Gopher (Thomomys talpoides) | 2 | 0 | 1 | 3 |
| Meadow Vole (Microtus pennsylvanicus) | 10 | 9 | 2 | 21 |
| Undifferentiated vole (Microtus spp.) | 9 | 6 | 1 | 16 |
| Deer Mouse (Peromyscus maniculatus) | 6 | 5 | 1 | 12 |
| Undifferentiated rodent | 4 | 4 | 0 | 8 |
| Total | 66 | 64 | 10 | 140 |

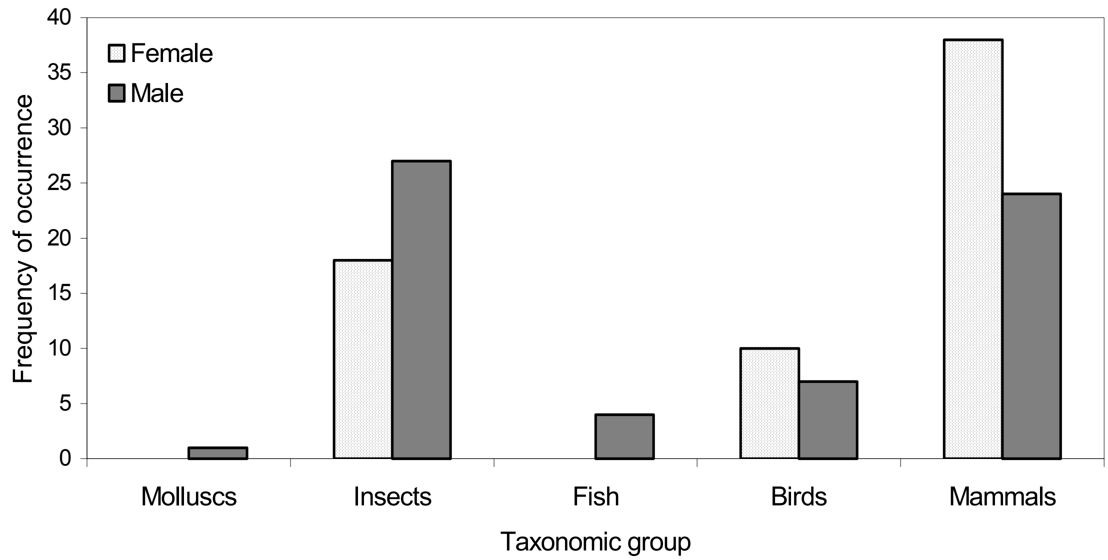


Figure 1. Frequency of occurrence of 4 taxonomic groups in pellets (*n* = 75) collected from Western Screech-Owls along the Shuswap River, British Columbia, 2006 and 2007.

We observed few noticeable differences in the seasonal occurrence of the different species of prey (Figure 2). However, beetles were used as soon as they became available at the end of March, peaked in use in April, and gradually declined in frequency in the pellets through autumn.

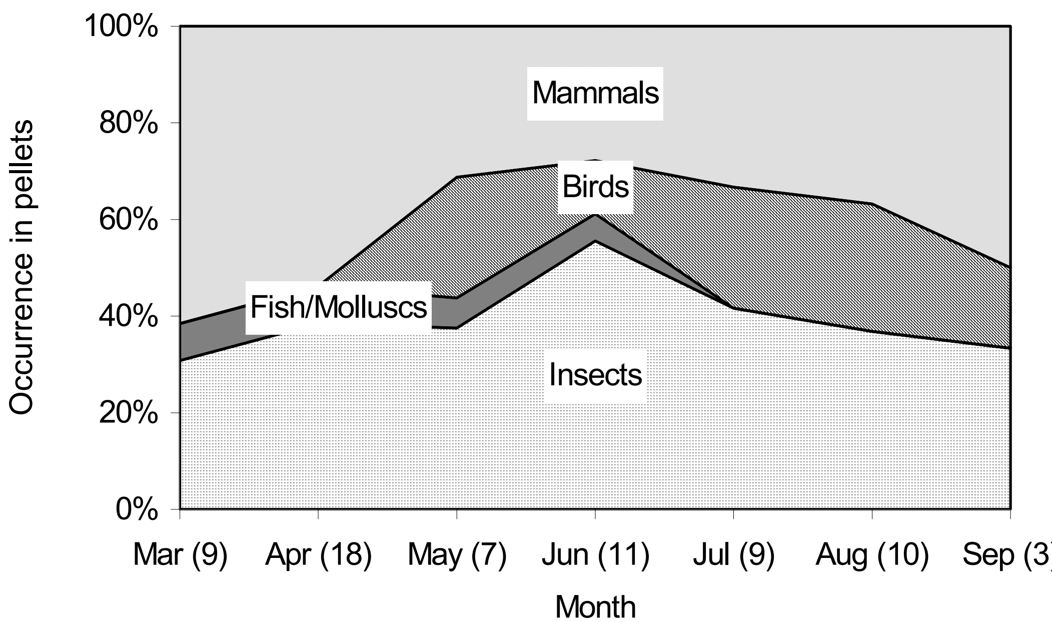


**Figure 2. Monthly variation in occurrence of taxonomic groups in pellets collected from Western Screech-Owls along the Shuswap River, British Columbia, 2006 and 2007. Number of pellet samples analysed in parentheses beside month name.**

## Discussion

Composition of the diet of Western Screech-Owls in the Shuswap River drainage was similar to that reported elsewhere within the range of the *macfarlanei* subspecies. Insects and small mammals were the primary components of their diet, although a wide variety of other species were consumed in minor amounts. Composition of the pellets varied; 50.2% contained insects, 38.9% mammals, and 7.9% of the items were birds. Interestingly, our results are different from those of Smith and Wilson (1971) whose 67 pellets collected during winter in Utah yielded a total of 80 prey items of which 23.8% were insects, 24.9% were mammals, and 51.3% were birds. One would expect diets to be different between our study and Smith and Wilson's (1971) study because of differences in the seasons of collection and ecological settings; very little snow cover occurred in the Utah study area (D. Smith, Southern Connecticut State University, personal communication).

While proportions varied, few prey species found in this study had not been detected in the diet of screech-owls or other small owls elsewhere. This observation suggests that screech-owls in our research area did not use a different suite of prey species than found in other areas. Our detection of a red squirrel in a pellet was the only diet item that has not been reported in other studies (Cannings and Angell 2001).

It is unclear how important birds are in the diet of Western Screech-Owls because they comprised such a small component of the prey items that we identified. Although unidentified bird bones were found in 10 pellet samples in this study, all prey items from birds that were identified to species consisted of feathers that we had collected on the ground beneath roosts. We found remains of a Cedar Waxwing, American Robin and Killdeer and 4 adult Ruffed Grouse under roosts. We cannot be sure that these feathers were of prey eaten by screech-owls; it is possible that the remains were left by another raptor. However, birds were a recognized diet item in other studies (e.g., Marks and Marks 1981; Rains 1997; Cannings and Angell 2001). Although Ruffed Grouse are large for this small owl, screech-owls do occasionally take large prey; adult cottontails (*Sylvilagus* spp.) were found 3 times in a screech-owl nest box in Idaho (Cannings and Angell 2001).

We observed substantial differences between diets of male and female screech-owls which has not been noted previously. Male screech-owls consumed more small prey items (fish and insects) than females, whereas females ate more small mammals than did males. Differential niche utilization within a common territory may reduce intersexual competition for food resources (Selander 1966). Differential niche utilization by sexes is not unexpected by Western Screech-Owls due to their sexual size dimorphism; male screech-owls in this study were much smaller ($\bar{x}$ = 191 g, SD = 12.0, $n$ = 6) than females ($\bar{x}$ = 242 g, SD = 34.2, $n$ = 10). In addition to segregation of food resources, we also found that the male and female owl of one breeding pair used different parts of the territory outside of the breeding season, which may further reduce intersexual competition for food resources.

Our results are consistent with the findings of Smith and Wilson (1971), who concluded Western Screech-Owls are relatively opportunistic predators, taking the most easily attainable prey. It is unlikely that lack of suitable prey contributes to the low population numbers and endangered status of this species. Prey species that owls consumed occur in a wide variety of habitats. However, exposure to predation by larger owls may affect the types of habitats that owls can safely exploit in order to acquire these prey resources.

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## Acknowledgements

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# Appendix II: Habitat selection models

Appendix II-1. Information-theoretic inference of candidate models examining the factors that affected selection of trees used for roosting by radio-tagged western screech-owls along the Shuswap River, British Columbia, 2005-2008. * demarks 95% confidence set of best models.

| Model ID | | Probability of use of patch for roosting within stand related to: | $K^a$ | $QIC_u{}^b$ | $\Delta_i{}^c$ | $w_i{}^d$ | Area under ROC curve |
|---|---|---|---|---|---|---|---|
| R-16 | * | Quadratic relationship with diameter | 4 | 523.888 | 0 | 0.743 | 0.82 |
| R-14 | * | Diameter class (20-40 cm dbh, >40 cm dbh) | 4 | 526.010 | 2.123 | 0.257 | 0.79 |
| R-7 | | Tree form depending upon diameter | 4 | 555.589 | 31.701 | 0 | 0.82 |
| R-5 | | Length of tree crown | 3 | 556.767 | 32.879 | 0 | 0.75 |
| R-13 | | Crypticness afforded by bark during leaf-off, crown length during leaf-on | 5 | 562.043 | 38.155 | 0 | 0.75 |
| R-11 | | Size of crown adjusted for phenology | 4 | 563.248 | 39.360 | 0 | 0.73 |
| R-3 | | Diameter | 3 | 563.618 | 39.731 | 0 | 0.82 |
| R-6 | | Height of tree | 3 | 568.758 | 44.871 | 0 | 0.74 |
| R-17 | | Length of crown adjusted for phenology and depending upon patch cover and length of coniferous crown depending upon patch cover | 4 | 601.579 | 77.691 | 0 | 0.66 |
| R-8 | | Similarity between colour and pattern of tree bark and plumage | 3 | 622.861 | 98.974 | 0 | 0.44 |
| R-9 | | Length of crowns of deciduous trees depending upon phenology | 3 | 632.115 | 108.227 | 0 | 0.51 |
| R-10 | | Crypticness afforded by bark depending upon phenology | 3 | 633.921 | 110.034 | 0 | 0.55 |
| R-null | | Nothing (no selectivity) | 2 | 634.548 | 110.661 | 0 | 0.50 |
| R-12 | | Presence of potential nests | 3 | 635.077 | 111.190 | 0 | 0.51 |
| R-15 | | Status of tree - live or dead | 3 | 636.488 | 112.600 | 0 | 0.50 |
| R-4 | | Coniferous tree species | 3 | 636.525 | 112.637 | 0 | 0.50 |
| R-2 | | Crown condition | 4 | 636.682 | 112.794 | 0 | 0.53 |
| R-1 | | Deciduous during leafout, coniferous otherwise | 4 | 638.499 | 114.612 | 0 | 0.50 |

[a] number of estimated parameters in associated model
[b] Quasi-likelihood Information Criterion for small samples (Pan 2001)
[c] difference in $QIC_u$ scores between model and best-selected model
[d] relative likelihood of model; Akaike weight (Burnham and Anderson 1998)

Appendix II-2. Descriptive statistics of patches of habitat (150 m²) used by radio-tagged western screech-owls for roosting and unused patches within the same stand along the Shuswap River, British Columbia, 2005-2008. Statistics were not stratified by time or individual owl, as was done for the selection analysis. *N* = 88 roost patches, 88 unused patches.

| | Used | | Unused | |
|---|---|---|---|---|
| Variable | Mean | SD | Mean | SD |
| Cover (%) | | | | |
| Trees (>10 m) | 34 | 24 | 27 | 28 |
| High-shrubs (2-10 m) | 17 | 21 | 12 | 14 |
| Low-shrubs (<2 m) | 9 | 10 | 15 | 20 |
| All shrubs (<10 m) | 23 | 23 | 26 | 24 |
| Tree and shrubs > 10 m | 52 | 35 | 39 | 33 |
| All trees and shrubs | 57 | 37 | 53 | 42 |
| Proximity to (m) | | | | |
| Nest | 349 | 278 | 409 | 292 |
| Stand edge | 27 | 21 | 34 | 27 |
| Shuswap River | 160 | 206 | 171 | 217 |
| Stem density (stem/ha) | | | | |
| All trees | 813 | 512 | 580 | 498 |
| All live trees | 731 | 447 | 542 | 468 |
| Western redcedar | 264 | 335 | 142 | 295 |
| Douglas-fir | 166 | 282 | 160 | 308 |
| Hybrid spruce | 112 | 178 | 24 | 69 |
| All coniferous trees | 575 | 465 | 344 | 430 |
| Paper birch | 110 | 171 | 53 | 124 |
| Black cottonwood | 59 | 132 | 63 | 141 |
| Alder | 41 | 153 | 114 | 294 |
| All deciduous trees | 238 | 270 | 236 | 338 |
| Trees 20-40 cm dbh | 251 | 160 | 161 | 178 |
| Trees >40 cm dbh | 85 | 86 | 35 | 53 |
| Trees <20 cm dbh | 477 | 473 | 383 | 413 |
| Other measures | | | | |
| Slope (°) | 18 | 28 | 17 | 48 |
| Number of trees in plot | 12 | 8 | 9 | 7 |
| Mean DBH (cm) | 26 | 10 | 18 | 11 |
| Standard deviation of DBH (cm) | 13 | 7 | 8 | 7 |

Appendix II-3. Information-theoretic inference of candidate models examining the factors that affected selection of patches used for roosting by radio-tagged western screech-owls along the Shuswap River, British Columbia, 2005-2008. * demarks 95% confidence set of best models.

| Model ID | Probability of use of patch for roosting within stand related to: | $K^a$ | $QIC_u{}^b$ | $\Delta_i{}^c$ | $w_i{}^d$ | Area under ROC curve |
|---|---|---|---|---|---|---|
| P-17 | * Density of trees >40 cm dbh, tree and high-shrub cover, and low-shrub cover | 5 | 216.833 | 0 | 0.99 | 0.75 |
| P-14 | Density of trees >40 cm dbh, proximity to edge, and cover of trees and shrubs | 5 | 227.816 | 10.983 | 0.004 | 0.71 |
| P-5 | Density of trees >40 cm dbh | 3 | 228.226 | 11.394 | 0.003 | 0.68 |
| P-16 | Density of trees >40 cm dbh and cover of trees and shrubs | 4 | 230.087 | 13.255 | 0.001 | 0.71 |
| P-15 | Mean dbh of trees and cover of trees and shrubs | 4 | 230.997 | 14.164 | 0.001 | 0.70 |
| P-11 | Density of conifers during winter and density of all trees during summer | 4 | 231.566 | 14.733 | 0.001 | 0.70 |
| P-12 | Tree and high-shrub cover, and low-shrub cover | 4 | 233.088 | 16.255 | 0 | 0.68 |
| P-4 | Tree density | 3 | 240.705 | 23.872 | 0 | 0.64 |
| P-2 | Tree cover | 3 | 246.796 | 29.963 | 0 | 0.61 |
| P-9 | Proximity to edge of stand | 3 | 246.843 | 30.01 | 0 | 0.57 |
| P-10 | Slope | 3 | 247.132 | 30.299 | 0 | 0.54 |
| P-null | Nothing (no selectivity) | 2 | 247.988 | 31.155 | 0 | 0.50 |
| P-1 | Cover of trees and shrubs | 3 | 249.363 | 32.53 | 0 | 0.55 |
| P-3 | Shrub cover | 3 | 249.562 | 32.729 | 0 | 0.53 |
| P-8 | Proximity to Shuswap River | 3 | 249.872 | 33.039 | 0 | 0.51 |
| P-7 | Shrub cover depending on amount of tree cover | 3 | 249.974 | 33.141 | 0 | 0.54 |
| P-6 | Density of deciduous trees | 3 | 249.985 | 33.153 | 0 | 0.52 |
| P-13 | Cover of trees and shrubs and proximity to nest during nesting period for males | 4 | 251.024 | 34.191 | 0 | 0.58 |

[a] number of estimated parameters in associated model
[b] Quasi-likelihood Information Criterion for small samples (Pan 2001)
[c] difference in $QIC_u$ scores between model and best-selected model
[d] relative likelihood of model; Akaike weight (Burnham and Anderson 1998)

Appendix II-4. Post-hoc analysis of factors affecting selection of patches of habitat for roosting by radio-tagged screech-owls along the Shuswap River, British Columbia, 2005-2008. The best a priori model (P-17) is shown for reference.

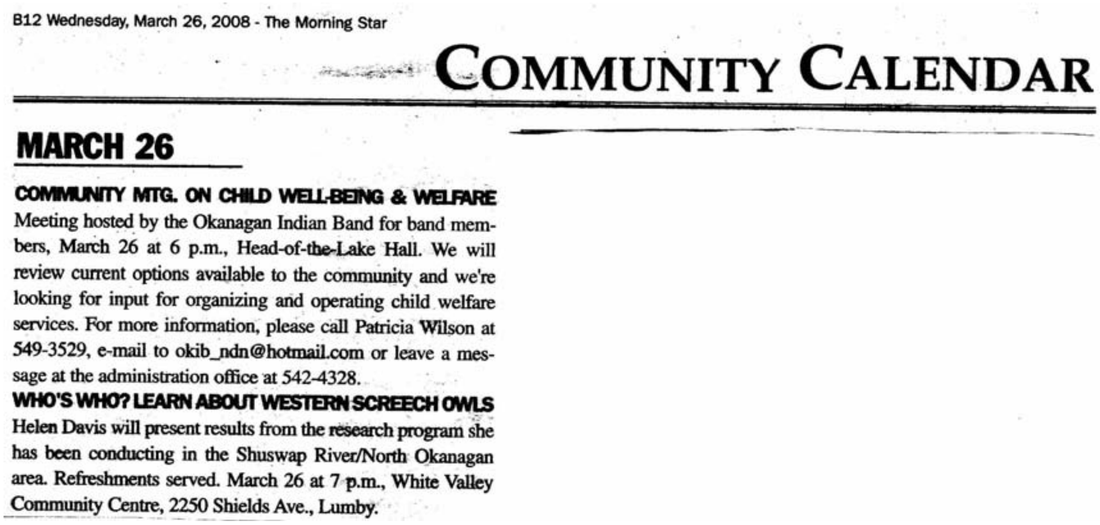
| Model ID | Probability of use of patch for roosting within stand related to: | $K^a$ | $QIC_u{}^b$ | $\Delta_i{}^c$ | Area under ROC curve |
|---|---|---|---|---|---|
| P-ph3 | High-shrub cover, low-shrub cover, density of paper birch, density of alder, density of hybrid spruce, density of all conifers, and density of trees >40 cm dbh | 9 | 193.262 | 0.00 | 0.84 |
| P-ph1 | High-shrub cover, density of paper birch, density of hybrid spruce, density of all conifers, and density of trees >40 cm dbh | 7 | 205.77 | 12.507 | 0.80 |
| P-17 | Density of trees >40 cm dbh, tree and high-shrub cover, and low-shrub cover | 5 | 216.833 | 23.57 | 0.75 |
| P-ph2 | Low-shrub cover and density of alder | 4 | 239.583 | 46.32 | 0.60 |

Appendix II-5. Information-theoretic inference of candidate models examining the factors that affected selection of stands within home ranges by radio-tagged western screech-owls along the Shuswap River, British Columbia, 2005-2008. The best model was the only plausible model in the entire set of candidate models.

| Model ID | Probability of use of stand related to: | $K^a$ | $QIC_u{}^b$ | $\Delta_i{}^c$ | $w_i{}^d$ | Area under ROC curve |
|---|---|---|---|---|---|---|
| S-7 | * Mature riparian forest | 3 | 7946.919 | 0 | 0.961 | 0.56 |
| S-4 | Broad stand categories | 8 | 7953.308 | 6.39 | 0.039 | 0.59 |
| S-6 | Riparian ecosystem | 3 | 7967.901 | 20.982 | 0 | 0.58 |
| S-2 | Ecosystem | 10 | 7985.889 | 38.970 | 0 | 0.59 |
| S-1 | Structural stage | 6 | 7998.323 | 51.405 | 0 | 0.56 |
| S-8 | Mature riparian forest, agricultural areas, zonal forests | 5 | 8023.937 | 77.018 | 0 | 0.55 |
| S-5 | Stand composition | 5 | 8032.551 | 85.632 | 0 | 0.56 |
| S-9 | Stand composition based upon phenology | 5 | 8094.243 | 147.324 | 0 | 0.53 |
| S-null | Nothing (no selectivity) | 2 | 8113.208 | 166.289 | 0 | 0.50 |
| S-3 | Stand area | 3 | 8117.944 | 171.025 | 0 | 0.50 |

# Appendix III: Funding recognition and public announcements

Announcement in newspapers:


B12 Wednesday, March 26, 2008 - The Morning Star

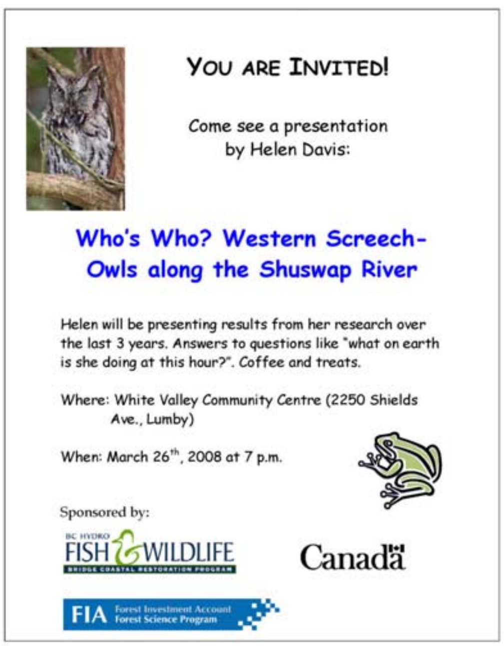
COMMUNITY CALENDAR

MARCH 26

**COMMUNITY MTG. ON CHILD WELL-BEING & WELFARE**
Meeting hosted by the Okanagan Indian Band for band members, March 26 at 6 p.m., Head-of-the-Lake Hall. We will review current options available to the community and we're looking for input for organizing and operating child welfare services. For more information, please call Patricia Wilson at 549-3529, e-mail to okib_ndn@hotmail.com or leave a message at the administration office at 542-4328.

**WHO'S WHO? LEARN ABOUT WESTERN SCREECH OWLS**
Helen Davis will present results from the research program she has been conducting in the Shuswap River/North Okanagan area. Refreshments served. March 26 at 7 p.m., White Valley Community Centre, 2250 Shields Ave., Lumby.

Invitation sent to landowners:




Funding acknowledgment in slide show:

# Appendix IV: Extension evaluation

To extend the results of the research project to landowners that manage screech-owl habitat on their property, we provided 43 landowners in the project area with an information package containing details on how best to conserve screech-owls and their habitats, nest box plans, conservation covenants, and other species at risk that live in the area (see *Extension* section). To assess the effectiveness of this extension product and the outreach program as a whole, an independent extension specialist (Susan Leech) conducted an evaluation of the program. Landowners were contacted via telephone after they received the information package. Thirty-two of the 43 landowners were contacted; of these, 14 were interviewed in depth about the effectiveness of the information package and their experience with the project in general. Landowners were asked a series of questions to evaluate what they learned from the package and what they will do differently as a result. A summary of key results is in the *Evaluation* section. The following are the questions presented and answers given:

| Question | Responses |
|---|---|
| 1. Did you receive the information package including the Shuswap Stewardship manual on paper? | Yes – 10 |
| 1b. Did you receive the information package on CD? | Yes – 4 |
| **Assessing materials** | |
| 2a. Did you read/browse through the Stewardship Manual? | Yes – 10<br>No – 4<br>(note: the 10 who said yes all received paper copies; the 4 who replied no all received CDs. One person couldn't access the CD because they don't have a computer) |
| 2b. Did you listen to the CD of owl calls? | Yes – 2<br>No – 8<br>(note: people who responded no all said that they thought it was a useful resource and that they intended to listen to it) |

| **Increasing knowledge: after reading the manual:** | |
|---|---|
| 3. Do you know more about screech-owls, including why they are endangered and what their habitat needs are? | Yes |
| | Yes, I know more about it – I didn't know much at all before. |
| | Yes – I already knew a lot. |
| | Yes |
| | Yes, I know more – I already knew a lot about it. |
| | Yes but I was already very aware. |
| | Yes |
| | I already knew it but it's nice to have a summary. |
| | Yes, very useful information. |
| | Yes, I already had quite a bit of information, but it's nice to have a summary to show other people. It's like a coffee table book – I will keep it in my living room for people to see when they visit. |
| 4. Do you know more about the other rare species that live in your area, including how to report information to the Conservation Data Centre? | Yes, very interesting information. |
| | Yes, very interested to see information about badgers. We often see them. |
| | Yes, great stuff. |
| | Yes. |
| | Yes. |
| | Yes, we used to see painted turtles and still see badgers occasionally. |
| | Yes, we have seen some of them. |
| | Yes, very interesting. |
| | Yes. |
| | Yes, useful information, nice to have a summary of other rare species. I didn't know about reporting to CDC so useful to have that information. |
| 5. Do you feel you are equipped with the information you need to protect or improve screech-owl habitat on your property? | Yes, I already knew to leave cottonwoods and leave the ones that aren't a hazard. They are mostly on the other side of the road from our house so that works out well. |
| | I have already cut down all of the big cottonwoods because they were dangerous (years ago). Didn't know they were important. |
| | I don't really have any good habitat (no cottonwood). |
| | Yes. |

| | |
|---|---|
| | Yes, it's covered nicely in the manual. |
| | Yes, I already knew but it's well laid out for someone who didn't. |
| | Yes. |
| | Yes but my husband is not so keen – but I'm convincing him. |
| | Yes. |
| | Yes but we need regulations to protect habitat on private land. |
| **Changes in motivation** | |
| 6. Are you interested in protecting important features of screech-owl habitat on your property? Are you interested in learning more about protecting owl habitat through the use of conservation covenants? | Already doing what I can. Am in the process of subdividing my land and land along river could revert to crown. Would be interested in exploring if this could be protected. |
| | I am doing what I can but not my land. Not interested in conservation covenants. |
| | Yes. Know enough about conservation covenants. Not interested but would like to keep habitat. |
| | Already do. Nice to know that owls like my trees. I bought the land to protect it from "progress" so I was already protecting. |
| | Yes, and I have the necessary information. |
| | Yes, interested in protecting habitat. Not interested in covenants. |
| | Yes, I'm motivated to look after my land. I have enough information about conservation covenants. |
| | Yes. |
| | Yes, we are already working on a conservation covenant with TLC on the whole property. It's a slow process. |
| | Yes, I am interested in protecting and already have been doing it. Don't need more information about covenants. |
| | Yes, would like to learn more about covenants. We are looking into it with three neighbours, possibly to do it all along the river. |

| Changes in behaviour | |
|---|---|
| 7. Are you actively protecting owl habitat, either through your own measures or through applying a conservation covenant to your land? | Not doing anything differently. Is pursuing subdividing land. |
| | No, nothing special really. |
| | Nothing different from what I was doing. |
| | Nothing that is very different. |
| | I am already doing it on my own. |
| | I'm building an owl box. We are pretty eco-friendly already. |
| | I'm already protecting my land. |
| | Not per se. We try to be environmentally conscious. |
| | Yes. I hope that everyone who has privilege to have owls on their lands knows what a privilege it is and looks after them. |
| | Not really (nothing special). |
| | Yes (working on a covenant). |
| | Building an owl box and keeping all old growth cottonwood. |
| | Yes, we are pursuing a covenant with neighbours. |
| **Questions about the information package** | |
| 8. Did you find the information package easy to understand? | Yes, well laid out. Great. |
| | Haven't seen it because I got it on CD and don't have a computer. |
| | Yes, very well set out. |
| | Yes, very good. Designed in a way that made us want to pick it up. |
| | Yes, very interesting. |
| | Yes. |
| | Yes. |
| | Yes, it was excellent. |
| | Yes, really good. |
| | Great reference for people who haven't been informed. |
| | Yes, it was well put together, great photos. |
| | Yes, excellent. Great reference. |

| | |
|---|---|
| 9. What was the most useful part? | All good. |
| | All good. Information about rare animals was especially interested. |
| | All good. |
| | Descriptions of cavities in cottonwood. Great to have owl calls on CD. |
| | All good. |
| | All good. |
| | Great to have information about other rare animals in manual. Now we know what lives here. |
| | All good. |
| | All good. Especially the letter and the aerial map showing where an owl uses our land. |
| | Information on covenants, other species at risk, who to call when you find something. Nice to have a resource like this. |
| 10. What was the least useful part? | Found information about status (yellow, red, blue lists) confusing. |
| **Overall project questions** | |
| 11. Are you happy you participated in the screech-owl project – was it a worthwhile experience? | Yes, we didn't do much because we live in Langley, but it was nice to get information. |
| | Yes, it was great to be involved. |
| | Yes, we need more funding to keep it going. |
| | Yes, anything to promote conservation is great. |
| | Yes, it was interesting. |
| | Yes, it's been very interesting. |
| | Yes, all great. First useful thing to come out of government in 25 years. |
| | Yes. |
| | Yes, I wish it was continuing. |
| | Yes – there were no problems at all, it would be nice if it continued. Will there be a follow-up study? |
| | I haven't had much participation. |
| | Yes, great experience. |
| | Oh yes, very interesting and worthwhile. |

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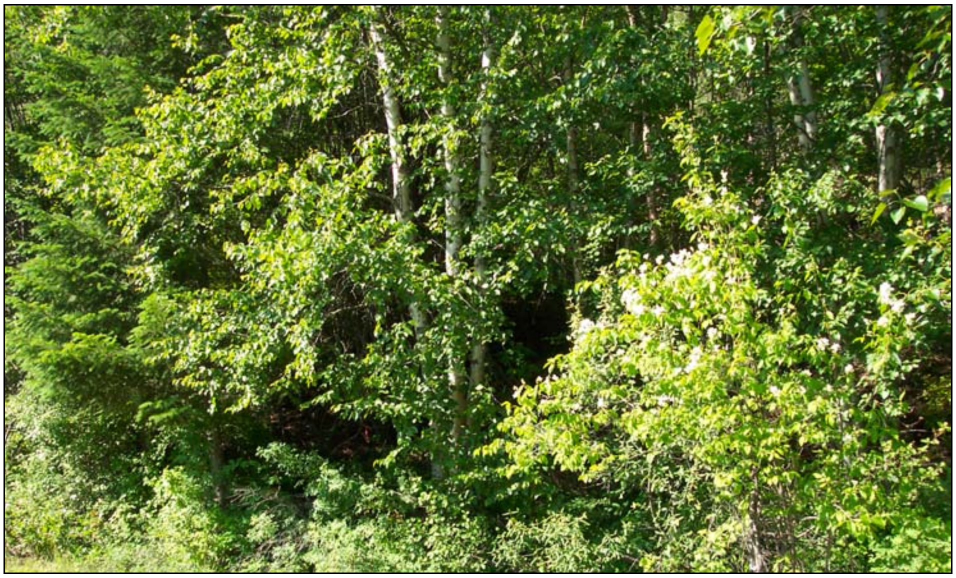
| 12. Is there anything you would do differently because you participated in this project? | No. |
| | No, but I have a better understanding of the range of owls because of the project. |
| | No, but if Helen needs support to keep the project going, she can call me. |
| | Nothing jumps to mind. |
| | No. |
| | Build an owl box. |
| | No. |
| | No, we are already environmentally conscious. |
| | Probably not. |
| | No – well, we are building an owl box. |
| | Build some screech-owl boxes. |
| | No, we are already doing a lot – but now I have the information and I can talk with confidence about it, so I'm more informed. I can use that to convince others. |
| | No, but I have talked to new neighbours about the owls. |
| Please let me know if you have any comments about the project in general. | It would be great if this information could be provided to all new landowners and to real estate agents – give them the binder so new residents know what is here and know how to protect. Suggest to the Regional District to send out information in a letter with the annual tax bills. |
| | Please send binder – I can't use the CD.(HD: this was done) |
| | The project should keep going. This is something government should be spending money on – it's a very useful project and there is a lot of money wasted on other things in government. |
| | I am concerned about the Hydro land below us and how it will be managed. |
| | The project was great for raising awareness of riparian forests – very good. We didn't know what a riparian forest was before, and now we know how important they are. |
| | It would be great if the binder could be translated into a resource for 5-7 year olds. |
| | I hope that everyone who has privilege to have owl on their land knows what a privilege it is. |

| | |
|---|---|
| | It would be great if you could do a follow-up study. |
| | Great project, great binder, looking forward to listening to CD. |

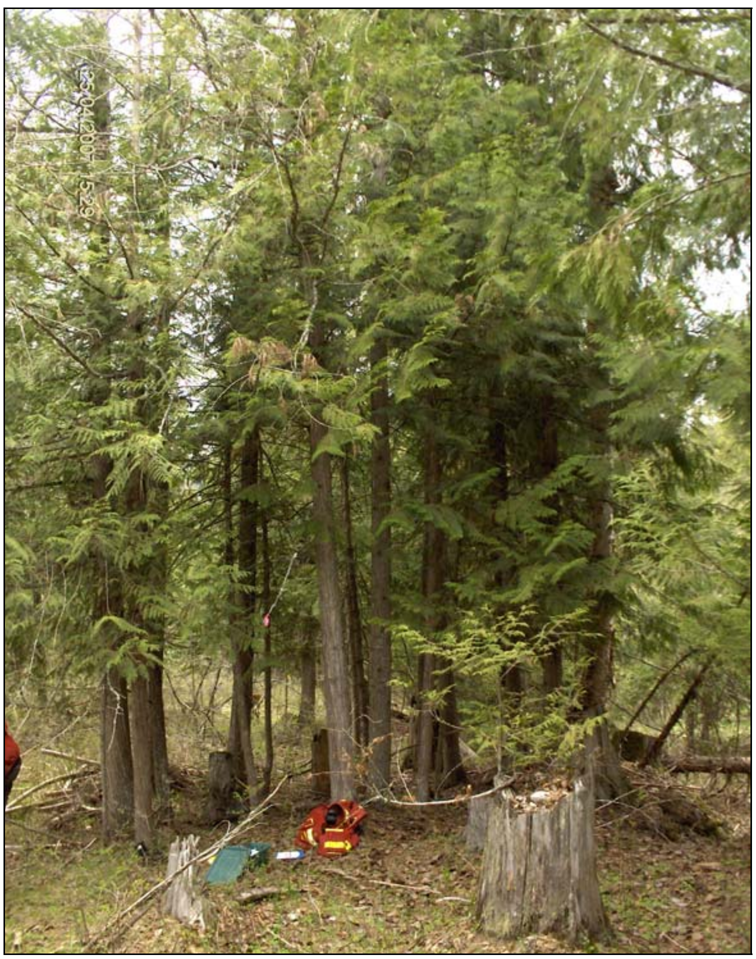
# Appendix V: Photographs

**Photograph 1. Riparian forests, such as those shown here, are vitally important for screech-owls along the Shuswap River.**

**Photograph 2. Typical roosting habitat for western screech-owls. Notice the low dense branches of the redcedar tree; these branches are often used for roosting. Screech-owls roost right next to the main stem of the tree.**



**Photograph 3. During summer, screech-owls often use dense shrubby areas for roosting. These sites aren't used much during winter because there are no leaves on the shrubs.**



**Photograph 4. Small clumps of dense conifer trees can also be important roost sites for screech-owls.**

**Photograph 5. This birch tree with a cavity was used as a nest by 2 pairs of owls: one pair in 2006, and a different pair in 2007. This tree was 70 cm (2’ 3”) wide at the base. The cavity entrance (detail) was 8 m (26’) above ground.**


**Photograph 6. Along the Shuswap River, old large black cottonwood trees are found only in riparian forests. These trees are extremely important for screech-owls, as they are one of the only tree species that produce cavities that they can use for nesting. The photo on the left is of a “branch hole” cavity.**

**Photograph 7. Standing dead trees can be important foraging perches, especially if they are on the edge of a small opening or field.**