DISTRIBUTION, ABUNDANCE, AND ECOLOGY OF FOREST OWLS IN SOUTHEAST ALASKA

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TABLE OF CONTENTS

LIST OF TABLES

Chapter 4

Chapter 5

Chapter 6

LIST OF FIGURES

OVERALL INTRODUCTION

The general rarity, nocturnal habits, and elusive behavior of forest owls have hampered large-scale study of their distribution, abundance, and ecology in Southeast Alaska. In a review of raptor populations in Alaska, Schempf (2001) ranked forest owls as the highest priority species group. Similarly, forest owls were included in Alaska's Comprehensive Wildlife Conservation Strategy because of concerns about their population status (Alaska Department of Fish and Game 2006). Recently, biologists in Canada and the United States developed guidelines for monitoring nocturnal owl species in North America by agreeing on a set of standard components that should be incorporated into surveys for breeding owls (Takats et al. 2001). Although these guidelines present a standardized approach to survey methods, a survey protocol appropriate for Southeast Alaska still needed to be developed in order to meet regional objectives and to contribute to ongoing continent-wide efforts for monitoring nocturnal owls.

We studied the distribution, occurrence, and ecology of forest owls in Southeast Alaska, 2005-2008. Our primary objectives were to (1) develop an efficient survey protocol for monitoring owl population trends, (2) evaluate survey methods for estimating relative abundance, (3) estimate occupancy and trends from 1986-2008, and (4) develop recommendations for a broad-scale monitoring strategy for nocturnal forest owls in Southeast Alaska. We also described habitat use, home range, phylogenetic structure, and diet of the Western Screech-Owl (*Megascops kennicottii*), a species of concern due to local extinction and declining populations in neighboring Canada (COSEWIC 2002, Elliott 2006).

Our study extended over four years (2005-2008); we intended a three-year study, but due to heavy snowfall in 2006 and 2007, we continued into the 2008 season. This report summarizes data collected during all four years of the study and is divided in 6 chapters and 5 appendices. We conducted intensive, repeated surveys in two focal areas (i.e., Mitkof Island and Juneau) to develop survey methods and protocol for maximizing detection probabilities. These surveys also provided information necessary to estimate survey effort and allocation for region-wide population monitoring of forest owls (Chapter 1). To assist us in achieving our objectives, we established a network of volunteers to conduct roadside surveys for all years of the study across Southeast Alaska. Volunteer surveys complemented our field-based efforts to develop and test the survey protocol, provided greater spatial coverage of stations, and allowed for community outreach and education. Surveys conducted by volunteers of the Southeast Alaska Owl Network comprised the majority of data used to estimate occupancy and trend of forest owls across the entire region (Chapter 2). We used radio-telemetry of Western Screech-Owls to help determine the appropriate spacing of survey stations. At the beginning of our study, new methods for estimating occupancy of rare and elusive species were being developed (described in full in MacKenzie et al. 2006), which we believed would be appropriate for monitoring nocturnal owl populations in Southeast Alaska. These methods assume that sites are closed to changes in occupancy and detection histories at each site are independent; therefore, we used the radio-telemetry data to guide the definition of a sample unit and determine any violation of the assumptions. We report home range, movements, and habitat use of Western Screech-Owls in Chapter 3. Surprisingly little information existed describing techniques for capturing forest owls when noosing or at-nest capture was not reasonable. We detailed our technique and summarized trapping effort and success to capture Western Screech-Owls in the dense forests of Southeast Alaska (Chapter 4). Similarly, there was a lack of information about Western Screech-Owl diet in the Pacific Northwest region of the United States. We compiled information from three different sources to describe the diet of Western Screech-Owls at the northern extent of their range (Chapter 5). We analyzed regurgitated pellets from radio-marked birds, identified stomach contents from carcasses (e.g., vehicle collisions, window strikes), and summarized information from museum specimens. We collaborated with colleagues at the University of Alaska Southeast to measure the phylogenetic structure of Western Screech-Owls in Southeast Alaska (Chapter 6). We conclude this report with a brief overall discussion and list of recommendations for future work related to forest owls in Southeast Alaska. We include the recommended survey protocol and associated datasheets in an appendix, along with summaries of owl detections and sightings by month in each community with participating members of the Southeast Alaska Owl Network.

LITERATURE CITED

Alaska Department of Fish and Game. 2006. Our wealth maintained: a strategy for conserving Alaska's diverse wildlife and fish resources. Alaska Department of Fish and Game, Juneau, Alaska, USA.

COSEWIC. 2002. COSEWIC assessment and update status report on the Western Screech-Owl *Otus kennicottii* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 31pp.

Elliott, K. 2006. Declining numbers of Western Screech-Owl in the lower mainland of British Columbia. British Columbia Birds 14:2-11.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Academic Press, Burlington, MA, USA

Schempf, P. 2001. Raptor Management Plan for Alaska. U. S. Fish and Wildlife Service, Juneau, unpublished report. 91pp.

Takats, L. D., C. M. Francis, G. L. Holroyd, J. R. Duncan, K. M. Mazur, R. J. Cannings, W. Harris, D. Holt. 2001. Guidelines for nocturnal owl monitoring in North America. Beaverhill Bird Observatory and Bird Studies Canada, Edmonton, Alberta. 32pp.

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We are indebted to all of our collaborators for their contribution to this study. Irene Morris (JRC) served as the Southeast Alaska Owl Network Coordinator for four years. She generated interest in owls, provided public presentations, distributed information via snail mail and email, and entered all of the survey data submitted by volunteers. Grey Pendleton (ADFG) assisted us in every aspect of the project – from survey design, to protocol development, to final analyses. His analytical approach quadrupled the value of the final product. We thank him for endless work late at night and on the weekends to help us meet deadlines and produce the most useful (and statistically valid!) report possible. Phil Schempf (USFWS) was extremely helpful during project development and provided valuable reviews of several chapters in the final report. We thank Lowell Suring (NE) for sharing his raw data files early enough in the design phase to allow us to resurvey his original stations. Throughout the study, we randomly contacted him with questions and he was always quick to respond with useful suggestions, specific answers, and words of encouragement. It has been a great pleasure working with Lowell, particularly given his role on the Tongass during such formative years. David Tallmon (UAS) is probably one of the smartest, but under-utilized resources in Southeast Alaska and we were fortunate to have the opportunity to work with him on the genetic component of this study. We look forward to continued work with the Tallmon Lab at UAS and David's contribution to conservation in Southeast Alaska.

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National Forest (USFS), Petersburg, Hoonah, and Yakutat Ranger Districts provided housing during our fieldwork. The ADFG Petersburg Office offered unlimited use of a reliable, 4-wheel drive vehicle that was the most important piece of field equipment during the entire study.

Finally, we dedicate this report to the memory of Glen Ith. His enthusiasm, support, and friendship helped to guide us through many sleepless nights conducting owl surveys on Mitkof Island. During the intensive surveys in 2005, we sipped our ‘morning’ coffee while Glen enjoyed his lunch and discussed the results of the previous night’s surveys and capture efforts. We spent many nights away from home in order to conduct this work and Glen and his family were always quick to invite us to dinner or drive us to the airport. His dedication to his family, his community, and the wildlife and natural resources of Southeast Alaska made a great impression on us. We thank you, Glen.

Owls play an important role in Tlingit and Haida cultures of Southeast Alaska. Since we began studying owls, many people have shared stories and personal experiences with us describing the importance of the owl, which are considered to be very powerful fortune-tellers and prophets. The hooting of an owl is “gin-nar-har”, or misfortune, indicating that something bad will happen (e.g., war or trouble). Tlingit warriors often hooted like an owl just before battle. A school teacher told us that children are especially afraid of owls; parents warn that if children cry too much, an owl will take them away. One person from Yakutat shared a story about a visit from a snowy owl just prior to the 1964 earthquake.

Surprisingly, owls are not often depicted in native artwork in Southeast Alaska, perhaps because of the bad omens that they often represent. In Yakutat, the Owl House is in the Kwaashk'i kwáan Clan (the Humpy Salmon Creek Clan), for which an owl serves as one of the clan crests. We examined the crest closely and it appears to be a Western Screech-Owl, the primary species of our study. One story we heard about the origin of the crest was that the owl was a woman who was mean to her mother-in-law, and therefore was transformed into an owl. We also found photographs of a large canoe that belonged to the chief of Ka-ghan-tan (Klukwan) with an anthropomorphic owl carved into the bow. It had out-stretched wings that were hinged to open and close and a human head and arms. In Hydaburg, we also found an owl carved into a totem pole in front of the school (see photo above).

We recognize that we certainly were not the first to study owl behavior and appreciate all of the stories that people have shared with us (many of which we did not include here) about these fascinating and mysterious birds. Gunalchéesh!

CHAPTER 1
FACTORS INFLUENCING FOREST OWL DETECTABILITY IN SOUTHEAST ALASKA

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ABSTRACT

Most species of nocturnal owls are poorly monitored by existing multi-species surveys. Patch-occupancy models offer a realistic approach to monitoring the status of nocturnal owl populations. However, because most owl species are relatively rare on the landscape, increasing the probability of detecting an owl if a site is occupied will result in more precise estimates of occupancy. We investigated the influence of temporal, biological, and environmental factors on forest owl detection rates in Southeast Alaska, 2005-2006. We modeled detection probabilities of Northern Saw-Whet Owl (*Aegolius acadicus*), Western Screech-Owl (*Megascops kennicottii*), and Barred Owl (*Strix varia*) using methods of MacKenzie et al. (2006). We conducted 479 point counts over a 100-day interval and recorded 147 owl detections. For all 3 species, the use of broadcast surveys increased detections from 21-86% over silent surveys. During the peak interval of detection from 9 April-8 May, Western Screech-Owl detection probability ($\bar{x} \pm SE$) was 0.39 ± 0.13, followed by Northern Saw-Whet Owl (0.44 ± 0.16), then Barred Owl (0.54 ± 0.25). Occupancy probabilities (ψ) were constant (i.e., did not vary with covariates) for both Barred Owl and Northern Saw-Whet Owl, but for Western Screech-Owl, ψ was found to be a function of whether large owls had been detected at a site, with ψ estimated to decline by about 66% for sites with large owls. Detection probability increased after sunset for Western Screech-Owl; Barred Owl had a non-linear pattern in relation to time since sunset with high detection probability near sunset and late at night, with lower detections in between. Northern Saw-Whet Owl detection probabilities were most influenced by weather covariates, primarily precipitation and wind. We provide recommendations on allocating survey effort and increasing detection probabilities of these 3 owl species in Southeast Alaska.

INTRODUCTION

With the exception of a few species of conservation concern, little is known about the distribution, abundance, and trend of nocturnal owls in North America (Takats et al. 2001). Because of their general rarity, elusive behavior, and nocturnal habits, most species of owls are poorly monitored by existing multi-species surveys (e.g., Breeding Bird Survey, Raptor Migration Monitoring; Takats et al. 2001). Therefore, specific surveys are required to monitor populations of nocturnal owls, but effective survey methods vary geographically and by species. Point count surveys are the most common method for monitoring relative abundance, distribution, and habitat of breeding owls over time (Andersen 2007). However, point count surveys for nocturnal owls are susceptible to incomplete detectability, or false absences (i.e., failure to detect an owl when present) that, if not accounted for, can lead to biased estimates and misleading inferences (Thompson et al. 1998, Williams et al. 2002, MacKenzie et al. 2006).

Many estimation methods estimate and adjust for detection probabilities <1 (Reynolds et al. 1980, Seber 1982, Buckland et al. 2001, Farnsworth et al. 2002, Williams et al. 2002), but the majority of these methods are not practical for nocturnal species with relatively low densities, such as most owls. Distance sampling techniques are not reliable because nocturnal conditions and the ventriloquial vocalizations of many owl species hinder accurate distance estimation. Capture-recapture methods are inefficient because of the difficulty in acquiring an adequate sample size relative to effort and individual resight-based models are unreasonable because of the near-impossibility of resighting marked individuals at night. Patch-occupancy models offer the most realistic approach to long-term monitoring of nocturnal owl populations (see Ganey et al. 2004, Olsen et al. 2005); these models rely on repeated surveys to determine species presence and estimate detection probabilities (MacKenzie et al. 2004). Designing a study to estimate occupancy that accounts for imperfect detection involves a tradeoff between efficiency and robustness. In general, if occupancy is low, more effort should be devoted to surveying more sites and to increasing the probability of detecting an owl if the site is occupied (MacKenzie et al. 2004). Identifying and quantifying factors that affect detection rates will result in improved estimates of detection probabilities and therefore more precise estimates of the parameter of interest (e.g., patch-occupancy, abundance; Hardy and Morrison 2000, Williams et al. 2002, MacKenzie et al. 2006); future field efficiency also might be improved by focusing survey effort in intervals when detection probability is likely higher.

Detection rates of owls are influenced by survey technique and by various environmental, biological, and temporal factors (Hardy and Morrison 2000, Andersen 2007). Broadcast recordings of owl vocalizations (hereafter, broadcasts) increase detection rates of most target species and can invoke or discourage responses from non-target species (Fuller and Moser 1981, Lepage et al. 1999, Hardy and Morrison 2000, and others). Environmental factors such as wind, precipitation, surrounding landscape, and temperature can affect owl calling rates as well as the ability of surveyors to detect owls (Fuller and Moser 1987, Andersen 2007). Time of year and annual variation in phenology can affect calling rates, which, at least for some owl species, are known to be positively correlated with pairing status (Lundberg 1978). Similarly, owl call rates are known to vary significantly throughout the night (Palmer 1987).

In this study, we investigated the influence of temporal, biological, and environmental factors on forest owl detection rates in Southeast Alaska, 2005-2006. Our overall objective was to establish an efficient survey protocol for monitoring occupancy of forest owls in an area with few maintained roads. We targeted 3 owl species for which we expected to obtain an adequate number of detections and were relevant to forest management in Southeast Alaska. We chose the Northern Saw-Whet Owl (*Aegolius acadicus*), a migratory species that breeds but does not overwinter in Southeast Alaska, Western Screech-Owl (*Megascops kennicottii*), a resident species, and Barred Owl (*Strix varia*), a resident species that has recently colonized Southeast Alaska and that is raising conservation concerns for smaller owls in other areas it has recently colonized (COSEWIC 2002, Olson et al. 2005, Elliot 2006). Our specific objectives were to (1) estimate detection probabilities for each target species using broadcast vocalizations, repeated surveys, and radio-telemetry (for Western Screech-Owl only), and (2) investigate the influence of temporal, lunar, weather, and biological factors on owl occupancy and detection probabilities.

STUDY AREA

We conducted this study in Southeast Alaska, near Juneau (58° 18’ N, -134° 25’ W) and Petersburg (56° 48’ N, -132° 56’ W; Figure 1.1). We chose these areas because they had relatively extensive road systems that were accessible most of the year and had landscapes representative of the region. Southeast Alaska is a sparsely populated region characterized by steep, rugged topography, costal fjords, and large tracts of temperate rainforest. It comprises over 2,000 islands of the Alexander Archipelago and a narrow stretch of mainland separated from the remainder of North America by the vast Coastal Mountain Range (Alaback 1982). The region is roughly 700 km long and averages 190 km wide and the majority (81%) of the land is federally-managed by the U.S. Forest Service (Tongass National Forest). A cool, wet maritime climate characterizes the entire region with between 75 and 500 cm of precipitation evenly distributed throughout the year (Harris et al. 1974). The landscape of Southeast Alaska is naturally fragmented by mountainous terrain, wetlands, and various fine-scale disturbances (e.g., wind-throw). Commercial timber harvesting has been common, with extensive, broad-scale clearcutting the most often used the silvicultural system. The forest is dominated by western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*) and the understory consists primarily of blueberry (*Vaccinium spp.*), devil's club (*Oplopanax horridus*), and salmonberry (*Rubus spp.*).

METHODS

Sampling design

We conducted point count surveys along road transects from 28 February-7 June 2005. We selected transects based on accessibility during winter months and the likelihood of encountering and detecting owls (e.g., forested habitat, minimal or no traffic, little noise disturbance). Overall poor access and logistical constraints precluded equal survey effort across all forest types and elevations, but we attempted to maximize the diversity of habitats surveyed given the access limitations. We established 5 transects: 2 in the Juneau area and 3 in the Petersburg area. Each transect consisted of 10 survey stations (n=50 total) spaced 1.6 km apart to avoid detecting individual owls at multiple count stations. We alternated the order that we surveyed each transect to avoid temporal bias. We divided the survey season into 10, 10-day intervals and therefore, each transect was surveyed 10 times (some survey stations were not always accessible) during the suspected breeding season of the 3 target species (Cannings 1993, Mazur and James 2000, Cannings and Angell 2001).

Survey protocol

The same two observers conducted point count surveys for owls at each count station. Each survey consisted of a 2-minute settling period, a 4-minute period of silent listening, and then a broadcast of male territorial songs (Mazur and James 2000, Cannings and Angell 2001).

We broadcasted Western Screech-Owl and Barred Owl songs using a handheld megaphone (PA Genie Amplifier APM-760, Fanon Courier, Irvine, CA) and a portable compact disk player (CD Walkman D-NS505, Sony). We always broadcast for Western Screech-Owls first to avoid attracting larger, predatory owls by playing the territorial call of Barred Owls. We did not specifically broadcast for Northern Saw-Whet Owls because, based on surveys conducted along the coast of British Columbia, we expected this species to respond to one of the other calls (D. Cannings pers. comm.). Using a digital sound level meter, we adjusted the volume to be 100-110 db at 1 m in front of the speaker (Fuller and Moser 1987). Each species' song was broadcast for 30 seconds while rotating the megaphone 360° and was followed by a one-minute silent count period. This was repeated once, so that each species broadcast series was 30 s broadcast–60 s silent–30 s broadcast–60 s silent. The broadcast rotation began with Western Screech-Owl and ended with Barred Owl, and there was one minute of silent listening between species broadcast series. The count ended with one minute of silent listening. In total, we spent approximately 12 minutes at each count station.

Surveys began at least 30 minutes after sunset (determined by the U.S. Naval Observatory; http://tycho.usno.navy.mil/srss.html) and were completed within 6 hours. Nocturnal owls are most responsive and closer to daytime roosts or nests during this time period (Johnson et al. 1981). At the beginning of each count, we recorded time, ambient air temperature, moon phase, precipitation, % snow cover, % cloud cover, wind speed (km/hr), and external noise (e.g., barking dogs, ocean surf). Air temperature, and wind speed and direction were determined with a handheld weather monitor (Kestrel 3000 Pocket Weather Station; Forestry Supply, Inc.). We also tallied the number of cars that passed during the silent and broadcast components separately. If an owl was detected, we recorded species, number, direction, estimated distance, and elapsed time to detection. Although estimating distance and direction to singing owls was challenging, it assisted us in determining whether detections of the same species were different birds. We did not conduct surveys during inclement weather (i.e., heavy rain, winds >20 km/h).

Radio-marked birds

We captured 8 Western Screech-Owls using mist nets with an audio lure and mouse decoy from 17 March – 11 May 2006 in Petersburg (Chapter 5). We equipped 3 females and 5 males with backpack-mounted radio transmitters (model TW-4, Biotrack, Ltd) with Teflon ribbon. To estimate detection probability, we located radio-marked birds at night by triangulating their position with a hand-held receiver and 2-element “H” antenna (Telonics, Inc., Mesa, Arizona). Immediately after successful triangulation, we followed the point count survey protocol described previously. If a bird was detected (either during silent count or by responding to broadcast), we recorded the elapsed time, type of response (aural, visual, both), type of call (bouncing ball, double trill, bark or bill snap, or begging whinny; Cannings and Angell 2001, Herting and Belthoff 2001), and whether the detected bird was the radio-marked bird. We stopped conducting the survey as soon as a bird responded to avoid excessively disrupting breeding activities.

Data analysis

We estimated occupancy probability for surveyed points (ψ) and detection probability (p) and investigated the influence of covariates on these probabilities for the 3 target species using the occupancy modeling procedures of MacKenzie et al. (2006) in PRESENCE (Hines 2006). We included models that allowed both ψ and p to be functions of covariates (Table 1.1). For modeling ψ, we included ‘b’, which was whether a large owl (i.e., Barred Owl or great horned owl) was ever detected at a point, ‘rt’, separate estimates for each survey route, and ‘area’, separate estimates for the Juneau (mainland) and Petersburg (island) areas. For modeling p, ‘period’ and the related quadratic term were the equal-length survey intervals (1-10); ‘hours’ (and the quadratic) was the time (hrs) after sunset; ‘temp’ was temperature(^{o}C); ‘precip’ was precipitation as snow (s), fog (f), drizzle (d), showers (sh), or rain (r). Drizzle, showers, and rain are included as 2 variables describing increasing intensity, the first for any of the 3 types and the second for only showers or rain; the sound characteristics of active snow and fog are different enough from the forms of rain that these were included as separate variables. ‘Snow’ was the proportion of the ground covered by snow within a 50-m radius of the station; ‘wind’ was in km/hr, ‘cloud’ was the proportion of the sky covered by clouds, ‘moon’ was the proportion of moonlight relative to the maximum possible at full moon (obtained from http://aa.usno.navy.mil/data/docs/MoonFraction.php). ‘Light’ was a combination of cloud cover and moonlight that we computed as (1-cloud)*moon, which was the theoretical amount of moonlight available reduced for that obscured by clouds. ‘Noise’ was the amount of ambient noise scaled 0 (quiet) to 4; noise is modeled as 3 variables of increasing intensity (e.g., noise $\geq$2, noise$\geq$3, noise=4; see Takats et al. 2001). The number of cars passing during a survey stop were categorized into 2 variables, 1 or 2 cars and $\geq$3 cars; 'big owls' was whether a large owl was detected at the station during the current survey. Interval, hours, temp, snow, wind, cloud, moon, and light were treated as continuous variables; all of the precip variables, all of the noise variables, and the big owl variable were binary indicator variables. We included quadratic terms for the continuous variables where we suspected that the relationship between detection probability and the variable might not be linear (on the logit scale; Table 1.1).

To select a final model for each owl species, we began by fitting models using each variable singly to predict ψ or p; we also fit a model with constant ψ across sites and constant p across surveys and a model with interval-specific p. Model fit was assessed with AIC and related model weights (Burnham and Anderson 2002). Once the single variable models had been fit, we fit a more complex model containing combinations of the best supported variables (from the single variable modeling described above) based on model weights and the precision of the estimated coefficients. From this 'base' model, we added additional variables singly examining model weights after each addition. We continued to add variables until all reasonably supported variables not in the model had been considered. The final model was the one that ranked with the highest model weight.

To assess the efficacy of broadcast surveys, we fit multi-method occupancy models (Hines 2006) that estimated detection probability separately for the initial silent listening period and the following broadcast survey. If an owl was detected during both the silent and the broadcast periods, it was included in both estimates. For these models we did not include covariates because they could affect method-specific detection probabilities differently and therefore could lead to a large and complex set of models. As such, our method-specific estimates should be viewed as averages over the range of the other covariates. To determine whether broadcast surveys negatively influenced detection rates, particularly of smaller owls, we considered the initial detection or response of each owl in relation to the segment of the broadcast recording (i.e., during the silent period, Western Screech-Owl song, or Barred Owl song).

We calculated detection probabilities for Western Screech-Owls only using radio-marked individuals. We used the program Location Of A Signal (Ecological Software Systems, http://www.ecostats.com) to estimate the location of owls based on directional azimuths obtained from known locations prior to conducting the survey. We measured the distance from the survey location to the estimated owl location in a GIS (ArcView, version 3.3, ESRI, Redlands, CA). We averaged distances for radio-marked birds that responded to the broadcast and those that did not respond.

We used occupancy and detection probability estimates from this study find the optimum combination of number of survey stations and repeat surveys in a season following methods outlined in MacKenzie and Royle (2005). We aimed for a level of precision (CV=20-25%) that was achieved in this study and therefore deemed realistic. Our goal was to evaluate tradeoffs in allocating survey effort and provide recommendations for broad-scale monitoring of occupancy of 3 forest owls in Southeast Alaska.

RESULTS

We conducted 479 point counts and recorded 147 owl detections of 6 species. We tallied 62 Northern Saw-Whet Owl, 37 Western Screech-Owl, 38 Barred Owl, 7 Great Horned Owl (*Bubo virginianus*), 2 Northern Pygmy-Owl (*Glaucidium gnoma*), and 1 Boreal Owl (*Aegolius funereus*) detections. We detected the greatest number of owls during the seventh survey interval (29 April-8 May; Figure 1.2). Overall, 44% of detections were recorded from 9 April-8 May, which was driven primarily by increased detections of Northern Saw-Whet Owls during this 30-day period (Figure 1.2), and this increased to 59% of the detections from 30 March-18 May. Detections of Northern Saw-Whet Owls were most variable compared to Barred Owls and Western Screech-Owls over the entire survey (Figure 1.2).

Modeling occupancy and detection probability

We evaluated between 30 and 36 models for each species (Tables 1.2-1.4); best models contained 0-1 covariates for ψ and 1-5 covariates for p; for Western Screech-Owl and Barred Owls we included 2 models with very similar weights (Table 1.5). Neither route nor area specific estimates of ψ were supported for any species. Constant occupancy probability (ψ) was estimated for both Barred Owl and Northern Saw-Whet Owl, but for Western Screech-Owl, ψ was best modeled as a function of whether large owls had been detected at a site, with estimated ψ about 66% lower for sites with large owls (Table 1.6). For both Western Screech-Owl and Northern Saw-Whet Owl, estimated p peaked in survey intervals 5-7 (9 April-8 May; Figure 1.3). Detection probability increased after sunset for Western Screech-Owl (Figure 1.4).

Precipitation (drizzle, showers, or rain) decreased detection probability for both Barred Owl and Northern Saw-Whet Owl; the pattern for Barred Owl was relatively weak and for Northern Saw-Whet Owl the coefficient and its standard error indicated estimation problems (Table 1.5). Further examination of the data showed no overlap in detections and precipitation. That is, none of the 57 detections of Northern Saw-Whet Owl occurred during the 62 surveys (of 482) when non-snow precipitation was recorded. So, although we cannot produce a precise estimate, the data strongly suggest that precipitation greatly reduces detections of Northern Saw-Whet Owls. Wind caused similar declines in p for both Western Screech-Owl and Northern Saw-Whet Owl (Figure 1.5). For Northern Saw-Whet Owl, estimated p increased with increasing light (i.e., cloud adjusted moonlight; Figure 1.6). Noise ≥3 negatively affected p for Western Screech-Owl and Northern Saw-Whet Owl with reductions of about two-thirds (Table 1.6).

Silent versus broadcast. – The average elapsed time to detect an owl during the silent period was 1min 5sec and 74% of these detections occurred within 2min from the start of the survey. For all 3 species, the use of broadcast surveys increased detection probability compared to the silent survey period (Figure 1.7). This increase was largest for Western Screech-Owls where the odds of detecting an owl were 16.0 (95% CI=3.8, 66.8) times higher during broadcasts than during the silent listening. The odds of detecting a northern saw-whet or Barred Owl during broadcasts were 3.2 (1.3, 7.93) and 3.0 (1.1, 8.3) times higher than detecting them during the silent period.

Across all species, initial detections were similar for the silent (48%; 71 of 147) and broadcast (52%; 76 of 147) periods, but this also varied considerably among species (Figure 1.8). Northern Saw-Whet Owls were most often first detected during the silent period (66% of the time; n=62), whereas 89% of Western Screech-Owls (n=37) were initially detected during the broadcast period. First detections of Barred Owls were comparable during silent (47%; 18 of 38) and broadcast (53%; 20 of 38) periods. Of those initially recorded during the broadcast period, the majority of Northern Saw-Whet Owls (67%; 14 of 21) and Western Screech-Owls (64%; 21 of 33) were detected during the Western Screech-Owl song; similarly, the majority (85%) of Barred Owls responded during the Barred Owl song. Although few smaller owls (i.e., northern saw-whet and Western Screech-Owls) initially responded during the Barred Owl song (19%; 19 of 99), only 45% of smaller owls that were already singing prior to the Barred Owl recording stopped singing.

Radio-marked birds. – We conducted 42 surveys for 8 radio-marked Western Screech-Owls from 4 April-31 May 2006. We detected 5 Western Screech-Owls, one saw-whet, and one Barred Owl during these surveys. Overall detectability of Western Screech-Owls was extremely low (12%; 5 of 42); furthermore, only 3 of 5 (60%) detections were radio-tagged birds. In limiting surveys to 9 April-8 May (3 survey intervals; n=15), only one Western Screech-Owl responded and it was not radio-marked. Distance ($\bar{x}\pm$SE) between the survey station and location of the radio-marked owls prior to the broadcast averaged 382 ± 125 m (n=3; range=239-468 m) for those that responded and 489 ± 390 m (n=39; range=143-1616 m) that were present but did not respond.

Sample size planning

During the peak interval (9 April-8 May), the average model-based estimates of occupancy ($\bar{x}\pm$SE) of Northern Saw-Whet Owl was 0.58 ± 0.08 (CV=14%), Western Screech-Owl occupancy was 0.48 ± 0.09 (CV=20%), and Barred Owl occupancy was 0.28 ± 0.07 (CV=24%). Considering estimates of detection probabilities for all 3 species during the peak interval (~p=0.3; Figure 1.3), we recommend conducting 3 surveys (k=3) at 180-200 stations in a single season in Southeast Alaska to achieve a level of precision comparable to this study (CV 20-25%; Table 1.7).

DISCUSSION

We examined many factors that affected detection probabilities of Northern Saw-Whet Owl, Western Screech-Owl, and Barred Owl. Assuming a site was occupied, detection of an owl depended on 3 factors: (1) availability, (2) cue production, and (3) detectability. Availability was whether the owl was close enough to the survey point during the survey to be detected if it called; cue production was whether owls that were available vocalized during the survey; and, detectability was whether an owl that was available and vocalized during the survey was heard by the surveyor. Each of the variables used to model p were related to one or more of these detection factors (Table 1.1).

Availability

For resident species (i.e., Barred Owl and Western Screech-Owl), availability is a function of where the owl is in its home range at the time of a survey, relative to the location of the survey point; large or irregularly-shaped home ranges would generally lower availability. Home ranges, including breeding sites, of Barred Owl and Western Screech-Owl are maintained year-round and there is strong site fidelity for both species (Mazur and James 2000, Cannings and Angell 2001). We began surveys in late February when we expected courtship behavior and calling to be centered on or near the nest for both species. But, we did not know the configuration of the owl home ranges or nest locations with respect to our survey points. In addition, home ranges of non-migratory owls in the nonbreeding (or winter) season typically are larger than during the breeding (or summer) season home range (Mazur and James 2000). Assuming that movements within the home range are independent of the survey timing and location, reduced detections because of availability are accounted for by the intercept term of the p portion of the model.

For migratory species (i.e., Northern Saw-Whet Owl), however, availability has a different connotation. A site might be ‘occupied’ by the species, but the occupants might be different individuals during different surveys as migration proceeds and territories are established. One of the critical assumptions for estimating occupancy and detection probabilities using these models is that sites are “closed” to changes in occupancy over the survey season (MacKenzie et al. 2006). Given the migratory behavior of Northern Saw-Whet Owls, we were concerned about violating this assumption, biasing the estimators, and incorrectly drawing inferences about the factors that influenced either occupancy or detection. However, assuming that saw-whet owls moved in and out of these sites at random, lack of owl detections when no owls were present was considered to be a component of availability, comparable to when a resident owl was at the far side of its home range (Kendall 1999, MacKenzie et al. 2006). The interpretation is slightly different because the occupancy estimator instead represents the proportion of sites “used” not “occupied” (MacKenzie et al. 2006).

Cue production

In this study, we primarily investigated variables that explained variation in cue production. In general, survey method (Figure 1.7) and date (Figure 1.2, 1.3) had the most consistent effect on detection probabilities for all 3 target species, but some variables influenced species differently (Table 1.5). The peak interval for detecting the target species was 9 April-8 May (30 days) with an extended peak interval of 30 March-18 May (50 days; Figure 1.2). In modeling detection probabilities, interval (referred to as “period” in models) was included in the final model for all 3 species (Table 1.5).

Our results confirm the effectiveness of using conspecific broadcasts to increase detection rates of Western Screech-Owls and Barred Owls relative to conducting silent point count surveys (Figure 1.7). The majority of initial detections of both species occurred during their respective broadcast call; however, a relatively large proportion (37%) of Western Screech-Owls was also recorded during the Barred Owl call (Figure 1.8). We believe that these birds were not responding to the Barred Owl recording, but instead had a slow response time to the Western Screech-Owl recording. Unlike Barred Owls which can be heard from great distances, the Western Screech-Owl song is relatively difficult to hear, requiring the bird to be close to the survey station in order to be detected by the surveyor (personal observation). We never detected both species during the same count period and, in fact occupancy of Western Screech-Owls was negatively associated with occupancy by larger owls (Table 1.5). Therefore, it’s unlikely that the delayed response of Western Screech-Owls will affect detection probabilities or occupancy estimates under the survey protocol we used in this study. However, these results suggest that the order of the broadcast calls should be played in sequence from smallest to largest owls. Although one could argue that broadcasting the calls in random order would be more statistically valid, our results demonstrate that the presence of larger owls negatively affects the detection probability of smaller owls. It is illogical to think that the reverse would be true, but we did not explicitly test this. As expected, Northern Saw-Whet Owls were most often detected during the silent portion of the survey, prior to broadcasting calls of larger owls.

Hours after sunset affected cue production of Western Screech-Owls. Western Screech-Owls vocalized more as the hours after sunset increased (Figure 1.4). Courtship-feeding in this species is common and males feed females during egg-laying, incubation, and brooding (Cannings and Angell 2001). Therefore, hunting activity may be higher immediately following sunset in order to deliver food to the female as quickly as possible, which likely strengthens pair bonds. In this species, territory defense may be secondary compared to nest attendance.

The detection probability of Northern Saw-Whet Owl was positively associated with the amount of ambient light at night (Figure 1.6). Migration of this species may be suppressed by a full moon or high amounts of light (Cannings 1993), possibly to avoid predation from larger owls. However, Palmer (1987) concluded that a full moon may proximally stimulate the seasonal onset of singing of Northern Saw-Whet Owls, which is almost exclusively used to attract mates for breeding (Cannings 1993).

Some variables (e.g., precip., wind) might affect cue production, detectability, or both, but it would be difficult to determine if reduced detections are due to fewer vocalizing owls or failure to hear those that are vocalizing. High winds and precipitation are known to inhibit song production by Northern Saw-Whet Owls (Palmer 1987). Our results confirm that detection probabilities of Northern Saw-Whet Owl and Western Screech-Owl are negatively affected by these weather variables (Table 1.5, Figure 1.5). Even moderate winds (<3 km/hr) had a negative effect on detection probabilities of both species. During the course of the study, we did not survey in constant, high winds, but we occasionally conducted surveys at some stations in strong, gusty winds. Similarly, our data also strongly suggest that precipitation reduced detection probability for Barred Owls and greatly reduces detections of Northern Saw-Whet Owls (Table 1.5); we did not detect any saw-whet owls during surveys conducted in even light precipitation, which is common in Southeast Alaska. The negative effects of wind and precipitation on detection probabilities of these smaller owls can be eliminated, or at least reduced, by implementing strict guidelines in the survey protocol to avoid conducting surveys in inclement weather.

Detectability

It is difficult to ascertain which detection factors, cue production or detectability, were affected by some variables considered in our study. We attempted to reduce heterogeneity in detectability by not conducting surveys under marginal or unacceptable survey conditions, but these conditions may have suppressed cue production (see above). Conversely, the noise and car variables most likely affected detectability, but reduced cue production cannot be completely ruled out. Significant noise decreased detection probability of Western Screech-Owl from 33% to 10% (Tables 1.6). This species is strongly associated with riparian habitats (Chapter 3) and therefore, this result is likely driven by an interaction between preferred habitat and detection rates. Stream noise also varied throughout the survey season because of snow melt; locations of stations in riparian areas should be selected to minimize stream noise, particularly as the season progresses.

RECOMMENDATIONS

Conducting point count surveys for nocturnal owls is cost-effective and can produce reliable estimates of occupancy provided that study objectives are clear, and that the survey design and protocol are robust (MacKenzie et al. 2006). We present extensive information necessary for developing an efficient survey protocol for monitoring occupancy of 3 species of forest owls in Southeast Alaska (Appendix I). We recommend the use of broadcast calls to improve detection probability, especially for Western Screech-Owls. To produce an occupancy estimate for Southeast Alaska with a CV of 20-25%, we recommend conducting 3 surveys (k=3) at 180-200 stations each season. We believe that despite the limitations in the scope of inference, roadside surveys constitute the most reasonable approach to monitoring owl populations in this region, where few roads exist and even fewer are maintained year-round.

LITERATURE CITED

Alaback, P.B. 1982. Dynamics of understory biomass in Sitka spruce-western hemlock forests of Southeast Alaska. Ecology 63:1932-1948.

Andersen, D. E. 2007. Survey techniques. Pages 89-100. *In* Raptor research and management techniques (D. M. Bird and K. L. Bildstein, eds.). Hancock House Publishers, Ltd., Blaine, WA, USA.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling. Oxford University Press, Oxford, United Kingdom.

Burnham, K. P., and Anderson, D.R. 2002. Model selection and inference: an information theoretic approach, 2nd edition. Springer-Verlag, New York.

Cannings, R. J. 1993. Northern Saw-Whet Owl (*Aegolius acadicus*). *In* The Birds of North America, No. 42 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Cannings, R. J., and T. Angell. 2001. Western Screech-Owl (*Otus kennicottii*). *In* The Birds of North America, No. 597 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

COSEWIC. 2002. COSEWIC assessment and update status report on the Western Screech-Owl *Otus kennicottii* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario, CAN.

Elliott, K. 2006. Declining numbers of Western Screech-Owl in the lower mainland of British Columbia. British Columbia Birds 14:2-11.

Farnsworth, G. L., K. H. Pollock, J. D. Nichols, T. R. Simons, J. E. Hines, and J. R. Sauer. 2002. A removal model for estimating detection probabilities from point-count surveys. The Auk 119(2):414-425.

Fuller, M. R., and J. A. Mosher. 1987. Raptor survey techniques. *In* Raptor Research Management Techniques Manual (B. A. Giron Pendleton, B. A. Millsap, K. W. Cline, and D. M. Bird, eds.). National Wildlife Federation, Washington D. C.

Ganey, J. L., G. C. White, D. C. Bowden, and A. B. Franklin. 2004. Evaluating methods for monitoring populations of Mexican Spotted Owls: a case study. Pages 337-385. *In* Sampling Rare or Elusive Species (W. L. Thompson). Island Press, Washington D.C.

Hardy, P. C., and M. L. Morrison. Factors affeacting the detection of Elf Owls and Western Screech-Owls. Wildlife Society Bulletin 28:333-342.

Harris, A. S., O. K. Hutchison, W. R. Meehan, N. Swanston, A. E. Helmers, J. C. Hendee, T. M. Collins. 1974. The forest ecosystem of Southeast Alaska: 1. The Setting. USDA Forest Service General Technical Report, PNW-12. Ref. 18718. 40pp.

Herting, B. L. and J. R. Belthoff. 2001. Bounce and double trill songs for male and female Western Screech-Owls: characterization and usefulness for classification of sex. Auk 118:1095-1101.

Hines, J. E. 2006. PRESENCE2-software to estimate patch occupancy and related parameters. USGS-PWRC. http://www.mbr-pwrc.usgs.gov/software/presence.html

Johnson, B. T., B. T. Brown, L. T. Haight, and J. M. Simpson. 1981. Playback recordings as a special avian censusing technique. *In* Estimating Numbers of Terrestrial Birds (C. J. Ralph and J. M. Scott, eds.). Studies in Avian Biology 6:68-75.

Kendall, W. L. 1999. Robustness of closed capture-recapture methods to violations of the closure assumption. Ecology 80: 2517-2525.

Lepage, D., C. M. Francis, and V. Deschamps. 1999. Ontario nocturnal owl survey 1998 pilot study – Final Report. Report by Bird Studies Canada for Ontario Ministry of Natural Resources Wildlife Assessment Program. WAP-99-01. 21pp.

Lundberg, A. 1978. Census methods for the Ural Owl (*Strix uralensis*) and the Tengmalm's Owl (*Aegolius funereus*). Anser Supplement 3:171-175.

MacKenzie, D. I., J. A. Royle, J. A. Brown, and J. D. Nichols. 2004. Occupancy estimation and modeling for rare and elusive populations. Pages 149-172. *In* Sampling Rare or Elusive Species (W. L. Thompson). Island Press, Washington D.C.

MacKenzie, D. I., and J. A. Royle. 2005. Designing occupancy studies: general advice and allocating survey effort. Journal of Applied Ecology 42: 1105-1114.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Academic Press, Burlington, MA, USA.

Mazur, K. M., and P. C. James. 2000. Barred Owl (*Strix varia*). *In* The Birds of North America, No. 508 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Olson, G. S., R. G. Anthony, E. D. Forsman, S. H. Ackers, P. J. Loschl, J. A. Reid, K. M. Dugger, E. M. Glenn, W. J. Ripple. 2005. Modeling of site occupancy dynamics for northern spotted owls, with emphasis on the effects of Barred Owls. Journal of Wildlife Management 69:918-932.

Palmer, D. A. 1987. Annual, seasonal, and nightly variation in calling activity of Boreal and Northern Saw-Whet Owls. *In* Biology and Conservation of northern forest owls. USDA General Technical Report, RM-142, Fort Collins, CO.

Reynolds, R. T., J. M. Scott, and R. A. Nussbaum. 1980. A variable circular-plot method for estimating bird numbers. Condor 82:309-313.

Seber, G. A. F. 1982. Estimation of animal abundance and related parameters. Second edition. Griffin, London.

Takats, L. D., C. M. Francis, G. L. Holroyd, J. R. Duncan, K. M. Mazur, R. J. Cannings, W. Harris, D. Holt. 2001. Guidelines for nocturnal owl monitoring in North America. Beaverhill Bird Observatory and Bird Studies Canada, Edmonton, Alberta. 32pp.

Thompson, W. L., G. C. White, and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press, San Diego, California, USA.

Williams, B. K., J. D. Nichols, and M. J. Conroy. 2002. Analysis and management of animal populations. Academic Press, San Diego, CA, USA.

Table 1.1. Covariates used to model occupancy (ψ) and detection probabilities (p) for Northern Saw-Whet Owl, Western Screech-Owl, and Barred Owl in Southeast Alaska, 2005. We included possible effects by model variables (including the intercept) on three components of detection ('a' = availability, 'c' = cue production, d = detectability; defined in text); codes followed by question marks indicate uncertainty as to whether that effect was possible.

Estimated parameter	Variable(s)	Description	Type	Possible effect on detection
Occupancy (ψ)	intercept		-	-
	b**	Larger owl previously detected at station	categorical	-
	area	Juneau or Petersburg study areas	categorical	-
	rt	Survey route	categorical	-
Detection probability (p)	intercept		-	a, c, d
	period; $period^2$	Equal length survey interval (1-10); quadratic term	continuous	a*, c
	hours, $hours^2$	Time (hrs) after sunset; quadratic term	continuous	c
	temp	Temperture (C)	continuous	c
	precip–s	Snow precipitation	categorical	c, d
	precip–d,sh,r	Drizzle, showers, and rain precipitation	categorical	c, d
	precip-sh, r	Showers and rain precipitation	categorical	c, d
	precip-f	Fog precipitation	categorical	c, d?
	snow	Proportion of ground covered by snow (50-m radius)	continuous	c
	wind	Wind in km/hr	continuous	c, d
	cloud	Proportion of sky covered by clouds	continuous	c
	moon	Fraction of the moon	continuous	c
	light	Combination of cloud cover and moonlight	continuous	c
	noise≥2	Ambient noise ≥2 noise; scaled 0 (quiet)-4	categorical	c?, d
	noise≥3	Ambient noise ≥3 noise; scaled 0 (quiet)-4	categorical	c?, d
	noise-4	Ambient noise = 4 noise; scaled 0 (quiet)-4	categorical	c?, d
	car-1,2	Number of cars (1-2) passing during survey	categorical	c?, d
	car ≥3	Number of cars (≥3) passing during survey	categorical	c?, d
	big owls**	Larger owl detected at station during current survey	categorical	a?, c

*Northern Saw-Whet Owl only.
**Not included for Barred Owls.

Table 1.2. Candidate models considered for estimating Barred Owl occupancy and detection probabilities. Models are ranked by AIC weights.

Model[a]	Δ AIC	AIC weight	Number of parameters
ψ(.),p(d)	0	0.103	3
ψ (.),p(d+p-dsr)	0.36	0.086	4
ψ (.),p(d+d2)	0.66	0.074	4
ψ (.),p(p-dsr)	0.89	0.066	3
ψ(.),p(t)	0.89	0.066	3
ψ(.),p(d+d2+p-dsr)	1.47	0.049	5
ψ(a),p(d)	1.68	0.044	4
ψ(.),p(d2)	1.69	0.044	3
ψ(.),p(d+t)	1.87	0.040	4
ψ(a),p(d+p-dsr)	2.05	0.037	5
ψ(.),p(.)	2.12	0.036	2
ψ(.),p(n4)	2.17	0.035	3
ψ(.),p(s)	2.18	0.035	3
ψ(.),p(p-f)	2.25	0.033	3
ψ(.),p(p-sr)	2.34	0.032	3
ψ(.),p(h2)	2.44	0.030	3
ψ(.),p(w)	2.59	0.028	3
ψ(.),p(n234)	3.60	0.017	3
ψ(.),p(L)	3.71	0.016	3
ψ(.),p(h)	3.75	0.016	3
ψ(a),p(.)	3.82	0.015	3
ψ(.),p(ca3u)	3.84	0.015	3
ψ(.),p(c)	3.93	0.014	3
ψ(.),p(m)	3.95	0.014	3
ψ(.),p(ca12)	3.97	0.014	3
ψ(.),p(p-s)	4.04	0.014	3
ψ(.),p(n34)	4.09	0.013	3
ψ(.),p(h+h2)	4.44	0.011	4
ψ(rt),p(.)	10.42	0.001	7
ψ (.),p(survey)	12.78	0.001	11

[a]Variable abbreviations: *ψ ()* = occupancy probability; *rt* = route specific, *a* = area specific. *p()* = detection probability; *d* = period, *d2* = period^2, *h* = hours past sunset, *h2* = hours^2, *t* = temperature, *p-s* = snow, *p-f* = fog, *p-dsr* = drizzle,showers, or rain, *p-sr* = showers or rain, *s* = snow cover, *w* = wind, *c* = cloud, *m* = moon, *L* = light (combination of cloud and moon), *n234* = noise≥2, *n34* = noise≥3, *n4* = noise4, *ca12* = 1 or 2 cars, *ca3u* = cars≥3.

Table 1.3. Candidate models considered for estimating Western Screech-Owl occupancy and detection probabilities. Models are ranked by AIC weights.

Model[a]	Δ AIC	AIC weight	Number of parameters
ψ(b),p(n34+h+d2)	0	0.107	6
ψ(b),p(n34+h+d2+w)	0.14	0.102	7
ψ(b),p(n34+h)	0.56	0.083	5
ψ(b),p(n34+w+h)	0.63	0.080	6
ψ(b),p(n34+w)	0.74	0.076	5
ψ(b),p(n34)	0.98	0.067	4
ψ(b),p(n34+h+d2+ca3u)	1.04	0.065	7
ψ(b),p(n34+h+d2+h2)	1.31	0.057	7
ψ(b),p(n34+h+d2+d)	1.84	0.044	7
ψ(b),p(n34+h+d2+m)	1.94	0.042	7
ψ(b),p(w)	2.73	0.028	4
ψ(b),p(n234)	2.90	0.026	4
ψ(b),p(h)	2.93	0.025	4
ψ(b),p(.)	3.49	0.019	3
ψ(b),p(d2)	3.56	0.019	4
ψ(b),p(ca3u)	4.45	0.012	4
ψ(b),p(h+h2)	4.47	0.012	5
ψ(b),p(n4)	4.61	0.011	4
ψ(b),p(p-sr)	4.77	0.010	4
ψ(b),p(m)	4.88	0.010	4
ψ(b),p(c)	4.97	0.009	4
ψ(b),p(p-dsr)	4.98	0.009	4
ψ(b),p(ca12)	5.02	0.009	4
ψ(b),p(h2)	5.03	0.009	4
ψ(b),p(s)	5.10	0.009	4
ψ(b),p(d+d2)	5.10	0.009	5
ψ(b),p(L)	5.17	0.008	4
ψ(b),p(p-f)	5.19	0.008	4
ψ(b),p(p-s)	5.21	0.008	4
ψ(b),p(d)	5.28	0.008	4
ψ(b),p(t)	5.28	0.008	4
ψ(b),p(bo)	5.48	0.007	4
ψ(.),p(.)	7.47	0.003	2
ψ(a),p(.)	9.47	0.001	3
ψ(rt),p(.)	13.03	0.000	7
ψ(.),p(survey)	13.22	0.000	11

[a]Notation as in Table 1.2 with the addition of two variables: (1) ψ(b) models occupancy probability as a function of whether a large owl (barred or great-horned owl) was previously detected at that station and, (2) p(bo) models detection probability as a function of whether a large owl was detected at that station during the current survey.

Table 1.4. Candidate models considered for estimating Northern Saw-Whet Owl occupancy and detection probabilities. Models are ranked by AIC weights.

ψ(.),p(d+d2+w+L+p-dsr)	0	0.956	7
ψ(.),p(p-dsr)	8.80	0.012	3
ψ(.),p(d+d2+w+L)	9.08	0.010	6
ψ(.),p(d+d2+w+L+c)	10.45	0.005	7
ψ(.),p(d+d2+w+L+m)	10.80	0.004	7
ψ(b),p(d+d2+w+L)	10.99	0.004	7
ψ(.),p(d+d2+w+L+s)	11.07	0.004	7
ψ(.),p(d+d2+w)	11.50	0.003	5
ψ(.),p(d+d2+L)	13.56	0.001	5
ψ(.),p(d+d2)	16.20	0.000	4
ψ(.),p(d2)	16.67	0.000	3
ψ(.),p(L)	17.83	0.000	3
ψ(.),p(survey)	18.29	0.000	11
ψ(.),p(w)	20.77	0.000	3
ψ(.),p(d)	22.89	0.000	3
ψ(.),p(m)	24.13	0.000	3
ψ(.),p(c)	24.35	0.000	3
ψ(.),p(s)	24.65	0.000	3
ψ(.),p(p-f)	25.00	0.000	3
ψ(.),p(.)	25.14	0.000	3
ψ(.),p(n4)	26.26	0.000	2
ψ(.),p(t)	26.69	0.000	3
ψ(.),p(d+p34)	27.24	0.000	3
ψ(.),p(n34)	27.57	0.000	3
ψ(.),p(n234)	27.79	0.000	3
ψ(.),p(h)	27.87	0.000	3
ψ(.),p(p-s)	27.98	0.000	3
ψ(.),p(h2)	28.01	0.000	3
ψ(.),p(ca3u)	28.03	0.000	3
ψ(b),p(.)	28.07	0.000	3
ψ(.),p(bo)	28.08	0.000	3
ψ(.),p(ca12)	28.25	0.000	3
ψ(a),p(.)	28.26	0.000	3
ψ(.),p(h+h2)	29.86	0.000	4
ψ(rt),p(.)	32.19	0.000	7
ψ(.),p(d+d2+w+L+p-dsr)	0	0.956	7
ψ(.),p(p-dsr)	8.80	0.012	3

[a]Notation as in Table 1.3.

Table 1.5. Final models predicting occupancy and detection probabilities for Barred Owl, Western Screech-Owl, and Northern Saw-Whet Owl, Southeast Alaska, 2005.

Species	Response	Variables[a]	Coefficients	SE
Barred Owl (model 1)	ψ	intercept	-0.94	0.34
	p	intercept	-1.14	0.24
		period	0.15	0.08
Barred Owl (model 2)	ψ	intercept	-0.92	0.34
	p	intercept	-1.07	0.24
		period	0.12	0.08
		precip – d,sh,r	-1.22	1.09
Western Screech-Owl (model 1)	ψ	intercept	0.50	0.51
		big owl	-1.81	0.82
	p	intercept	-1.29	0.32
		noise≥3	-1.48	0.77
		hours	0.20	0.13
		$period^2$	-0.04	0.03
Western Screech-Owl (model 2)	ψ	intercept	0.59	0.55
		big owl	-1.87	0.84
	p	intercept	-1.15	0.34
		noise≥3	-1.46	0.77
		hours	0.19	0.13
		$period^2$	-0.04	0.03
		wind	-0.32	0.24
Northern Saw-Whet Owl	ψ	intercept	0.33	0.34
	p	intercept	-0.73	0.31
		period	0.06	0.06
		$period^2$	-0.06	0.03
		wind	-0.41	0.21
		light	0.75	0.48
		precip – d,shr	-27.51	315807.9

[a]Notation as in Table 1.1.

Table 1.6. Estimates of occupancy and detection probability for Barred Owl, Western Screech-Owl, and Northern Saw-Whet Owl as a function of categorical predictor variables included in final models (Table 1.5), Southeast Alaska, 2005.

Species	Response	Variables included	Estimate	95% CI
Barred Owl (model 1)	ψ	all	0.28	0.17 , 0.43
	p	no precip	0.42	0.21, 0.66
		drizzle, showers, rain	0.42	0.02, 0.71
Western Screech-Owl (model 1)	ψ	w/o big owls	0.62	0.38 , 0.82
		w/ big owls	0.21	0.07 , 0.50
	p	quiet (noise≤1)	0.33	0.17 , 0.53
		noise≥3	0.10	0.02 , 0.38
Northern Saw-Whet Owl	ψ	all	0.58	0.42 , 0.73

Table 1.7. Number of survey stations required in a single season to estimate occupancy and detection probabilities for northern saw-whet, Western Screech-Owl, and Barred Owls such that the estimates have CVs of 20-25%. Calculations are based on occupancy estimates from this study and methods follow MacKenzie and Royle (2005). The cumulative detection probability (p*) is the probability of confirming that the target species is present at a site.

Repeat surveys (k) per site	Single visit detection probability (p)	Cumulative detection probability (p*)	# of survey stations		
			Northern Saw-Whet Owl	Western Screech-Owl	Barred Owl
3	0.1	0.271	2265	1439	1611
	0.2	0.488	457	295	340
	0.3	0.657	172	114	139
	0.4	0.784	88	62	80
	0.5	0.875	57	42	58
	0.6	0.936	44	34	49
	0.7	0.973	39	30	45
	0.8	0.992	36	29	44
4	0.1	0.344	1110	708	799
	0.2	0.590	230	151	180
	0.3	0.760	95	66	85
	0.4	0.870	57	42	58
	0.5	0.938	44	33	49
	0.6	0.974	38	30	45
	0.7	0.992	36	29	44
	0.8	0.998	36	28	43
5	0.1	0.410	656	421	480
	0.2	0.672	143	96	118
	0.3	0.832	66	48	65
	0.4	0.922	46	35	50
	0.5	0.969	39	30	46
	0.6	0.990	37	29	44
	0.7	0.998	36	28	43
	0.8	0.999	36	28	43
6	0.1	0.469	434	280	323
	0.2	0.738	101	70	89
	0.3	0.882	53	39	56
	0.4	0.953	41	32	47
	0.5	0.984	37	29	44
	0.6	0.996	36	29	44
	0.7	0.999	36	28	43
	0.8	0.999	36	28	43

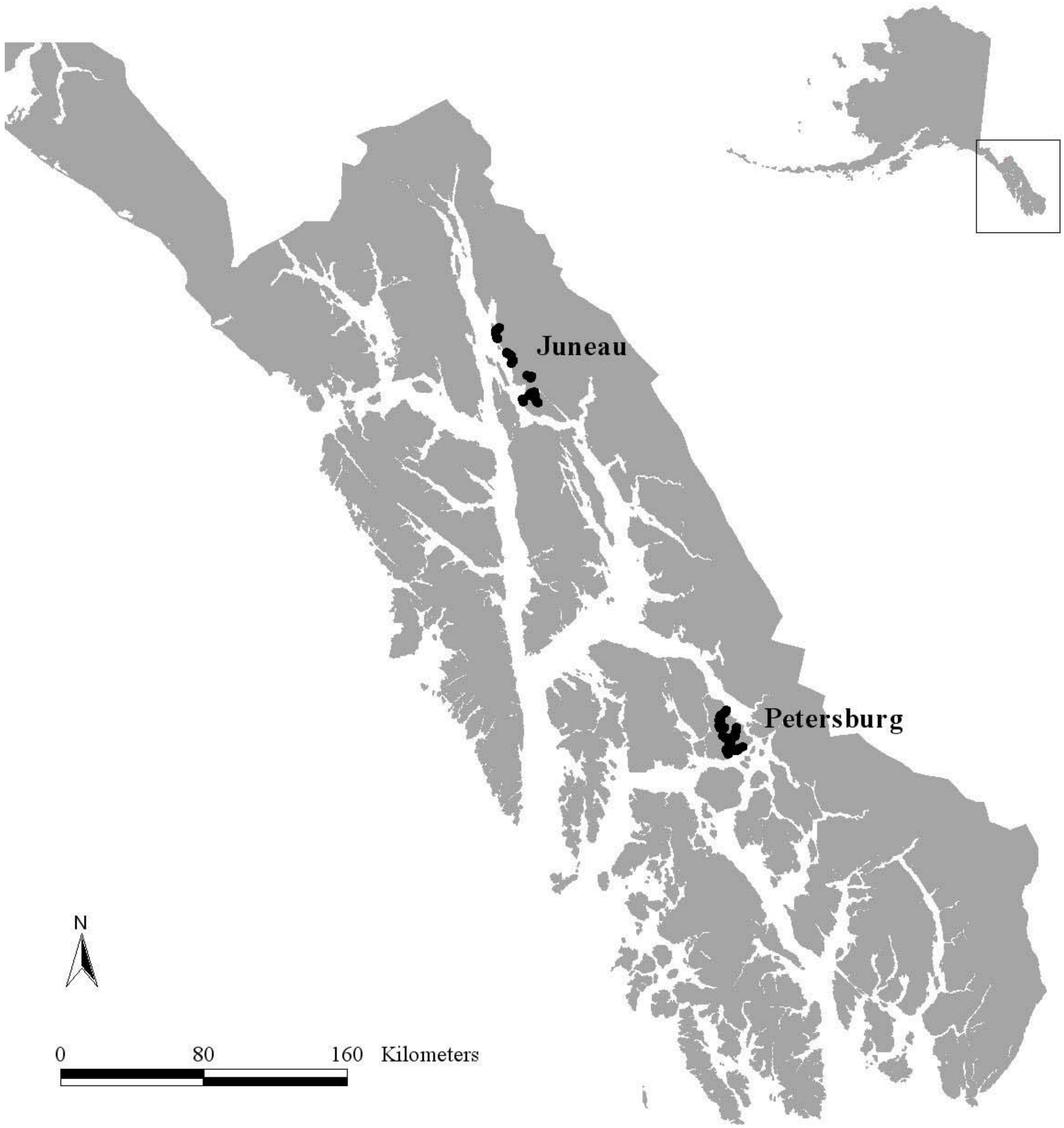

Figure 1.1. Map of Southeast Alaska identifying study areas, Juneau and Petersburg, and survey stations where forest owl surveys were conducted, 2005-2006.

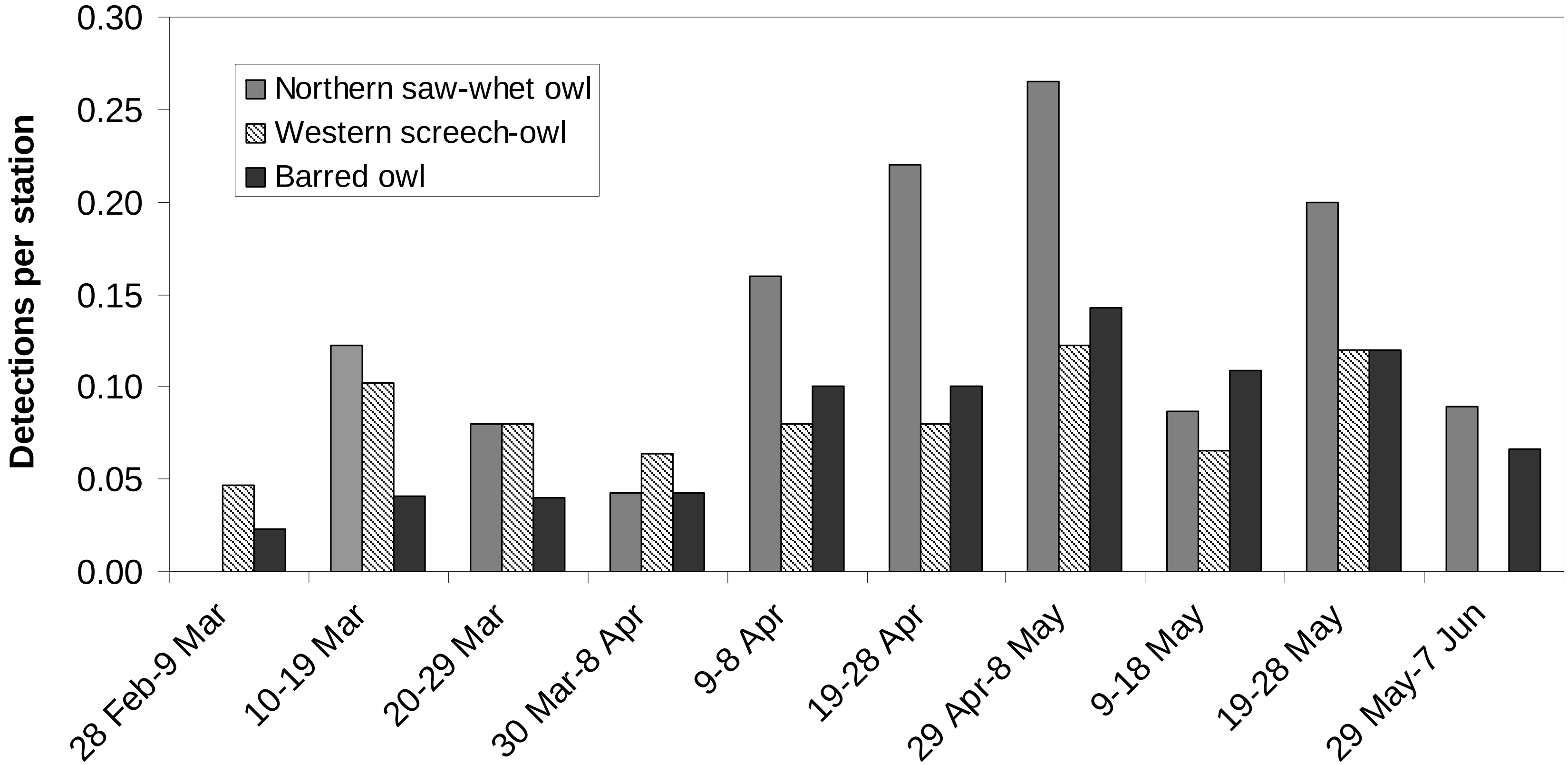

Figure 1.2. Owl detections per survey station by species and by survey interval, Southeast Alaska, 2005.

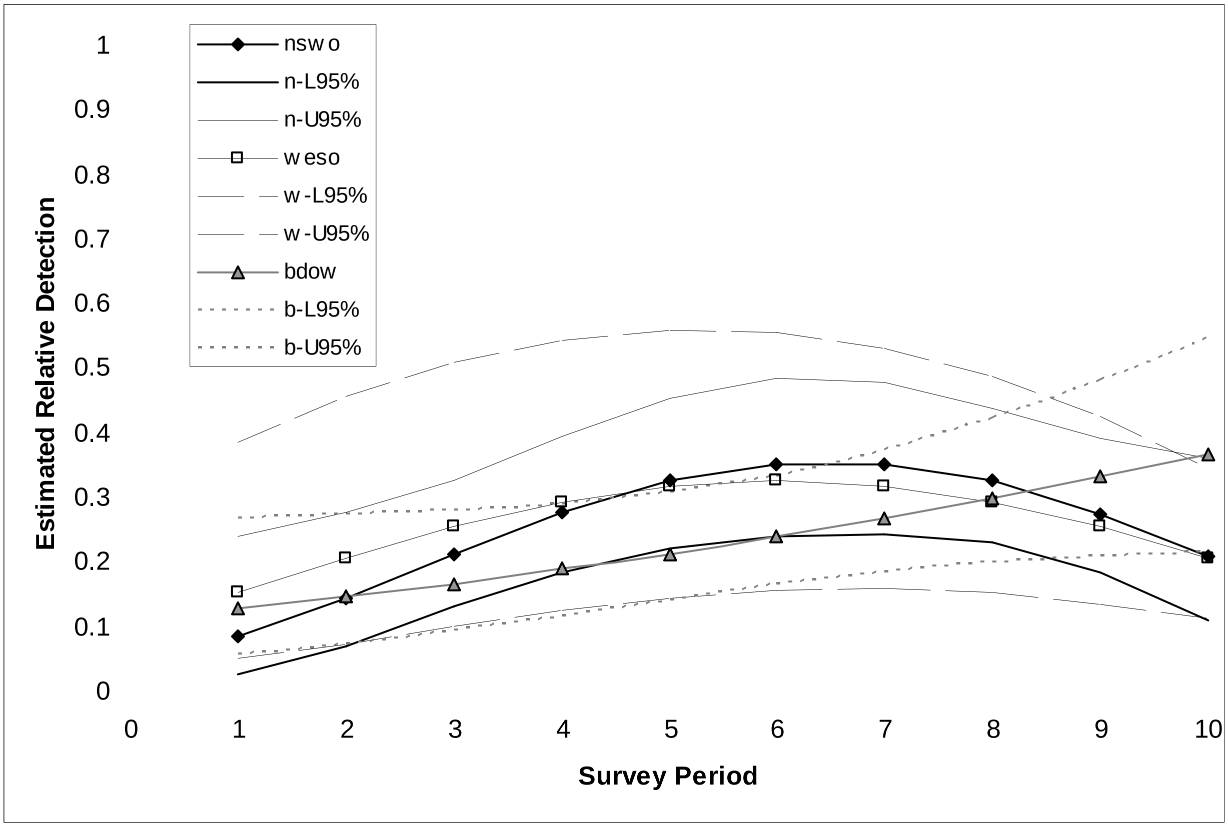

Figure 1.3. Modeled detection probabilities based on parameter estimates of 'period' selected in final models for Northern Saw-Whet Owl and Western Screech-Owl (Table 1.5).

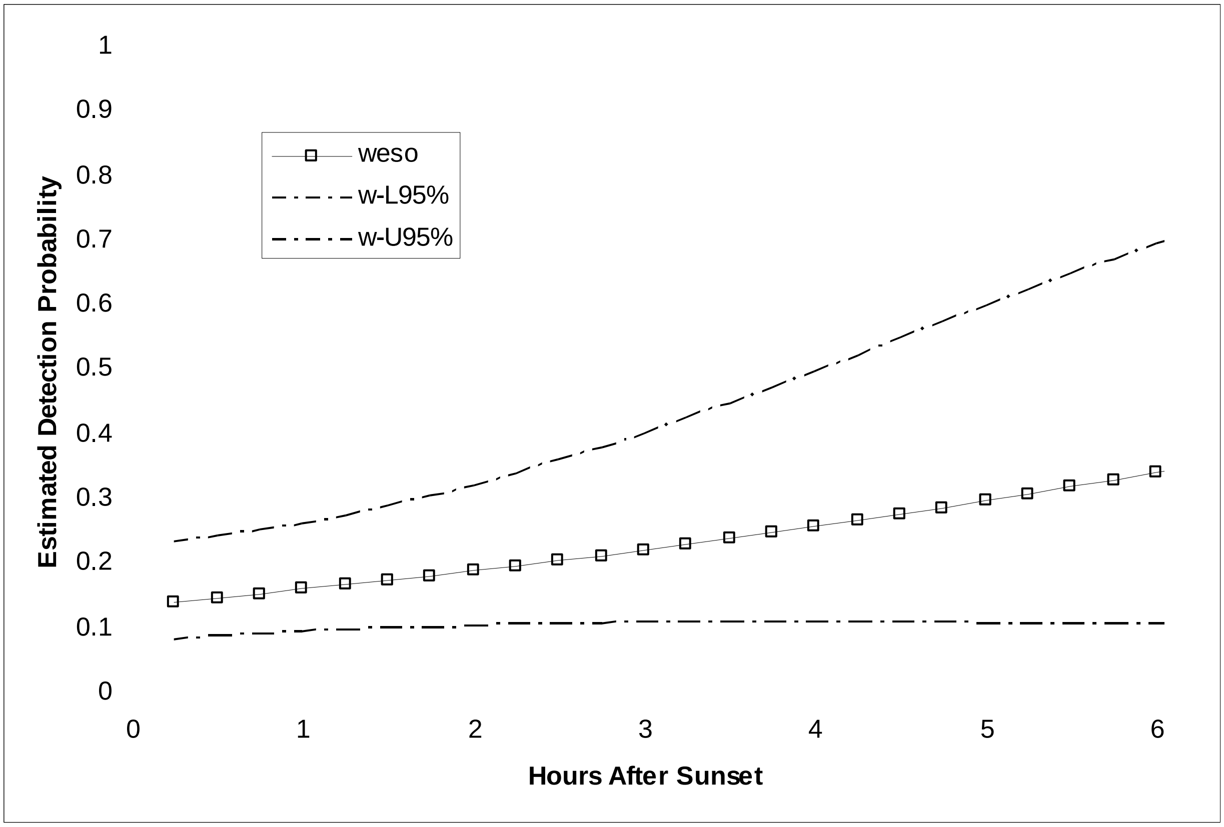

Figure 1.4. Modeled detection probabilities based on parameter estimates of 'hours' selected in the final model for Western Screech-Owl (Table 1.5).

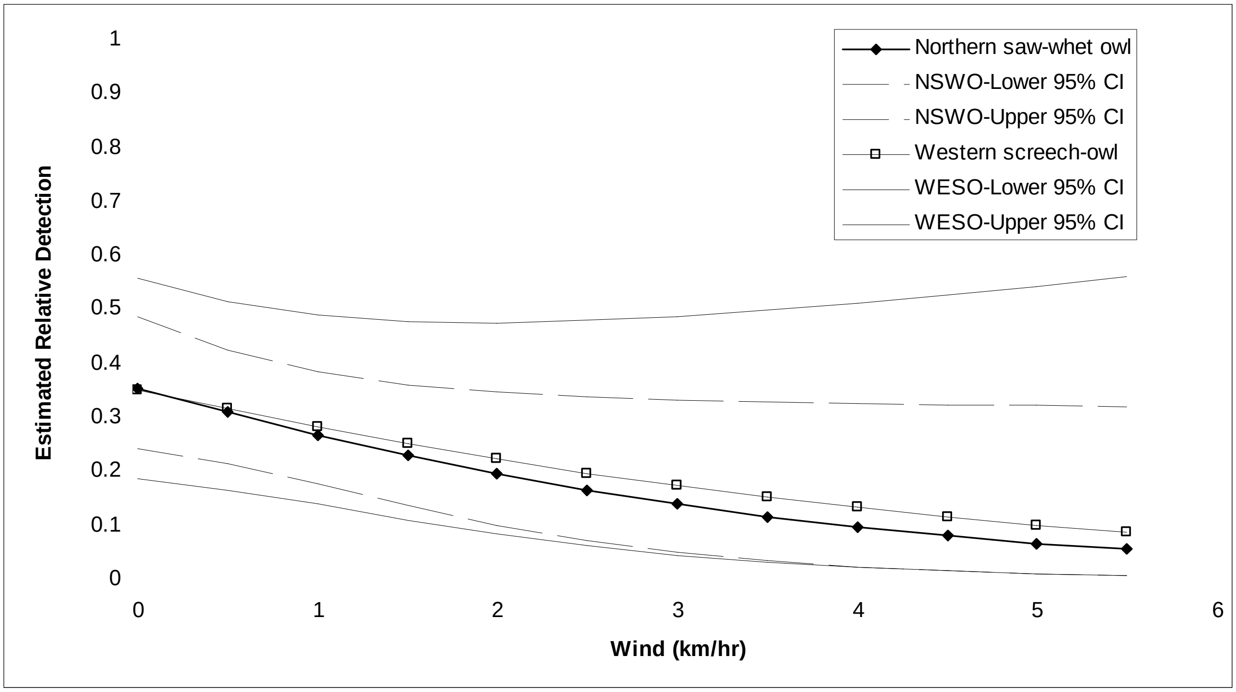

Figure 1.5. Modeled detection probabilities based on parameter estimates of 'wind' selected in final models for Northern Saw-Whet Owl and Western Screech-Owl (Table 1.5).

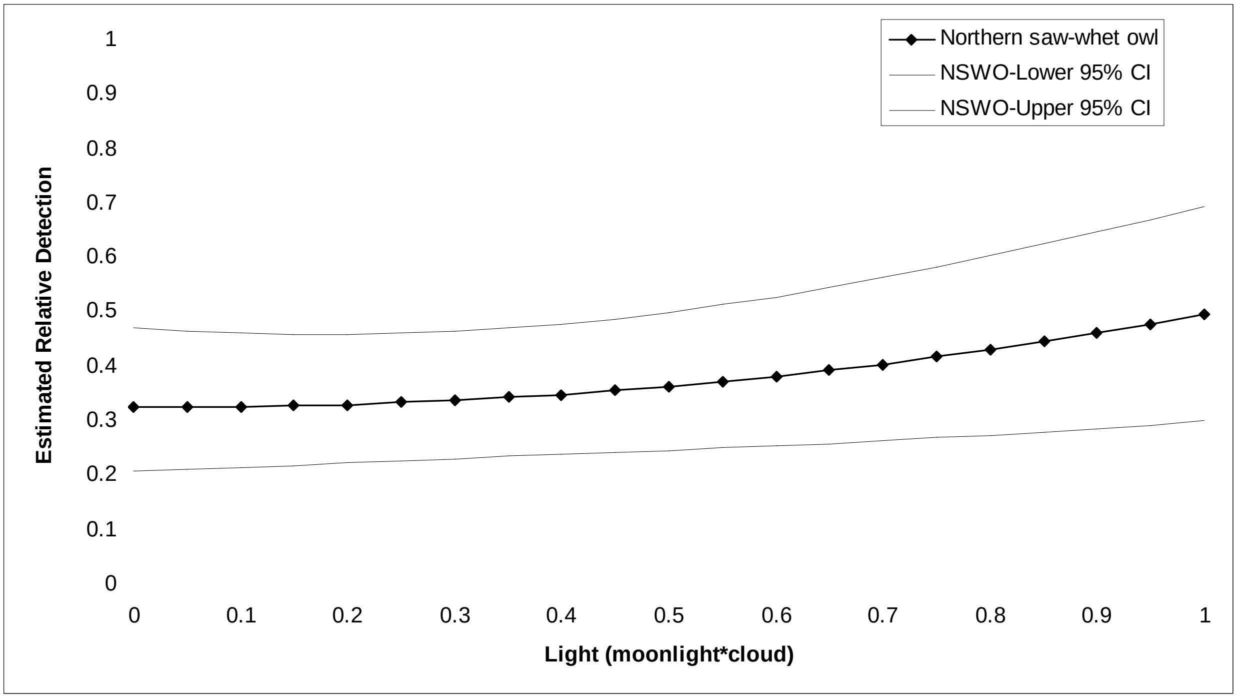

Figure 1.6. Modeled detection probabilities based on parameter estimates of ‘light’ selected in the final model for Northern Saw-Whet Owl (Table 1.5).

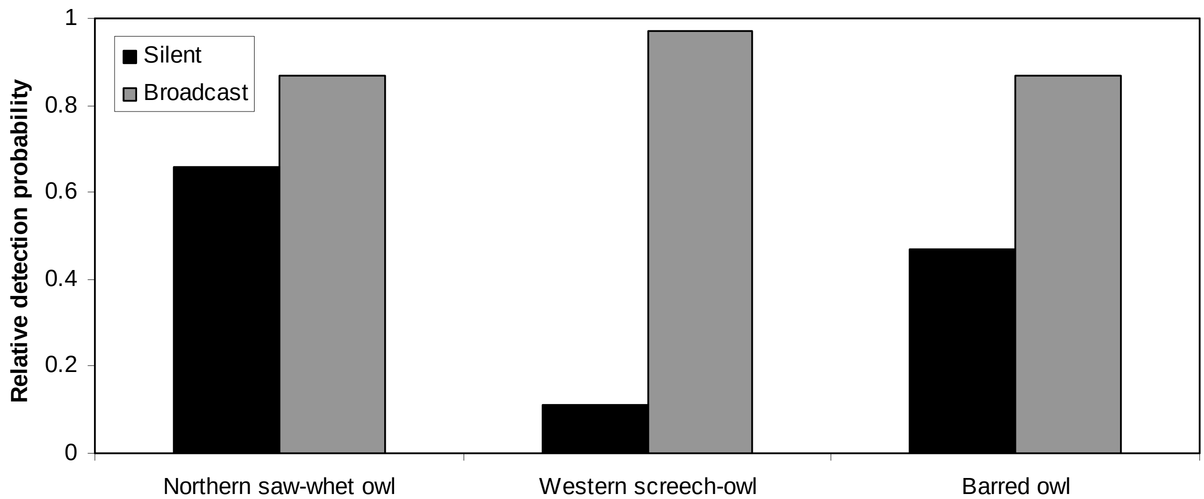

Figure 1.7. Relative detection probabilities by survey method for each target owl species, Southeast Alaska, 2005.

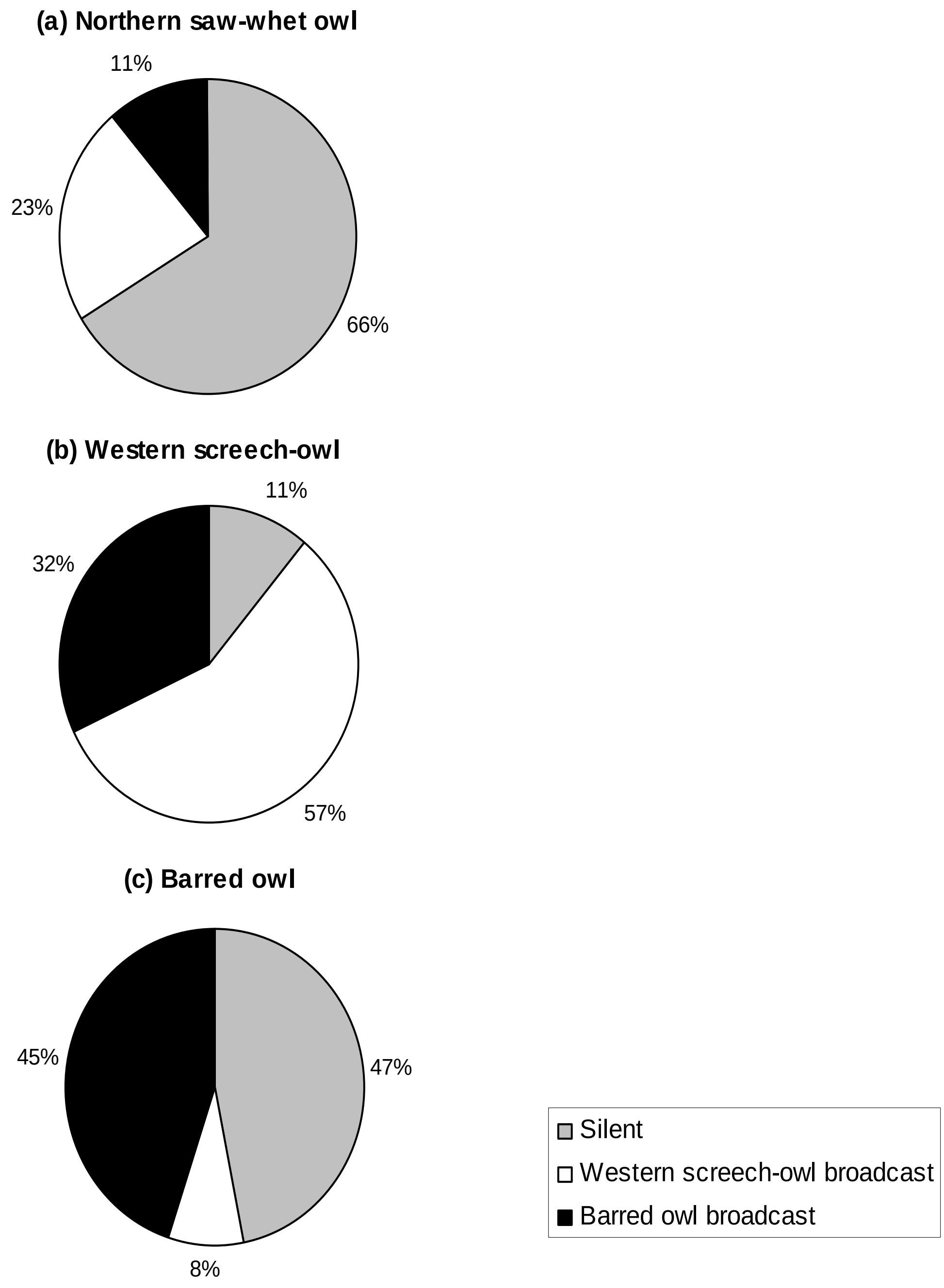

Figure 1.8. Proportion of initial detections by survey segment for Northern Saw-Whet Owl (n=62), Western Screech-Owl (n=37), and Barred Owl (n=38), Southeast Alaska, 2005.

CHAPTER 2
DECADAL CHANGES IN OCCUPANCY OF FOREST OWLS IN SOUTHEAST ALASKA, 1986-2008

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ABSTRACT

Nocturnal owls are not adequately monitored using existing multi-species surveys, such as the Breeding Bird Survey, and therefore, population status of most owl species in North America is unknown. We studied the occurrence of forest owls in Southeast Alaska, 2005-2008. We estimated occupancy as a function of habitat characteristics and change in occupancy of 3 owl species from historical (1986-1992) and current (2005-2008) surveys using methods outlined by MacKenzie et al. (2006). We conducted 1,238 point count surveys at 346 independent sites across Southeast Alaska from 1 April-15 May 2005-2008 and tallied 253 detections of 7 owl species. Detection probabilities ($p \pm SE$) were lowest for Western Screech-Owl ($p_{weso}=0.13 \pm 0.10$) and Northern Saw-Whet Owl ($p_{nswo}=0.19 \pm 0.06$), and highest for Barred Owl (0.29 ± 0.06) across all surveys. Occupancy ($\psi \pm SE$) of Barred Owls (*Strix varia*) was the lowest ($\psi_{bdow}=0.12 \pm 0.04$), followed by Western Screech-Owl (*Megascops kennicottii*; $\psi_{weso}=0.31 \pm 0.16$), and then Northern Saw-Whet Owl (*Aegolius acadicus*; $\psi_{nswo}=0.45 \pm 0.18$). Occupancy of Barred Owls was positively associated with % of productive forest. Western Screech-Owl occupancy was primarily influenced by 'longitude', a covariate distinguishing sites on the mainland and those on the islands of Southeast Alaska; a higher proportion of sites on the mainland were occupied by Western Screech-Owls. Occupancy of the migratory Northern Saw-Whet Owl was best predicted by survey year. Across all of Southeast Alaska, the proportion of sites occupied by Barred Owls doubled from historical to current surveys, while Western Screech-Owl and Northern Saw-Whet Owl occupancy remained relatively stable. However, Western Screech-Owl and Northern Saw-Whet Owl distribution narrowed over the 2 time periods, especially in the southern portion of Southeast Alaska where Barred Owls now commonly occur.

INTRODUCTION

With the exception of a few species of conservation concern, little is known about nocturnal owls in North America. Because of their general rarity, elusive behavior, and nocturnal habits, fundamental information such as distribution and abundance is poorly described for most owl species. However, owls are sensitive to environmental change, such as timber harvest (e.g., Northern Spotted Owl [*Strix accidentalis caurina*]; Forsman et al. 1984), road development (e.g., Cactus Ferruginous Pygmy-Owl [*Glaucidium brasilianum cactorum*]; Carton and Finch 2000), and contaminants (e.g., Burrowing Owl [*Athene cunicularia*]; Haug et al. 1993, Gervais and Catlin 2004). Similarly, owls play an important role in ecosystem function (e.g., as predators) and pest control (e.g., as predators of rodents), and are affected by forest management (e.g., as cavity nesters), and therefore, can serve as valuable indicators of environmental condition (Sundell et al. 2004, Cheveau et al. 2004).

In the Pacific Northwest region of the United States, recent expansion of the Barred Owl (*S. varia*) range has negatively affected other forest owls. Barred Owls have interbred with Northern Spotted Owls (Kelly and Forsman 2004), displaced and harassed Northern Spotted Owls (Kelly et al. 2003, Pearson and Livezey 2003), and altered calling behavior and therefore detectability of Northern Spotted Owls (Olson et al. 2005). Barred Owls have also been suspected of outcompeting and directly depredating Western Screech-Owls (*Megascops kennicottii*; COSEWIC 2002, Elliott 2006). In Canada, the negative effects of Barred Owls on Western Screech-Owls prompted listing of the *macfarlanei* subspecies of Western Screech-Owl as 'endangered' and the *kennicotti* subspecies as of 'special concern'. Although loss of preferred habitat, landscape fragmentation, and declines in the availability of prey are likely affecting the population trends of owls in the Pacific Northwest region of the United States, recent evidence suggests that range expansion of Barred Owls is also having a significant effect (Kelly et al. 2003, Pearson and Livezey 2003, Olson et al. 2005), particularly on populations of smaller owls (e.g., Western Screech-Owl; COSEWIC 2002, Elliott 2006). Lack of information on population trends of these owl species, however, has inhibited the development of conservation plans and management actions.

One of the major limitations to monitoring nocturnal owl populations has been methodology. Point count surveys conducted along the roadside at night are the most common method used to estimate relative abundance of owls (Takats et al. 2001). However, these surveys are susceptible to imperfect detectability (i.e., false absences) that, if not accounted for, can lead to biased estimates of abundance and faulty inferences about the population. Patch-occupancy models offer a realistic approach to monitoring nocturnal owl populations; instead of using abundance as the metric of interest, occupancy (i.e., the probability of sites being occupied) is the estimated population parameter (MacKenzie et al. 2006). These models adjust estimated occupancy probabilities for imperfect detection and model variation in detection and occupancy probabilities as functions of site- and survey-specific covariates; they also are often less demanding to implement than most techniques for estimating animal abundance. This approach has great potential for monitoring rare or elusive species, such as nocturnal owls, and has already been successfully used to estimate occupancy of northern spotted owl (Olson et al. 2005), Burrowing Owl (Tipton et al. 2009) and other forest owls (Wintle et al. 2005).

We studied the occurrence of forest owls in Southeast Alaska from 2005-2008. Our primary objectives were (1) to estimate occupancy of forest owls during the breeding season, (2) to identify habitat characteristics influencing occupancy, and (3) to estimate changes in occupancy over 2 time periods: 1986-1992 and 2005-2008. We focused our efforts on 3 species of owls for which we expected to obtain an adequate number of detections and were relevant to forest management in Southeast Alaska. We chose the Northern Saw-Whet Owl (*Aegolius acadicus*), a migratory species, Western Screech-Owl, a resident species, and Barred Owl, a resident species that has recently colonized Southeast Alaska and has raised conservation concerns for other owls in the Pacific Northwest region of the United States (Olsen et al. 2005, Elliott 2006).

STUDY AREA

We conducted this study in Southeast Alaska (Figure 2.1), a region with sparse human population characterized by steep, rugged topography, costal fjords, and large tracts of temperate rainforest. Southeast Alaska includes over 2,000 islands of the Alexander Archipelago and a narrow stretch of mainland separated from the remainder of North America by the vast Coastal Mountain Range (Alaback 1982). The region is roughly 700 km in length and averages 190 km in width. The majority (81%) of the land is managed by the U.S. Forest Service as the Tongass National Forest). Southeast Alaska has a cool, wet maritime climate with 75-500 cm of precipitation which is evenly distributed throughout the year (Harris et al. 1974). The forested landscape of Southeast Alaska is naturally fragmented by mountainous terrain, wetlands, and various fine-scale disturbances (e.g., wind-throw). Large-scale commercial timber harvesting that began in 1954 uses extensive, broad-scale clearcutting. Forests are dominated by western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*) and the understory consisted primary of blueberry (*Vaccinium spp.*), devil's club (*Oplopanax horridus*), and salmonberry (*Rubus spp.*).

METHODS

Field sampling

We conducted nocturnal point count surveys on roadside transects for owls from 2005-2008. We selected survey locations by (1) using transects established during a previous study conducted from 1986-1992 (hereafter referred to as "historical transects"; Suring, unpubl. data), and (2) identifying previously unsurveyed areas that were accessible during winter months (i.e., road maintenance occurred regularly). Stations along historical transects were spaced at 0.8 km intervals with 2-17 stations per transect, depending on the length of road available. However, on new transects and on historical transects we only surveyed stations at 1.6 km intervals in order to minimize double-counting owls, to avoid leading an owl from one point to the next with a broadcast call, and to maximize spatial coverage by increasing the area surveyed (following Takats et al. 2001).

Surveys conducted during the historical period (1986-1992) used 2 observers at each station and involved broadcasting owl calls to solicit a response. Recorded calls were played as loud as possible without distortion, beginning with a 2-min sequence of northern pygmy-owl (*Glaucidium gnoma*) calls, occurring at about 1 per 15 sec. The call sequence was followed by 1 min of silence. Similar sequences followed for Northern Saw-Whet Owl, Western Screech-Owl, Boreal Owl (*Aegolius funereus*), Northern Hawk-Owl (*Surnia ulula*), and Barred Owl. Sequences for Great Gray Owl (*Strix nebulosa*) and Great Horned Owl (*Bubo virginianus*), which were played last, were 3 min each with 30 sec between calls. The general sequence of calls (from small to large owls) was used in an attempt to ensure that responses from the smaller owls would not be influenced by the calls of larger owls which may be potential predators. All owls heard at each station were recorded, whether the response followed the appropriate species recording or occurred during some other portion of the tape. In total, observers spent approximately 24 min at each station. Surveys were conducted from 1 April-15 May, started at least 1 hour after sunset, and were not conducted if wind exceeded 25 km/h or when precipitation was in excess of drizzle or light snow occurred.

In the current study (2005-2008), the survey protocol involved 2 observers conducting 1 of 2 types of surveys: silent or broadcast. Both types of surveys began with a 2-minute settling period. Silent surveys were then followed by a 4-minute silent listening period. Broadcast surveys consisted of a 4-minute silent listening period, and then a broadcast of male territorial songs (Bird Songs of Alaska, Cornell Laboratory of Ornithology). We broadcasted Western Screech-Owl and Barred Owl songs using a megaphone (Radio Shack Musical Powerhorn, #320-2037) and a compact disk player. We always played Western Screech-Owl calls first to avoid attracting larger owls (e.g., Barred Owl, Great Horned Owl) that may be predators. We did not broadcast for Northern Saw-Whet Owl because, based on surveys conducted along the coast of British Columbia, we expected that if present, this species would respond to one of the other calls or would call independently of broadcasts (D. Cannings pers. comm.). Each species' song was broadcast for 30 sec while rotating the megaphone 360° and was followed by a 1-min silent count period. This was repeated once, so that each species broadcast series was 30-60-30-60 sec (3 min total). The broadcast rotation began with western-screech owl and ended with Barred Owl, and there was 1 minute of silent listening between broadcast series. The count ended with 1 minute of silent listening. In total, we spent approximately 12 min at each station. We limited our survey interval to 1 April-15 May. We began surveys at least 30 min after sunset (as determined by the U.S. Naval Observatory; http://aa.usno.navy.mil/data/docs/RS_OneDay.php) and completed the surveys within 6 hrs. We did not conduct surveys during inclement weather (i.e., heavy rain, winds >20 km/h). In order to conduct a sufficient number of surveys within the 45-day survey period (Chapter 1), especially given the large distances and associated travel costs in Southeast Alaska, surveys were conducted by both hired personnel and volunteers. All surveyors completed a training session on calls and songs of owls likely to be encountered during surveys.

Data analysis

We estimated occupancy (ψ) and detection probabilities (p) of Northern Saw-Whet Owl, Western Screech-Owl, and Barred Owl from 2005-2008 using modeling procedures outlined in MacKenzie et al. (2006). We used habitat and geographic variables to explain variation in occupancy of these 3 species. We buffered each station with a circle of 400-m radius using ArcView v3.3 (ESRI, Redmond, CA, USA) to characterize the surrounding habitat with data from the USDA Tongass National Forest geographic information system. We chose a 400-m radius because historical stations were spaced 800 m apart and therefore, this was the maximum distance to avoid overlapping circles. For stations that were not located within Tongass National Forest boundaries (i.e., Skagway, Haines, and Gustavus), we used a statewide ecosystem map (USGS Major Ecosystems of Alaska; http://agdc.usgs.gov/data/usgs/erosafo/ecosys/metadata/ecosys.html). Habitat variables included % non-forest, % low productive forest (i.e., productivity <1.4 m^3/ha), % productive forest (i.e., productivity >1.4 m^3/ha), elevation, and streams (total km). We standardized elevation and stream variables using z-score transformations (Zar 1999). We lacked sufficient data to model occupancy by route or island; therefore, we considered a latitudinal variable dividing the entire region into "north" (Yakutat, Skagway, Haines, Gustavus, Juneau, Hoonah), "middle" (Petersburg, Wrangell, Sitka), and "south" (Hyder, Ketchikan, and all of Prince of Wales Island), and a longitudinal variable distinguishing "mainland" (Yakutat, Skagway, Haines, Gustavus, Juneau, Hyder) and "island" (Hoonah, Sitka, Petersburg, Wrangell, Ketchikan, and all of Prince of Wales Island) stations (Figure 2.1). We modeled detection probabilities as a function of method (silent, broadcast) and environmental and biological covariates including hours after sunset (and the quadratic term), wind (coded using the Beaufort scale; Takats et al. 2001), precipitation, light (moon illumination*cloud cover), external noise (e.g., stream or surf), and presence of larger owl (Chapter 1).

We estimated the difference in occupancy across 2 time periods: historical (1986-1992) and current (2005-2008). The set of candidate models to estimate occupancy change for each species included the final model from the exercise above (i.e., the 2005-2008 dataset) and an additional variable 'time period' which refers to the historical and current periods of interest. We lacked data to run year-specific models for all species. Therefore, we considered the same habitat and geographic variables as those described above only if they were important for a particular species. We were unable to estimate p directly from the historical data. Environmental covariates (e.g., time, date, wind, cloud cover) were not recorded (or we did not have access to these data) during historical surveys. In addition, historical surveys were not repeated in a given year (i.e., each station was only surveyed once each year), which also eliminated the ability to include presence of larger owls as a potential covariate. We used method in estimating p if it was included in the final model describing the current dataset only. Essentially, we used detection histories from current surveys to estimate p for all surveys, and we assumed that p only could have varied by method and otherwise was constant across all years (1986-2008).

We modeled ψ and p in the program PRESENCE (v2.2; Hines 2006). We began by constructing the null model (constant ψ and p) and fitting models using each covariate singly to predict ψ or p. To model p, we only considered the explanatory variables identified in Chapter 1 for each species. Model fit was assessed with AIC and related model weights (Burnham and Anderson 2002). We evaluated c-hat values of the global model (i.e., the model with the most parameters to estimate) generated with 10,000 bootstraps to determine if any overdispersion existed in the dataset, but c-hat<1.0 for all models considered in our analysis. Once the single variable models had been fit, we fit a more complex model containing combinations of the best supported variables based on model weights and the precision of the estimated coefficients. From the 'base' model, we added additional variables singly examining model weights after each addition. We continued to add variables until all reasonably supported variables not in the model had been considered. The final model was the one tested with the highest model weight. We estimated overall occupancy by averaging the individual site estimates of occupancy based on the beta estimates from the final model; therefore, the overall occupancy estimates should be interpreted as the average occupancy given the stations surveyed.

RESULTS

We conducted 1,238 (744 broadcast and 494 silent) surveys at 346 sites across Southeast Alaska from 1 April-15 May 2005-2008. We recorded 253 detections of 7 owl species; 6 Northern Pygmy-Owl, 125 Northern Saw-Whet Owl, 50 Western Screech-Owl, 5 Boreal Owl, 48 Barred Owl, 16 Great Horned Owl, 1 Great Gray Owl, and 2 unidentified owls. Survey effort and the number of owl detections varied annually (Table 2.1). Stations surveyed during 2005–

2008 had similar habitat characteristics (Table 2.2). We did, however, primarily sample low elevation forested sites (Table 2.2). Survey-specific covariates varied annually with more surveys conducted in increased wind and light conditions in 2008 compared to the other years (Table 2.2); however, relatively few surveys (n=93) were conducted in 2008 (Table 2.1).

Estimates of occupancy and detection probabilities

Barred Owl occupancy was positively associated with % of productive forest (Table 2.3, Figure 2.3), but none of the covariates we considered helped to explain variation in detection probability (Table 2.4). Some habitat variables (e.g., elevation, stream) were included in the top-ranked models, but only when coupled with % of productive forest (Table 2.4). Furthermore, estimates of ψ varied little among these models, suggesting that % of productive forest was the driving covariate across all models for Barred Owl. However, the influence of productive forest on ψ was relatively weak (Figure 2.2). Estimated overall occupancy ($\psi \pm SE$) of Barred Owls was $\psi_{bdow}=0.12 \pm 0.04$ and p was estimated to be constant ($p \pm SE$; 0.29 ± 0.06; 95% CI=0.20,0.41) across all surveys (Figure 2.3).

The best model describing Western Screech-Owl occupancy included 2 explanatory variables: 'longitude' and 'streams'. Longitude, a categorical variable separating stations on the mainland and those on islands of the archipelago, was included in all of the top models (Table 2.5). Western Screech-Owl occupancy was higher on islands ($\psi_{island}=0.45$; 95% CI=0.26,0.66) than the mainland ($\psi_{mainland}=0.14$; 95% CI=0.07,0.28). Kilometers of stream surrounding each station was positively associated with occupancy (Table 2.3), but the relationship was extremely weak with large confidence intervals (Figure 2.4), at least when it was coupled with 'longitude'. Five explanatory variables were used to estimate p; 3 variables (i.e., wind, noise, and hours after sunset) had similar effects on p as found in Chapter 1 with 'wind' having marginal value (Table 2.3). The presence of larger owls was more useful in predicting p compared to ψ (Table 2.5; Chapter 1) and method (i.e., silent versus broadcast) was an important explanatory variable. Detection probability was negatively associated with the presence of larger owl ($p_{large\ owl}=0.02$; 95% CI=0.00,0.10); estimates of p increased when large owls were not present ($p_{no\ large\ owl}=0.07$; 95% CI=0.03,0.17), but precision in these estimates was low. Probability of detecting a Western Screech-Owl was much greater using broadcast surveys ($p_{broadcast}=0.28$; 95% CI=0.17,0.42) compared to silent surveys ($p_{silent}=0.07$; 95% CI=0.03,0.17). The overall occupancy estimate

($\psi \pm SE$) for Western Screech-Owls was $\psi_{weso}=0.31 \pm 0.16$ and the detection probability ($p \pm SE$) was $p_{weso}=0.13 \pm 0.10$ (Figure 2.3).

Three models predicting occupancy of Northern Saw-Whet Owls ranked with Δ AIC<1.0 (Table 2.6). On closer examination of the parameter estimates it appeared that 'longitude' and 'larger owl' were contributing very little to the model; however, given the relatively high model weight, we selected the simpler of the 2 highest ranked models as the final model. This model estimated occupancy by year and the presence of larger owls (Table 2.6). Annual estimates of occupancy were $\psi_{2005}=0.47$ (95% CI=0.31,0.64), $\psi_{2006}=0.72$ (95% CI=0.30,0.94), $\psi_{2007}=0.25$ (95% CI=0.14,0.42), and $\psi_{2008}=0.24$ (95% CI=0.08,0.53). Occupancy was positively associated with the presence of larger owls during previous surveys ($\psi_{large\ owl}=0.43$; 95% CI=0.11,0.82) compared to those without larger owls ($\psi_{no\ large\ owl}=0.24$; 95% CI=0.08,0.53), but the precision of these estimates was extremely low and their reliability is questionable. The parameter estimates for the third ranked model that does not include either 'larger owls' or 'longitude' were virtually identical to those in the final model. Similar to results in Chapter 1, 'rain' and 'light' remained important explanatory variables, but the influence of 'wind' diminished (Tables 2.3, 2.6). The overall occupancy estimate ($\psi \pm SE$) for Northern Saw-Whet Owls was $\psi_{nswo}=0.45 \pm 0.18$ and the detection probability ($p \pm SE$) was $p_{nswo}=0.19 \pm 0.06$ (Figure 2.3).

Decadal changes in occupancy

We considered 2-8 candidate models to estimate change in occupancy of Northern Saw-Whet Owl, Western Screech-Owl, and Barred Owl between historical (1986-1992) and current (2005-2008) time periods (Table 2.7). 'Time period' was included in the top-ranked models for Barred Owl and Western Screech-Owl, but not Northern Saw-Whet Owl, suggesting that there was not a significant change in occupancy across the 2 time periods for Northern Saw-Whet Owl. Estimated occupancy of Barred Owls and Western Screech-Owls increased between the historical and current time periods. Barred Owl occupancy estimates were best predicted from 'time period' alone and doubled from $\psi_{bdow\ historical}=0.07$ (95% CI=0.03,0.16) and $\psi_{bdow\ current}=0.14$ (95% CI=0.08,0.21). The final model for Western Screech-Owls included the 'longitude' and 'streams' variables, plus 'time period' to estimate ψ and 'method' to estimate p. Once again, on closer examination of the parameter estimates, the 'longitude' variable was driving the model, with 'streams' and 'time period' contributing very little, particularly for estimating current occupancy probabilities. Based on the top-ranked model, however, occupancy of Western Screech-Owls also increased from $\psi_{weso\ historical}$=0.20 (95% CI=0.11,0.36) to $\psi_{weso\ current}$=0.35 (95% CI=0.21,0.53), but with more variability in the estimates. Using the model that included only 'time period' for ψ and 'method' for p, occupancy estimates were similar for both time periods ($\psi_{weso\ historical}$=0.24 (95% CI=0.12,0.42) and $\psi_{weso\ current}$=0.27 (95% CI=0.16,0.42). Although 'time period' was not included in the final model for Northern Saw-Whet Owl, occupancy estimates were $\psi_{nswo\ historical}$=0.37 (95% CI=0.23,0.55) and $\psi_{nswo\ current}$=0.44 (95% CI=0.31,0.57).

The number of stations where Barred Owls were detected at least once increased from the historical to current time periods and distribution broadened across Southeast Alaska (Figure 2.5). In contrast, the distribution of Western Screech-Owl and Northern Saw-Whet Owl was reduced in the southern portion of the study area over the 2 time periods (Figures 2.6, 2.7). During the historical surveys, Western Screech-Owls were detected on southern Prince of Wales Island, Ketchikan, and Hyder, but during current surveys were recorded in Ketchikan only (Figure 2.6). Similarly, Northern Saw-Whet Owls were never detected in these areas (and Wrangell) during current surveys (Figure 2.7). Barred Owls, however, were detected at more stations in these areas in the current period compared to the historical period (Figure 2.5). Western Screech-Owl was the only species detected during surveys in either time period in Sitka (Figures 2.5-2.7).

The number of owl detections per station on the first visit only across all years was consistent with the occupancy estimates across the historical and current time periods (Figure 2.8). Detections of Barred Owls per station averaged across all years doubled from the historical ($\bar{x}_{historical}$=0.02) to the current ($\bar{x}_{current}$=0.05) time periods, but annual variability in detections was relatively high (Figure 2.5). Average detections for Western Screech-Owl was similar across time periods ($\bar{x}_{historical}$=0.05, $\bar{x}_{current}$=0.06) and remained fairly consistent across years (Figure 2.8). Detections of Northern Saw-Whet Owls varied considerably among years with average detections increasing from the historical time period ($\bar{x}_{historical}$=0.08) to the current time period ($\bar{x}_{current}$=0.11; Figure 2.5).

DISCUSSION

Our study was the first to estimate occupancy, including decadal changes, of the most common forest owls in Southeast Alaska. In general, we found the methods developed by MacKenzie et al. (2006) to be well-suited for addressing our study objectives, particularly when survey effort was consistent across years. Unfortunately, we lacked a sufficient sample to model colonization and extinction probabilities for the 4 years of our study (using a multi-season model in PRESENCE, MacKenzie et al. 2006) because few stations were surveyed multiple times in a year and in consecutive years. However we believe that with consistent survey effort, these methods, provide a realistic and reliable approach to monitoring owl populations in Southeast Alaska and recommend their use in future monitoring and research studies.

Barred Owls were more likely to occupy sites that consisted primarily of high productive forest (>1.4 m^3/ha). We conclude that Barred Owls are well-distributed across Southeast Alaska because neither 'latitude' nor 'longitude' were included in the final model, with distribution largely driven by the amount of high productive forest. Throughout its range, this species prefers old forests presumably due to greater availability of potential nest sites, lower stem density facilitating hunting, and increased diversity of prey (Nicholls and Warner 1972, Haney 1997, Mazur et al. 1998). Barred Owls are generalist predators and fierce competitors (Mazur and James 2000), which may have a negative impact on other large avian predators associated with the same habitat features in Southeast Alaska (e.g., Northern Goshawk [*Accipiter gentilis*]). We were surprised that 'method' was not included in the final model of p for Barred Owls because we broadcast specifically for this species, which is known to be responsive to conspecific calls (McGarigal and Fraser 1985), and our more intensive investigation of factors affecting detection probability suggested higher detectability when broadcasts were used (Chapter 1). We suspect that because Barred Owls have such a resonating song that can be heard from large distances, the detection probability during silent surveys was reasonable and was only incrementally improved with broadcasting methods. We still recommend the use of broadcast surveys for Barred Owls during occupancy studies because this method does improve p even though the increase might be small.

We provided evidence that Barred Owl occupancy rates has doubled in Southeast Alaska since the 1986-1992 surveys. Although Barred Owl range and numbers have been reduced in eastern North America, presumably due to forest clearing over the last 200 years, this species has flourished in recent years (>1970's) in the mature and old-growth forests of western North America (Mazur and James 2000 and references therein; Livezy 2009). The first confirmed observation (i.e., recorded vocalization) of a Barred Owl in Alaska was in 1977 on Douglas Island, near Juneau (Armstrong and Hermans 2004). In late August 1978, near Auke Lake in Juneau, a fledgling Barred Owl was sighted and photographed; the bird died shortly thereafter, presumably due to starvation (B. Armstrong, pers. comm.). Although strong evidence suggested that Barred Owls previously nested successfully in Alaska, the first confirmed nest was located in 1988 near Coon Cove, Revillagigedo Island where 2 down-covered nestlings were found beneath a fallen tree (J. Gustafson, pers. comm.). Since then, Barred Owls have been regularly sighted in Southeast Alaska, but their potential impact on other owls in the region has not been investigated until this study. We suspect that Barred Owl occupancy will continue to increase in Southeast Alaska where nesting habitat is plentiful, but prey resources may not be sufficient for continued population growth as has been reported for other raptor species (Lewis et al. 2006). Barred Owls are opportunistic predators and, while mostly considered to be semi-nocturnal to nocturnal hunters, diurnal hunting is not uncommon (Mazur and James 2000); the ability to hunt efficiently during both daylight and night hours may give this species a competitive edge over other large avian predators in Southeast Alaska (e.g., northern goshawk; Newton 1998). Barred Owls now occur in the southern portion of the archipelago where both Northern Saw-Whet Owl and Western Screech-Owl occurred historically. Northern Saw-Whet Owls and Western Screech-Owls may not currently be present or may have altered their behavior (Figures 2.5-2.7). This finding may be the result of negative impacts of Barred Owls on the smaller owls in the southern region, where Barred Owls presumably first colonized Southeast Alaska.

Western Screech-Owl occupancy was best predicted by longitude with higher probabilities of occurrence on the islands compared to the mainland of Southeast Alaska. The magnitude of the difference was 3-fold and was clearly the driving factor in modeling both occupancy and change-in-occupancy of this species. We hypothesized that streams would be a useful explanatory variable to estimate occupancy of Western Screech-Owls because this species is strongly associated with riparian habitats throughout their range (Cannings and Angell 2001 and references therein). Although this covariate was included in the final model, the relationship was either weak or potentially masked by longitude. When we compared a model which based occupancy on just 'longitude' versus one with just 'streams', the 'longitude' model was stronger

(~3 AIC units; Table 2.5). This implies that the 'streams' variable may be a "ghost" variable being brought along with 'longitude' and that 'longitude' is the real variable driving our models of Western Screech-Owl occupancy. We did not consider class of streams in our analysis, but we recommend that this be included in future modeling efforts because ephemeral streams likely have little influence on Western Screech-Owl occurrence. We suspect that occupancy was higher on the islands because the climate is milder (NOAA 2009), allowing some streams to remain unfrozen on the islands throughout the winter and early spring when territories are established. Western Screech-Owl diet varies tremendously, but invertebrates including insects, arthropods, and caterpillars are commonly taken as prey (Chapter 5, Cannings and Angell 2001). We hypothesize that this is especially true during winter in Southeast Alaska when migratory birds are absent resulting in a poor prey base. Unfrozen, freshwater streams may provide adequate prey for Western Screech-Owls to survive the prey-poor winter months. Detections of larger owls during previous surveys within the same year were found to negatively affect detection probability; however, it is difficult to determine if the larger owls are influencing occupancy or detection probability, or both. Barred Owls are known to prey directly on Western Screech-Owls (COSEWIC 2002), which may influence their calling behavior and explain the overall low detection probability for Western Screech-Owl. Although we report an increasing or stable (i.e., not decreasing) trend in occupancy of Western Screech-Owls, we recommend continued monitoring of occupancy for this species in light of their apparent population declines in British Columbia and the potential negative impact of large owls (mostly Barred Owls).

For Northern Saw-Whet Owl, which are migratory, we interpret the occupancy probabilities as "use" probabilities because we may be violating the closed population assumption required of these methods (e.g., different individual owls might 'occupy' a site during different surveys; MacKenzie et al. 2006). We found that occupancy of Northern Saw-Whet Owls varied annually is not expected because the timing of their migration varies by sex, age class, and year-to-year, but peak movements generally occur on clear, calm, dark nights in April and May (Evans 1980, Cannings 1993). We cannot explain the positive association with larger owls except that perhaps due to their migratory behavior individuals were not aware of the presence of larger owls in the vicinity. We believe the relationship between Northern Saw-Whet Owl occupancy and larger owls is not biologically meaningful, especially given the low precision of the estimates. The overall detection probability was lower than we anticipated (roughly half of those estimated in Chapter 1), which may reflect annual variation in migratory behavior (the estimates in Chapter 1 were calculated on a single year of data, 2005). The Northern Saw-Whet Owl population in Southeast Alaska appears to be stable, but due to the annual variability in occupancy, it would be prudent to have additional years of data collected using the survey protocol recommended as part of this study (Appendix I).

Our study provided much needed information on decadal changes in occupancy of 3 forest owl species, but we did encounter severe logistical limitations. Most notably, surveys were constrained to roads that were maintained in the late winter and early spring. We investigated conducting surveys in unroaded areas using boats, snowmachines, and on foot, but determined that the effort required per station surveyed would be too high and would likely result in very few detections (based on the historical dataset). We recommend exploring the use of automated recording systems (e.g., “frogloggers”) for sampling in remote areas. These devices have recently been used successfully in amphibian monitoring programs even in areas with high rainfall (see North American Amphibian Monitoring Program; http://www.pwrc.usgs.gov/naamp). Our study extended over several years of record snowfall in Southeast Alaska (NOAA National Weather Service; http://pajk.arh.noaa.gov/index.php), preventing repeated access to many stations particularly in the middle and northern areas. The majority of surveys were conducted by volunteers and not all had access to a high-clearance, 4-wheel drive vehicle; in many cases, a reliable vehicle would not have provided access anyway. Therefore, we were unable to survey many stations multiple times in a given year and in consecutive years, which was necessary for estimating colonization and extinction rates. We recommend using this approach in the future, particularly to monitor effects of Barred Owls on smaller owls.

We interpret the estimates of the change in occupancy with full knowledge of the limitations in comparing the historical and current datasets. We were unable to adjust the historical data for differences in detection probabilities as a function of environmental (e.g., wind, rain, hours after sunset) and biological (e.g. larger owls) factors. Also, historical surveys were not repeated within the same year, which also prevented direct estimation of p based on detection histories. In addition survey methodology differed (e.g., more time spent at each survey stop). Therefore, we had to assume that the range of survey-specific conditions we experienced during ‘current’ surveys were equivalent to those encountered during ‘historical’ surveys and that the differences in survey methods were not sufficient to overwhelm true patterns. This is not an unreasonable assumption given the number of surveys conducted in both time periods, but failing to account for differences in detection probabilities could lead to faulty inferences. In fact, the advantage to using the occupancy estimation methods outlined by MacKenzie et al. (2006) is that probability of detection is incorporated in the occupancy probabilities.

MANAGEMENT IMPLICATIONS

Occupancy of the 3 nocturnal owl species we studied was relatively low ($\psi \leq 0.45$) in Southeast Alaska, which is consistent with the relatively depauperate small mammal prey base and corresponding lack of diurnal avian predators that hunt in the forest (Lewis et al. 2006). Despite their rarity, however, continued monitoring of occupancy of these 3 owl species, especially the 2 resident species (i.e., Western Screech-Owl and Barred Owl) could provide useful information on the status of small mammal populations, the expansion and impact of Barred Owls, and the effects of habitat manipulation and restoration. Their use as indicators of environmental and landscape condition is particularly valuable given the relatively little effort required to monitor occupancy sufficiently.

LITERATURE CITED

Alaback, P.B. 1982. Dynamics of understory biomass in Sitka spruce-western hemlock forests of Southeast Alaska. Ecology 63:1932-1948.

Armstrong, R.H., and M. Hermans. 2004. Southeast Alaska's Natural World. Todd Communications, Anchorage, Alaska.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and inference: a practical information-theoretic approach. Springer-Verlag, New York, USA.

Cannings, R. J. 1993. Northern Saw-Whet Owl (*Aegolius acadicus*). *In* The Birds of North America, No. 42 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Cannings, R. J., and T. Angell. 2001. Western Screech-Owl (*Otus kennicottii*). *In* The Birds of North America, No. 597 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Carton, J. E., and D. M. Finch. 2000. Ecology and conservation of the Cactus Ferruginous pygmy-Owl in Arizona. USDA Forest Service General Technical Report, RMRS-GTR-43.

Cheveau, M., P. Drapeau, L. Imbeau, and Y. Bergeron. 2004. Owl winter irruptions as an indicator of small mammal population cycles in the boreal forest of eastern North America. Oikos 107:190-198.

COSEWIC. 2002. COSEWIC assessment and update status report on the Western Screech-Owl *Otus kennicottii* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 31pp.

Elliott, K. 2006. Declining numbers of Western Screech-Owl in the lower mainland of British Columbia. British Columbia Birds 14:2-11.

Evans, D. L. 1980. Multivariate analyses of weather and fall migration of Saw-Whet Owls at Duluth, Minnesota. M.Sc. thesis, North Dakota State University, Fargo.

Forsman, E. D., E. C. Meslow, and H. M. Wight. 1984. Distribution and biology of the Spotted Owl in Oregon. Wildlife Monographs 87.

Gervais, J. A., and D. H. Catlin. 2004. Temporal patterns of DDE in burrowing owl eggs from the Imperial Valley, California. The Southwestern Naturalist 49:509-512.

Haney, J. C. 1997. Spatial incidence of Barred Owl (*Strix varia*) reproduction in old-growth forest of the Appalachian Plateau. Journal of Raptor Research 31:241-252.

Harris, A. S., O. K. Hutchison, W. R. Meehan, N. Swanston, A. E. Helmers, J. C. Hendee, T. M. Collins. 1974. The forest ecosystem of Southeast Alaska: 1. The Setting. USDA Forest Service General Technical Report, PNW-12. Ref. 18718. 40pp.

Haug, E. A., B. A Millsap, and M. S. Martell. 1993. Burrowing Owl (*Athene cunicularia*). *In* The Birds of North America, No. 61 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Hines, J. E. 2006. PRESENCE2-software to estimate patch occupancy and related parameters. USGS-PWRC. http://www.mbr-pwrc.usgs.gov/software/presence.html

Kelly, E. G., E. D. Forsman, and R. G. Anthony. 2003. Are Barred Owls displacing spotted owls? Condor 105:45-53.

Kelly, E. G., and E. D. Forsman. 2004. Recent records of hybridization between Barred Owls (*Strix varia*) and Northern Spotted Owls (*S. occidentalis caurina*). Auk 121:806-810.

Lewis, S. B., K. Titus, M. R. Fuller. 2006. Northern Goshawk diet during the nesting season in Southeast Alaska. Journal of Wildlife Management 70:1151-1160.

Livezy, K. B. 2009. Barred Owl range expansion, Part I: chronology and distribution. American Midland Naturalist 161:49-56.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Academic Press, Burlington, MA, USA.

Mazur, K. M., and S. D. Frith, and P. C. James. 1998. Barred Owl home range and habitat selection in the boreal forest of central Saskatchewan. Auk 115:746-754.

Mazur, K. M., and P. C. James. 2000. Barred Owl (*Strix varia*). *In* The Birds of North America, No. 508 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

McGarigal, K., and J. D. Fraser. 1985. Barred Owl responses to recorded vocalizations. Condor 87:552-553.

Newton, I. 1998. Population limitation in birds. Academic Press Inc., San Diego, California, USA.

Nicholls, T. H., and D. W. Warner. 1972. Barred Owl habitat use as determined by radiotelemetry. Journal of Wildlife Management 36:213-224.

NOAA. 2009. Winter climate guide to Southeast Alaska. http://pajk.arh.noaa.gov/info/brochures/winter.pdf

Olson, G. S., R. G. Anthony, E. D. Forsman, S. H. Ackers, P. J. Loschl, J. A. Reid, K. M. Dugger, E. M. Glenn, W. J. Ripple. 2005. Modeling of site occupancy dynamics for Northern Spotted Owls, with emphasis on the effects of Barred Owls. Journal of Wildlife Management 69:918-932.

Pearson, R. R., and K. B. Livezey. 2003. Distribution, numbers and site characteristics of Spotted Owls and Barred Owls in the Cascade Mountains of Washington. Journal of Raptor Research 37:265-276.

Sundell, J. O. Huitu, H. Henttonen, A. Kaikusalo, E. Korpimaki, H. Pietiainen, P. Saurola, and I. Hanski. 2004. Large-scale spatial dynamics of vole populations in Finland revealed by the breeding success of vole-eating predators. Journal of Animal Ecology 73:167-178.

Takats, L. D., C. M. Francis, G. L. Holroyd, J. R. Duncan, K. M. Mazur, R. J. Cannings, W. Harris, D. Holt. 2001. Guidelines for nocturnal owl monitoring in North America. Beaverhill Bird Observatory and Bird Studies Canada, Edmonton, Alberta. 32pp.

Tipton, H. C., V. J. Dreitz, P. F. Doherty, Jr. 2009. Occupancy of Mountain Plover and Burrowing Owl in Colorado. Journal of Wildlife Management 72:1001-1006.

Wintle, B. A., R. P. Kavanagh, M. A. McCarthy, and M. A. Burgman. 2005. Estimating and dealing with detectability in occupancy surveys for forest owls and arboreal marsupials. Journal of Wildlife Management 69:905-917.

Zar, J. H. 1999. Biostatistical analysis, Fourth edition. Prentice Hall, Upper Saddle River, New Jersey, USA.

Table 2.1. Survey effort and number of owl detections by species during roadside surveys conducted in Southeast Alaska from 1 April-15 May during two time periods: historical (1986-1992) and current (2005-2008).

	Historical Years								Current Years				
	1986	1987	1988	1989	1990	1991	1992	All	2005	2006	2007	2008	All
# of independent stations	59	98	101	96	109	95	19	282	203	86	152	31	346
# of surveys	59	98	101	96	109	95	19	577	627	145	373	93	1238
# broadcast	59	98	101	96	109	95	19	577	239	57	355	93	744
# silent	0	0	0	0	0	0	0	0	388	88	18	0	494
# of owl detections	12	19	29	13	47	32	3	155	130	45	64	14	253
Northern pygmy-owl	2	4	4	1	14	1	1	27	0	2	1	3	6
Northern Saw-Whet Owl	0	6	4	4	12	18	0	44	68	24	26	7	125
Western Screech-Owl	5	3	6	2	5	7	1	29	21	7	20	2	50
Boreal owl	1	1	3	0	8	5	1	19	0	2	3	0	5
Barred Owl	1	0	2	2	7	1	0	13	31	8	7	2	48
Great-horned owl	3	4	10	4	1	0	0	22	9	2	5	0	16
Great grey owl	0	0	0	0	0	0	0	0	1	0	0	0	1
Unknown owl	0	1	0	0	0	0	0	1	0	0	2	0	2

Table 2.2. Mean and range of explanatory variables characterizing habitat surrounding stations within a 400-m radius and survey conditions, Southeast Alaska, 1 May-15 April, 2005-2008.

Response variables[a]	Explanatory variables[a]	Year								All years	
		2005		2006		2007		2008			
		mean	range	mean	range	mean	range	mean	range	mean	range
ψ											
	elevation (m)	86	5-650	69	5-341	70	5-198	113	5-198	80	5-650
	streams (km)	0.61	0-3.97	0.92	0-2.69	0.58	0-2.37	0.69	0-2.32	0.67	0-3.97
	% of high productive forest	0.67	0-1.00	0.68	0-1.00	0.55	0-1.00	0.70	0-1.00	0.64	0-1.00
	% of low productive forest	0.21	0-1.00	0.17	0-0.84	0.24	0-1.00	0.20	0-1.00	0.21	0-1.00
	% non-forested	0.11	0-1.00	0.15	0-1.00	0.21	0-1.00	0.10	0-0.76	0.15	0-1.00
	Longitude[b]										
	mainland	92	-	28	-	89	-	26	-	235	-
	island	111	-	58	-	63	-	5	-	237	-
	Latitude[b]										
	north	78	-	28	-	80	-	21	-	207	-
	middle	91	-	10	-	36	-	0	-	137	-
	south	34	-	48	-	36	-	10	-	128	-
p											
	noise	0.23	0-1.00	0.09	0-1.00	0.12	0-1.00	0.03	0-1.00	0.17	0-1.00
	wind	0.46	0-4.00	0.66	0-3.00	0.77	0-5.00	1.33	0-5.00	0.64	0-5.00
	hours after sunset	2.47	0-6.22	2.07	0.22-4.53	1.72	0.13-6.17	1.92	0.32-4.93	2.16	0-6.22
	light illumination	0.27	0-1.00	0.17	0-0.90	0.15	0-1.00	0.63	0-1.00	0.25	0-1.00
	rain	0.09	0-1.00	0.09	0-1.00	0.20	0-1.00	0.08	0-1.00	0.12	0-1.00

[a]Variable abbreviations: ψ = occupancy probability; p = detection probability; hours = hours after sunset; noise = noise$\geq$3; wind = 0-5 Beaufort scale; light = combination of moon phase and cloud cover; rain = drizzle, showers, or rain.
[b]Categorical variable with sample size (n) indicated in table.

Table 2.3. Final models predicting occupancy and detection probabilities for Barred Owl, Western Screech-Owl, and Northern Saw-Whet Owl, Southeast Alaska, 2005-2008.

Species	Response	Variables[a]	Coefficients	SE
Barred Owl	ψ	intercept	-2.72	-0.54
		highprod	1.11	-0.69
	p	intercept	-0.88	-0.27
Western Screech-Owl	ψ	intercept	-0.19	-0.44
		longitude	-1.58	-0.49
		streams	0.03	-0.36
	p	intercept	-2.57	-0.52
		method	1.63	-0.48
		noise	-1.17	-0.66
		wind	-0.29	-0.20
		hours	0.18	-0.13
		larger owl	-1.34	-0.70
Northern Saw-Whet Owl	ψ	intercept	-1.17	-0.66
		larger owl	0.88	-0.62
		year 2005	1.06	-0.69
		year 2006	2.09	-1.05
		year 2007	0.08	-0.72
	p	intercept	-1.40	-0.21
		light	0.32	-0.32
		rain	-1.53	-0.62

[a]Variable abbreviations: ψ = occupancy probability; highprod = % of high productive forest; streams = km of streams; elevation = elevation; lowprod = % of low productive forest; nonforest = % of nonforested area; longitude = mainland or island; latitude = north, middle, or south region; year = year-specific. p = detection probability; method = silent or broadcast survey; hours = hours after sunset; noise = noise≥3; wind = 0-5 Beaufort scale; larger owl = larger owl detected at station during previous survey in same year; light = combination of moon phase and cloud cover; rain = drizzle, showers, or rain.

Table 2.4. Candidate models considered for estimating Barred Owl occupancy and detection probabilities, 1 April-15 May, 2005-2008. Models are ranked by AIC weights.

Model[a]	Δ AIC	AIC weight	Number of parameters
ψ (highprod),p(.)	0.00	0.141	3
ψ (highprod,streams),p(.)	0.93	0.088	4
ψ (highprod),p(hours2)	1.12	0.080	4
ψ(highprod,elevation),p(.)	1.22	0.076	4
ψ(highprod),p(method)	1.54	0.065	4
ψ(lowprod),p(.)	1.59	0.064	3
ψ(streams),p(.)	1.68	0.061	3
ψ(nonforest),p(.)	1.81	0.057	3
ψ(lowprod,highprod),p(.)	1.99	0.052	4
ψ(highprod,nonforest),p(.)	1.99	0.052	4
ψ(elevation),p(.)	2.08	0.050	3
ψ(highprod,streams),p(hours2)	2.09	0.050	5
ψ(highprod,streams,elevation),p(.)	2.18	0.047	5
ψ(highprod),p(hours2,method)	2.44	0.042	5
ψ(longitude,highprod,elevation),p(hours2)	2.65	0.037	6
ψ(year,highprod),p(.)	3.96	0.019	6
ψ(nonforest,highprod,streams),p(hours2)	4.08	0.018	6
ψ(.),p(.)	11.76	0.000	2
ψ(longitude),p(.)	12.38	0.000	3
ψ(.),p(hours2)	12.65	0.000	3
ψ(.),p(method)	13.75	0.000	3
ψ(latitude),p(.)	14.29	0.000	4
ψ(.),p(hours2,method)	14.57	0.000	4
ψ(latitude),p(hours2,method)	17.5	0.000	6
ψ(global),p(global)	18.54	0.000	16

[a]Variable abbreviations: ψ () = occupancy probability; '.' = constant; highprod = % of high productive forest; streams = km of streams; elevation = elevation; lowprod = % of low productive forest; nonforest = % of nonforested area; longitude = mainland or island; latitude = north, middle, or south region; year = year-specific. p() = detection probability; '.' = constant; method = silent or broadcast survey; hours2 = quadratic term of hours after sunset.

Table 2.5. Candidate models considered for estimating Western Screech-Owl occupancy and detection probabilities, 1 April-15 May, 2005-2008. Models are ranked by AIC weights.

Model[a]	Δ AIC	AIC weight	Number of parameters
ψ(longitude,streams),p(method,hours,noise,wind, larger owl)	0.00	0.337	9
ψ(longitude,streams),p(method,hours,noise,larger owl)	0.24	0.299	8
ψ(longitude,streams),p(method,larger owl)	1.90	0.130	6
ψ(longitude,streams,lowprod,highprod),p(method,hours, noise, larger owl,wind)	2.31	0.106	11
ψ(longitude,streams),p(method)	3.15	0.070	5
ψ(longitude,lowprod,highprod),p(method,hours,noise, larger owl)	3.81	0.050	9
ψ(longitude),p(method,noise,hours)	8.32	0.005	6
ψ(streams),p(method,noise,wind,hours)	11.91	0.001	7
ψ(highprod,lowprod,streams),p(method,noise,hours)	12.22	0.001	8
ψ(highprod,lowprod),p(method,noise,hours,wind, larger owl)	13.05	0.001	9
ψ(lowprod,highprod),p(method,noise,hours)	14.73	0.000	7
ψ(latitude),p(method,noise,hours)	19.41	0.000	7
ψ(streams),p(.)	20.16	0.000	3
ψ(highprod),p(.)	20.17	0.000	3
ψ(lowprod),p(.)	20.92	0.000	3
ψ(highprod,lowprod),p(.)	21.6	0.000	4
ψ(longitude),p(.)	22.03	0.000	3
ψ(nonforest),p(.)	23.56	0.000	3
ψ(.),p(larger owl)	31.34	0.000	3
ψ(latitude),p(.)	31.46	0.000	4
ψ(.),p(.)	32.17	0.000	2
ψ(larger owl),p(.)	33.05	0.000	3
ψ(year),p(.)	35.37	0.000	5
ψ(global),p(global)	109.19	0.000	20
ψ(elevation),p(.)	111.27	0.000	3

[a]Variable abbreviations: ψ () = occupancy probability; '.' = constant; highprod = % of high productive forest; streams = km of streams; elevation = elevation; lowprod = % of low productive forest; nonforest = % of nonforested area; longitude = mainland or island; latitude = north, middle, or south region; year = year-specific. p() = detection probability; '.' = constant; method = silent or broadcast survey; hours = hours after sunset; noise = noise$\geq$3; wind = 0-5 Beaufort scale; larger owl = larger owl detected at station during previous survey in same year.

Table 2.6. Candidate models considered for estimating Northern Saw-Whet Owl occupancy and detection probabilities, 1 April-15 May, 2005-2008. Models are ranked by AIC weights.

Model[a]	Δ AIC	AIC weight	Number of parameters
ψ(year,larger owl),p(light,rain)	0.00	0.245	8
ψ(longitude,year, larger owl),p(light,rain)	0.00	0.245	10
ψ(year),p(light,rain)	0.48	0.193	7
ψ(longitude,year),p(light,rain)	1.03	0.146	9
ψ(longitude,year,larger owl),p(light,rain,wind)	2.00	0.090	11
ψ(year),p(light,wind,rain)	2.43	0.073	8
ψ(year),p(light)	8.13	0.004	6
ψ(year),p(.)	8.51	0.004	5
ψ(longitude),p(.)	11.44	0.001	3
ψ(larger owl),p(.)	16.06	0.000	3
ψ(.),p(larger owl)	17.26	0.000	3
ψ(.),p(.)	17.55	0.000	2
ψ(latitude),p(.)	20.75	0.000	4
ψ(global),p(global)	142.15	0.000	20
ψ(lowprod,highprod,year),p(light,rain)	147.21	0.000	9
ψ(year,lowprod),p(light,wind,rain)	148.42	0.000	9
ψ(year,lowprod),p(.)	153.64	0.000	6
ψ(elevation,year),p(light,rain)	155.19	0.000	8
ψ(prodforest,year),p(light,rain)	155.61	0.000	8
ψ(lowprod),p(wind,rain,light)	162.44	0.000	6
ψ(nonforest),p(.)	167.30	0.000	3
ψ(lowprod),p(.)	169.66	0.000	3
ψ(streams),p(.)	172.90	0.000	3
ψ(elevation),p(.)	173.64	0.000	3
ψ(highprod),p(.)	173.88	0.000	3

[a]Variable abbreviations: ψ () = occupancy probability; '.' = constant; highprod = % of high productive forest; elevation = elevation; lowprod = % of low productive forest; nonforest = % of nonforested area; longitude = mainland or island; latitude = north, middle, or south region; year = year-specific. p() = detection probability; '.' = constant; light = combination of moon phase and cloud cover; rain = drizzle, showers, or rain; wind = 0-5 Beaufort scale; larger owl = larger owl detected at station during previous surveys in same year.

Table 2.7. Candidate models considered for estimating occupancy of Barred Owl, Western Screech-Owl, and Northern Saw-Whet Owl across two time periods: historical (1986-1992) and current (2005-2008). All surveys were conducted 1 April-15 May, Southeast Alaska. Models were ranked by AIC weights for each species.

Species	Model[a]	Δ AIC	AIC weight	Number of parameters
Barred Owl	ψ (time period),p(.)	0.00	0.60	3
	ψ (.),p(.)	0.77	0.40	2
	ψ (highprod),p(.)	18.87	0.00	3
	ψ highprod,time period),p(.)	19.76	0.00	4
Western Screech-Owl	ψ (time period,mainland,streams), p(method)	0.00	0.633	6
	ψ (mainland,streams),p(method)	1.50	0.299	5
	ψ (streams,time period),p(method)	5.49	0.041	5
	ψ (time period,mainland),p(method)	7.46	0.015	5
	ψ (mainland),p(method)	8.17	0.011	4
	ψ (.),p(method)	14.05	0.001	3
	ψ (time period),p(method)	15.84	0.000	4
	ψ (.),p(.)	24.42	0.000	2
Northern Saw-Whet Owl	ψ (.),p(.)	0.00	0.659	2
	ψ (time period),p(.)	1.32	0.341	3

[a]Variable abbreviations: ψ () = occupancy probability; '.' = constant; highprod = % of high productive forest; longitude = mainland or island; year = year-specific. p() = detection probability; '.' = constant; method = silent or broadcast survey; time period = historical or current time period.

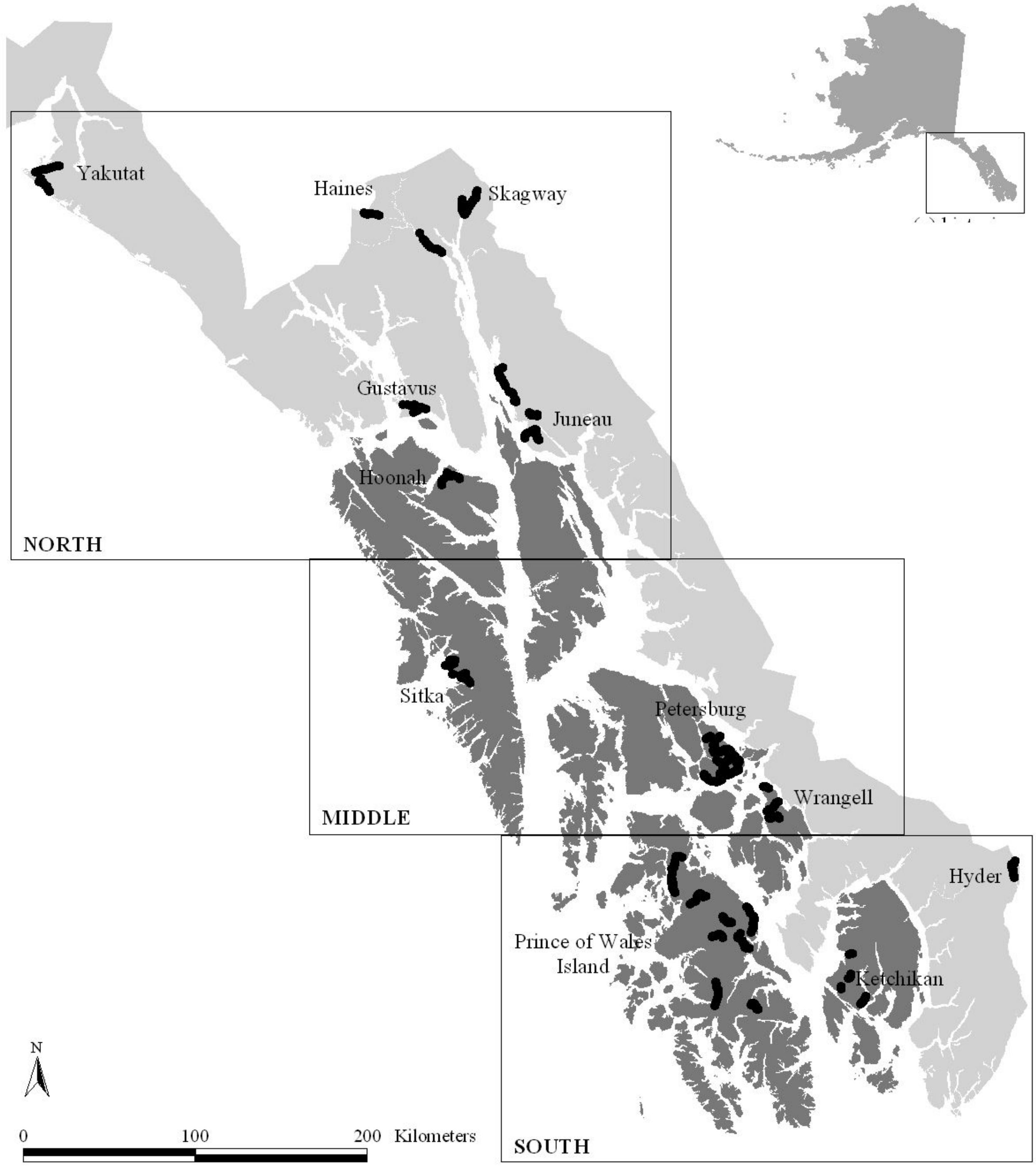

Figure 2.1. Spatial distribution of stations surveyed for forest owls from 1 April-15 May, 2005-2008 in Southeast Alaska. Latitudinal (i.e., north, middle, and south) and longitudinal variables are depicted; light gray shaded areas indicate ‘mainland’ sites and dark gray indicate ‘island’ sites.

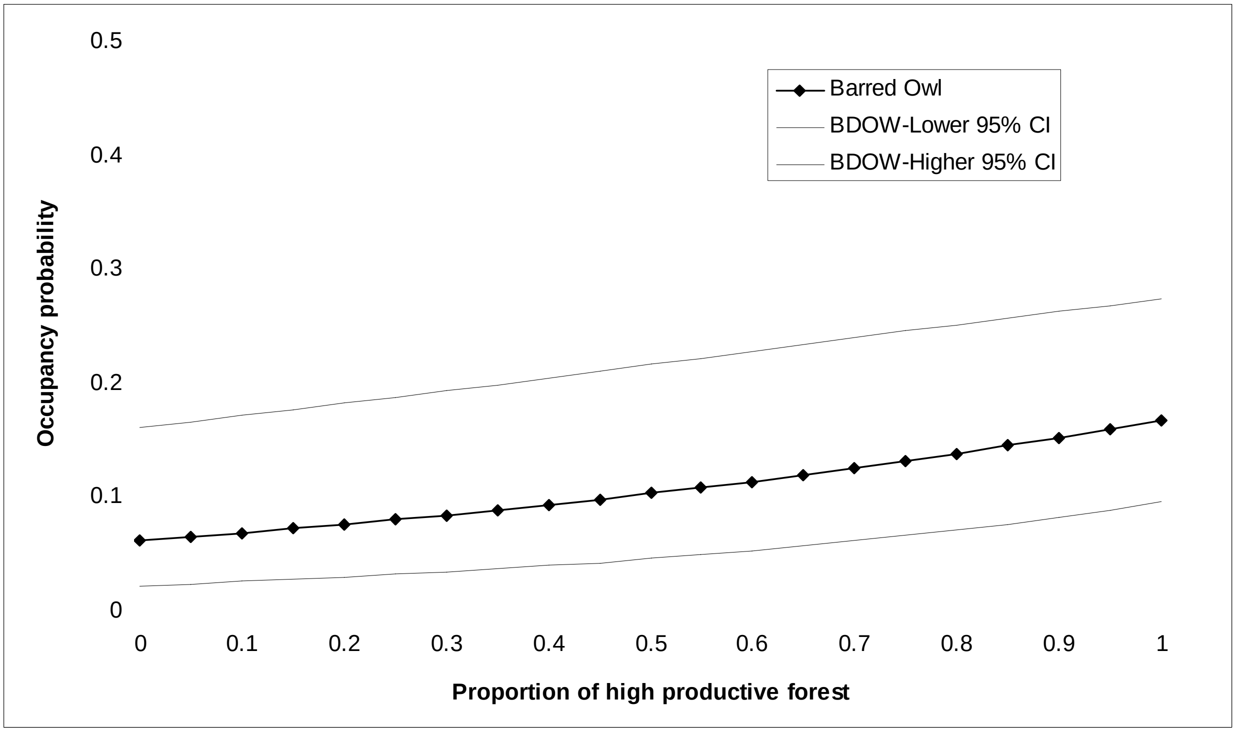

Figure 2.2. Modeled occupancy probabilities as a function of proportion of high productive forest (final model for Barred Owl, Table 2.3)

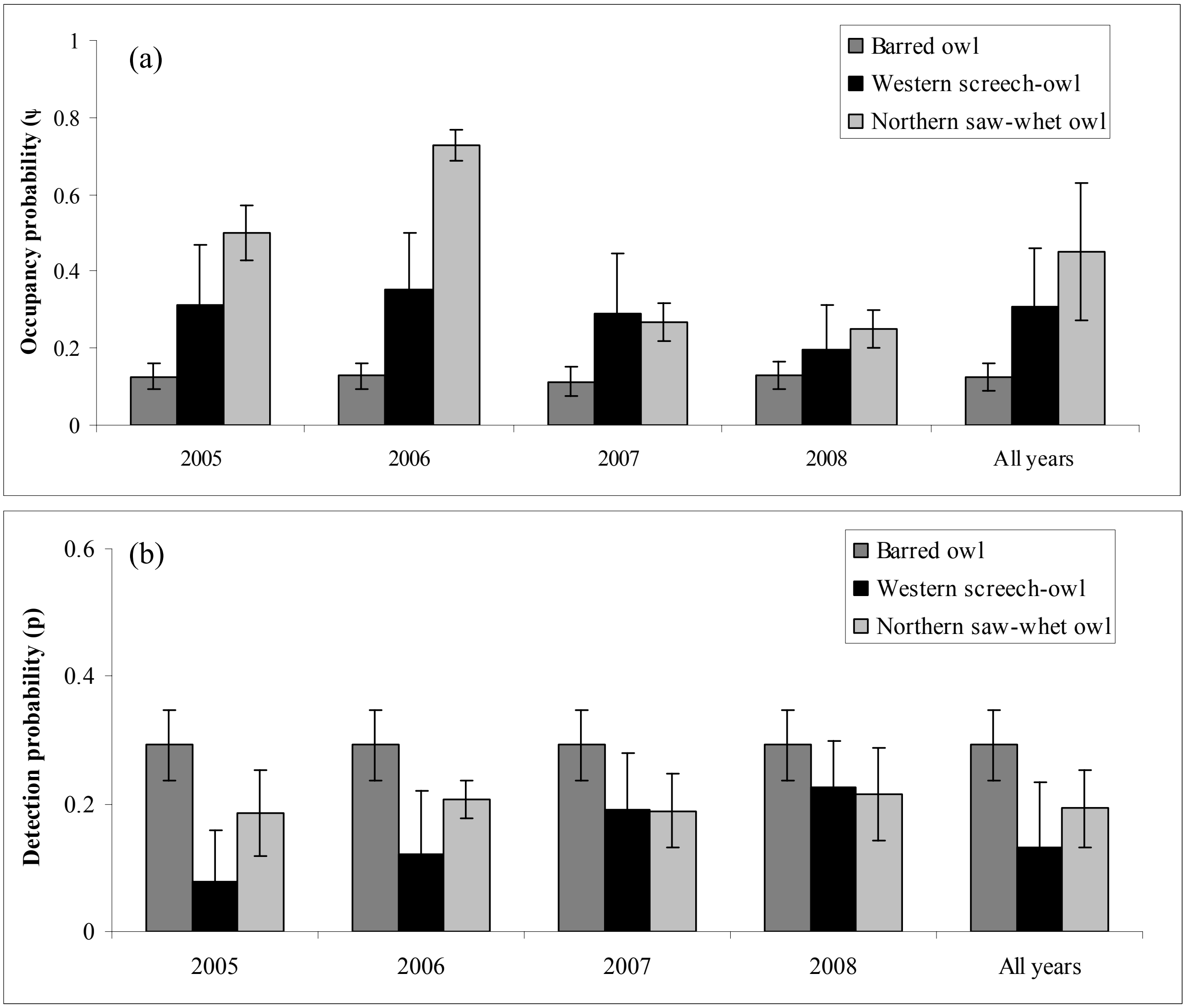

Figure 2.3. Estimates of (a) occupancy and (b) detection probabilities for three species of forest owls in Southeast Alaska, 1 May-15 April, 2005-2008.

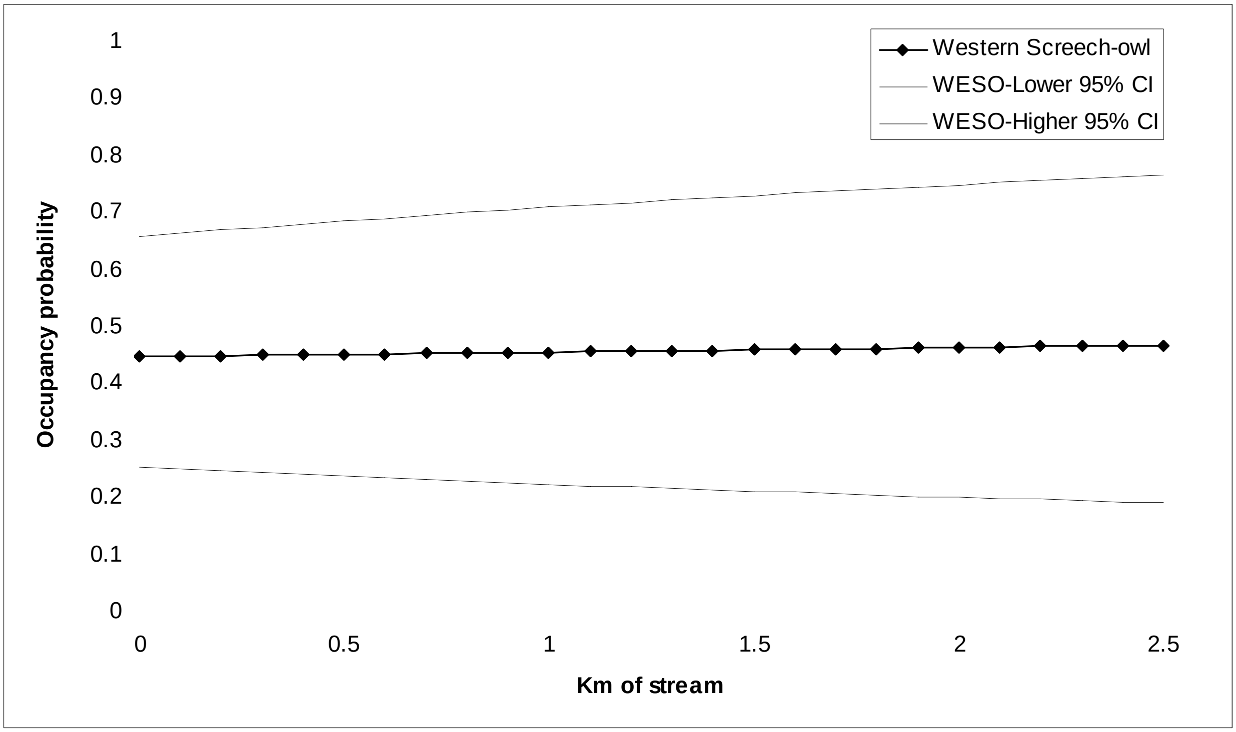

Figure 2.4. Modeled occupancy probabilities as a function of kilometers of stream (final model for Western Screech-Owl, Table 2.4).

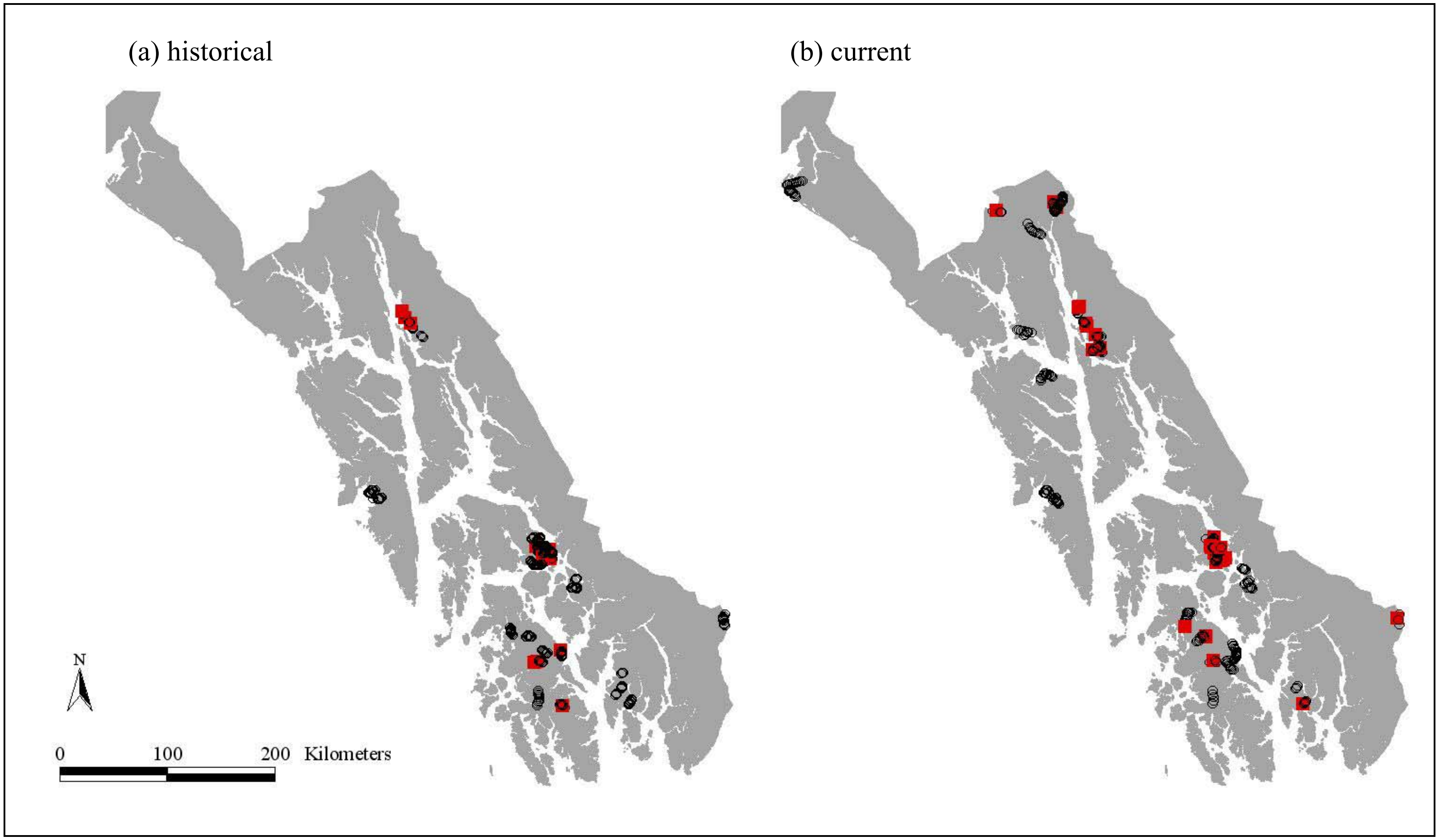

Figure 2.5. Owl survey stations where at least one Barred Owl was detected during the (a) historical (1986-1992) and (b) current (2005-2008) time periods, in Southeast Alaska. Black rings indicate stations surveyed with no Barred Owl detections and red squares identify stations surveyed with Barred Owl detections. We did not adjust for survey effort per station.

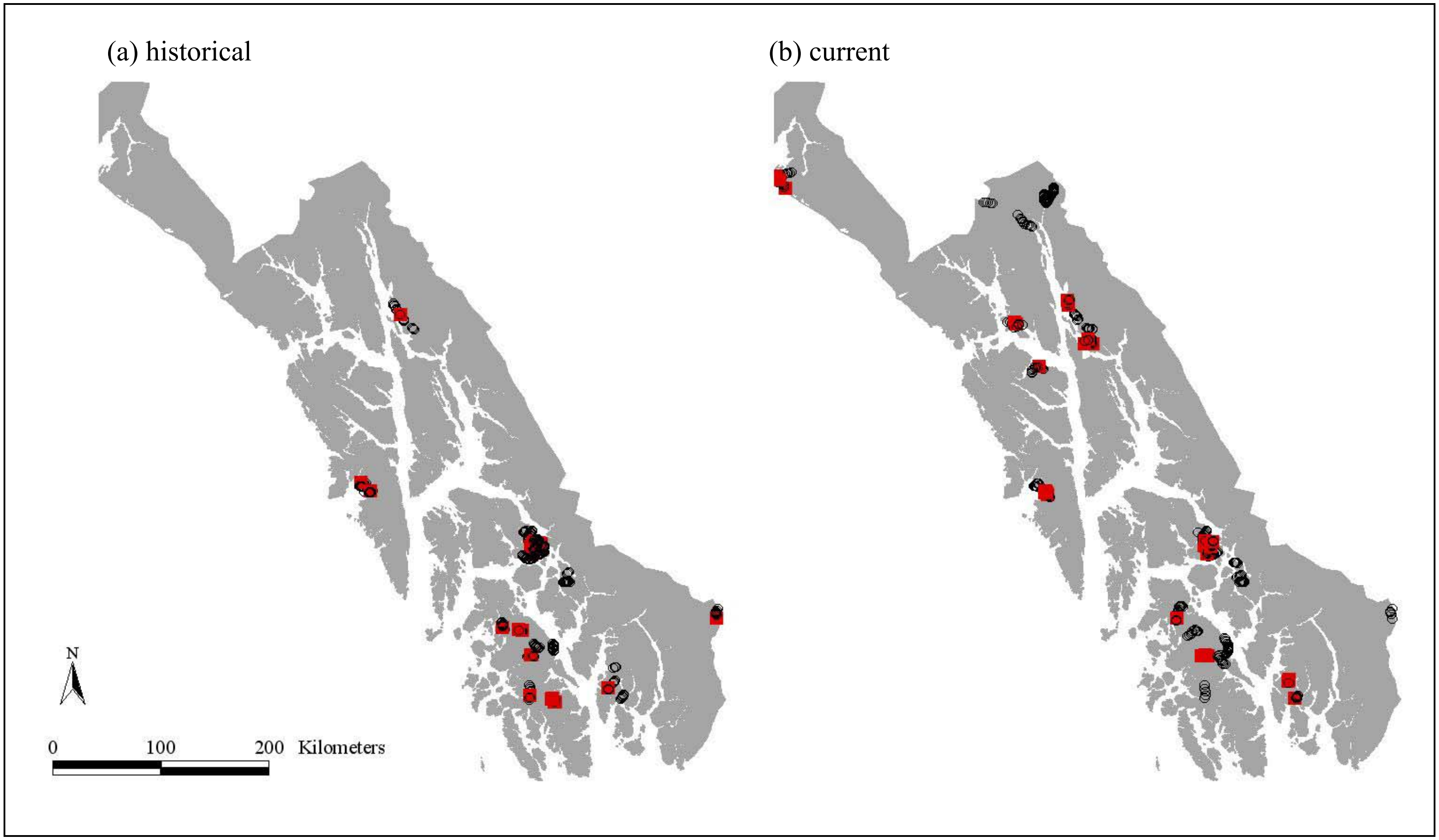

Figure 2.6. Owl survey stations where at least one Western Screech-Owl was detected during the (a) historical (1986-1992) and (b) current (2005-2008) time periods. Black rings indicate stations surveyed with no Western Screech-Owl l detections and red squares identify stations surveyed with Western Screech-Owl detections. We did not adjust for survey effort per station.

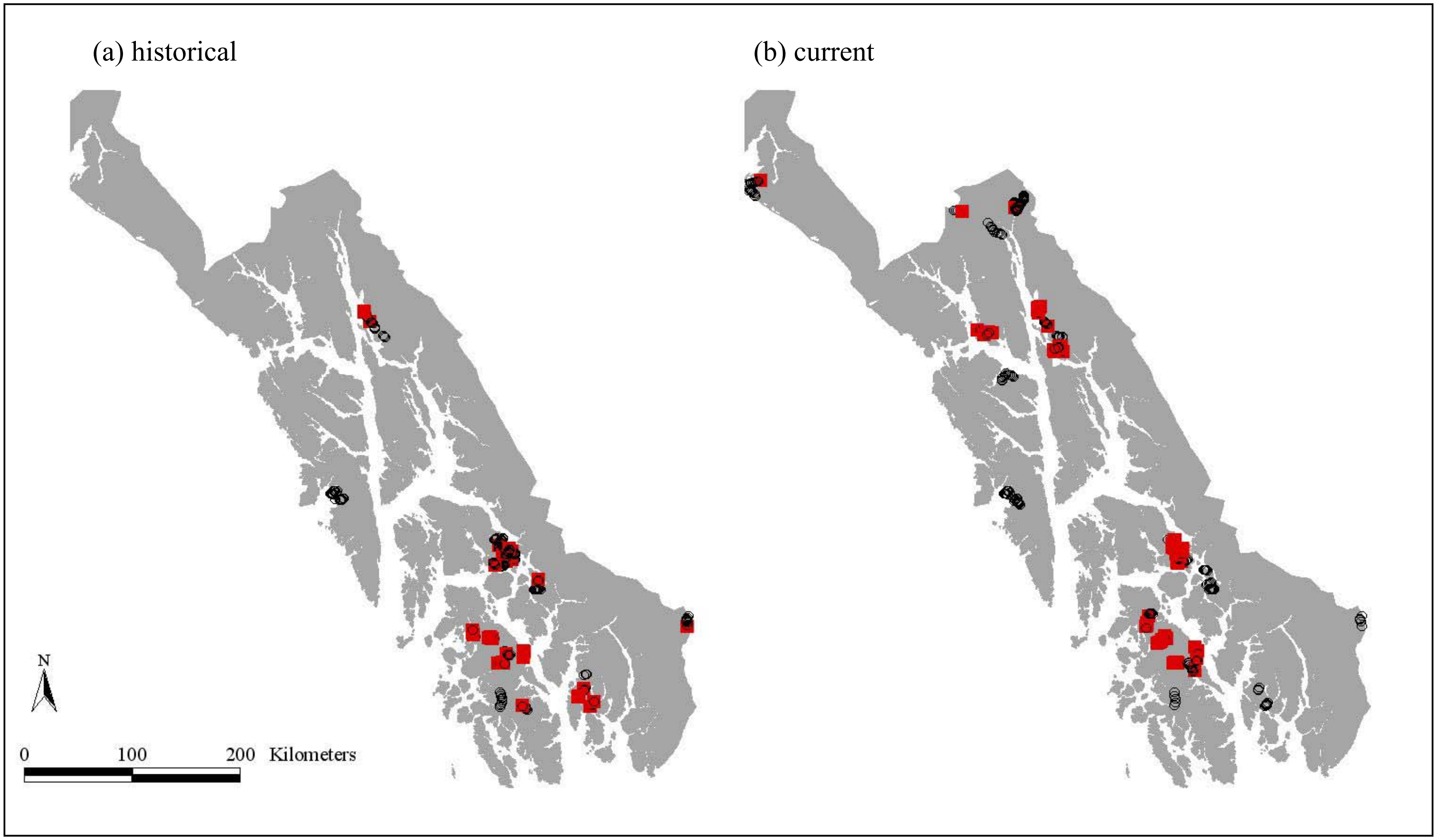

Figure 2.7. Owl survey stations where at least one Northern Saw-Whet Owl was detected during the (a) historical (1986-1992) and (b) current (2005-2008) time periods. Black rings indicate stations surveyed with no Northern Saw-Whet Owl detections and red squares identify stations surveyed with Northern Saw-Whet Owl detections. We did not adjust for survey effort per station.

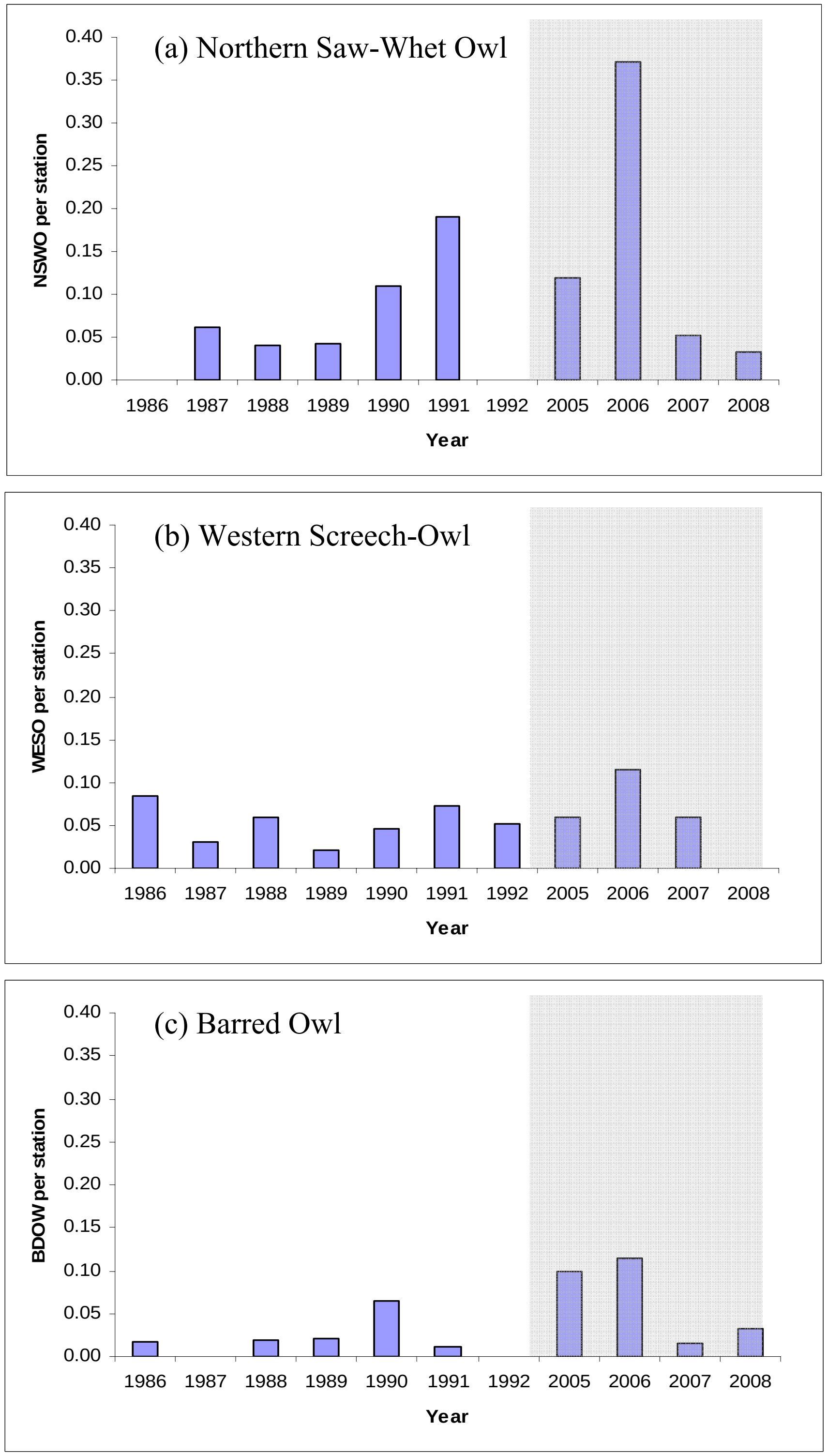

Figure 2.8. Number of detections of (a) Northern Saw-Whet Owl, (b) Western Screech-Owl, and (c) Barred Owl per station recorded on the first visit each year. Only stations where broadcast surveys occurred were included in order for data to be comparable across all years. These raw values were not adjusted for differences in detection probabilities. The shaded area indicates the surveys conducted during this study, or 'current' time period.

CHAPTER 3
HOME RANGE, HABITAT USE, AND MOVEMENTS OF WESTERN SCREECH-OWLS (*MEGASCOPS KENNICOTTII*) IN CENTRAL SOUTHEAST ALASKA

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ABSTRACT

Although habitat loss is the primary cause of concern for the conservation of Western Screech-Owls, little quantitative information exists on home range size and habitat use, especially in extensive coniferous forests that lack deciduous woodlands. We studied Western Screech-Owl movements, habitat use, and home range in Southeast Alaska, 2005-2006. We radiotracked 10 Western Screech-Owls (7 males and 3 females) on Mitkof Island in central Southeast Alaska during 2005 – 2006. The 95 % contour of the adaptive kernel home range of Western Screech-Owls was 551 ± 148 ha, with male home range tending to be larger than female. Core areas (50 % contour) were 70.6 ± 24.8 ha. Screech-owls roosted in small (≤ 38 cm dbh) or very large (> 89 cm) western hemlock trees that were usually part of the canopy. The owls usually roosted beneath the canopy, about ½ way up the trunk; the distance of the owl from the bowl depended on tree size. Western Screech-Owl nests were in dead trees or dead portions of live trees, usually one of the trees in a site dominated by small trees forming a relatively dense understory around nests. Screech-owls were found closer to large streams than random points. Because of Western Screech-Owl use of riparian forests and need for trees relatively large and old enough to support natural cavities, continued protection of the valley-bottom forest of Southeast Alaska would benefit Western Screech-Owls in this area.

INTRODUCTION

The Western Screech-Owl (*Megascops kennicottii*) is a small, nocturnal owl found in western North America (Johnsgard 2002). They use a variety of habitats throughout their range, but are generally associated with riparian woodlands and deciduous trees (Cannings and Angell 2001, COSEWIC 2002). Most information about habitat use of Western Screech-Owl comes from the desert and woodlands of the southwestern United States where the highest densities occur in mesquite (*Prosopis velutina*) riparian zones (e.g., Arizona; Johnson et al. 1981, Hardy et al. 1999). In areas where coniferous forests are the dominant forest type, this species is most commonly found in riparian habitats and deciduous bottomlands (e.g., Idaho; Hayward and Garton 1988). Because riparian habitats are often the first to suffer the effects of human development (e.g., agricultural, industrial, housing), habitat loss has prompted listing of some populations (i.e., *macfarlanei* subspecies in British Columbia; Cannings and Angell 2001) and has raised concerns for the status of others (Hardy et al. 1999).

Western Screech-Owls may serve as good indicators of environmental conditions. In addition to their apparent preference for riparian habitats, Western Screech-Owls are obligate secondary cavity-nesters and therefore, are limited to either natural tree cavities or old woodpecker holes for nesting (Cannings and Angell 2001). In areas where few primary cavity-forming species occur, cavities must be created by natural disturbance (e.g., from wind events) which requires trees old enough and large enough for them to form in (Pickett and White 1985). Furthermore, Western Screech-Owls are non-migratory and thought to be resident on territories year-round (Cannings and Angell 2001). Resident species are better indicators of local environmental changes than migrants, because variation in migrant populations may be explained by changes in the breeding or wintering habitats (Landres et al. 1988).

Although habitat loss is the primary cause of concern for the conservation of Western Screech-Owls, little quantitative information exists on home range size and habitat use, especially in extensive coniferous forests that lack deciduous woodlands (Cannings and Angell 2006). We studied Western Screech-Owl movements, habitat use, and home range in Southeast Alaska, 2005-2006. Our objectives were to (1) describe Western Screech-Owl home range during the breeding season in coastal temperate rainforest; (2) describe nest- and roost-site characteristics; (3) examine habitat use within the home range; and (4) provide habitat information to assist resource managers when making management decisions.

STUDY AREA

We studied Western Screech-Owls in Southeast Alaska on Mitkof Island, south of Petersburg (56° 48' N, -132° 56' W; Figure 3.1). Mitkof Island is 540 km^2 in size, ranges in elevation from sea level to 1011 m, and is characterized by clusters of glacially rounded mountains separated by broad U-shaped valleys (Nowacki et al. 2001). The landscape is naturally fragmented by mountainous terrain, wetlands, and forest patches of various sizes shaped by wind in concert with other natural forest disturbance agents (Harris 1989, Nowacki and Kramer 1998 DeGayner et al. 2005). The forests are a coastal, temperate rainforest dominated by western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*), that occur at low elevations as a mosaic with muskegs and other wetlands (Neiland 1971). The forest floor is a complex terrain of decaying logs and tipped-up root wads cloaked in shrubs, herbs, ferns, and mosses (Alaback 1982, Schoen et al. 1988). Industrial-scale timber harvesting in this region has added significantly to the already fragmented landscape in portions of the archipelago, and approximately 20 % of the original productive forest has been harvested on Mitkof Island (U.S. Forest Service 1997). A cool and wet maritime climate characterizes the region, with average annual precipitation of 288 cm evenly distributed throughout the year. We chose to study Western Screech-Owls here because the island offered a range of habitats in which screech-owls might occur, an existing network of forest roads to access different habitats and relocate owls, and several known Western Screech-Owl territories (based on previous owl surveys; Chapter 1).

METHODS

Capture and marking

We captured Western Screech-Owls during the early nesting season (late March to early May) in 2005 and 2006 and monitored them throughout the breeding season or until we lost contact with the radiotag. We trapped individuals with a mist-net, using an audio lure to attract them to the trap area and a decoy mouse to entice the owls to stoop into the net (for more details, see Chapter 4). We trapped along forest roads in areas where we had previously detected screech-owls during broadcast surveys. We banded each screech-owl with a U.S. Fish and Wildlife Service band on one leg. We weighed each owl and gathered standard morphological measurements (e.g., wing cord, exposed culmen) to determine the sex of the screech-owl (Appendix III). We attached a backpack-style, radio transmitter (model TW-4, Biotrack Ltd., Dorset, UK) to each owl using Teflon ribbon. Transmitters weighted 4.5 g and were ≤ 3% of the owl's body weight. We released all screech-owls on site within 1 hour of capture and watched them for several minutes to ensure the backpack was not impeding their movement. During capturing and handling, we followed animal care and use guidelines from the Ornithological Council (Gaunt et al. 1997).

Owl telemetry and re-location

We used 2 ground-based, radiotelemetry techniques to estimate the location of owls during day and night (White and Garrott 1990, Fuller et al. 2005, Kenward 2001). We either triangulated to estimate the owl's location or we homed in on the owl on foot to locate it. We located owls no more than once per night and separated day and night locations by ≥ 4 hours to assume independence of the location (i.e., we would not gather a night location unless 4 hours had elapsed since nightfall of the day we acquired a roost location). We triangulated each owl by obtaining directional azimuths, using a 2-element yagi antenna and compass from ≥ 3 known locations (White and Garrott 1990, Kenward 2001). Because Western Screech-Owls are only active at night, we reduced error for each night location (i.e., when the owl might be moving) by limiting data collection to within 10 minutes. If it seemed that the animal had moved or was moving during the location, we monitored the signal until it stopped moving and gathered new bearings on the bird. For day locations, we triangulated on the owl to learn its general location and then homed in on it (Mech 1983, Fuller et al. 2005) to gather a GPS location, identify roosts and nest sites, and to learn about error in our triangulations.

We conducted a telemetry error study to estimate the precision of our telemetry locations (White and Garrott 1990). We estimated error in our triangulations using the day telemetry locations when screech-owls were roosting and not likely to move and the subsequent GPS location we gathered once we had homed in on the owl at that roost. Based on this, we estimated that our triangulations had a mean linear error of 132.3 m (SE = 10.9 m; n =118 locations,). We estimated each location for a triangulation event using Lenth's maximum likelihood estimate (White and Garrott 1990) in the program Location of a Signal (LOAS; Ecological Software Systems, http://www.ecostats.com). To account for telemetry error, we eliminated any triangulations with an error polygon that had a radius larger than the mean linear telemetry error determined above. This caused us to eliminate 2 % of our overall locations.

Home range estimation

We used an information-theoretic approach in the program Animal Space Use 1.2 (ASU; Horne and Garton 2007), to select the home range model that best fit our Western Screech-Owl data. We used only those screech-owls with ≥30 locations, given the potential bias associated with home range estimations with small sample size (Seamen et al. 1999). For each owl, the adaptive kernel technique provided the best fit given the data (Worton 1989, Horne and Garton 2006b). We computed an adaptive kernel utilization distribution (UD) with likelihood cross-validation to select the appropriate smoothing parameter for our home range analysis using ASU (Worton 1989, Seaman and Powell 1996, Horne and Garton 2006a).

Owl site location

We located owl roosts and nests by homing in on marked owls and visually locating each owl. We identified roost sites by visual observation of roosting owls, often in combination with the observation of regurgitated pellets and whitewash at the base of the tree. We located nest trees by homing in on female owls during the day and searching for obvious cavities and waiting until nightfall to attempt to observe her leaving the nest cavity, and by locating male owls near sunset and attempting to watch them make a delivery to the nest cavity. If we could not identify the nest tree, we attempted to locate the nest site based on locations of marked owls or presence of fledglings. We marked roost and nest trees and visited them later (to reduce disturbance to nesting and roosting owls) to measure habitat characteristics. We recorded the location of each roost and nest location using a hand-held GPS unit (Garmin Map76S).

Roost and nest measurements

We collected vegetation and physiographic data at Western Screech-Owl roosts and nests. We listed variables measured or created by aggregation at each plot in Table 3.1. We sampled vegetation in screech-owl roosting and nesting areas using 3 spatial scales: 1) roost or nest tree; 2) nest site; 3) nest stand. For the purpose of this study, a nest site is defined as the nest tree and the 0.05 ha circular forested area surrounding the nest. A nest stand is the circular area, centered on the nest tree, which encompasses 1.24 ha of relatively homogeneous forest.

At roost and nest trees, we recorded species, dbh, height, and crown class (i.e., position in the main canopy): dominant (extending above the main canopy layer), co-dominant (part of the main canopy layer), intermediate (below the main canopy but not entirely shaded), or suppressed (shaded by main canopy; Helms 1998; Table 3.1). We recorded the stage of decay of each tree by ocular estimation and comparison with descriptions and figures from Maser et al. (1979). Additionally, we recorded the height of the owl, the distance from the owl to the bole of the tree, and the percent that the roosting owl was concealed from above and below. We also estimated the percent of the trunk that was covered by branches, bark, and moss, and counted the number of cavities on the tree. We recorded the aspect, % slope, and elevation of the site and estimated % canopy closure. At nest trees, we recorded cavity height and aspect. We measured dbh with a standard forestry tape and used a digital hypsometer to measure all heights. We measured elevation using an altimeter, and determined aspect (compass) and slope (clinometer) standing at the base of the tree and facing down slope.

For nest site characteristics, we sampled vegetation at the nest site using a fixed-radius (12.8 m) plot, centered on the nest tree (Table 3.1). A tree was considered in the plot if the center of the tree was ≤ 12.8 m from plot center. For each tree in the plot, we recorded species, crown class, and dbh. Site characteristics measured or estimated included plot aspect and slope, percent shrub cover, percent midstory cover, and percent canopy cover. We calculated basal area from live trees in the nest site. We tallied overall number of live trees and snags per hectare and classified trees into one of 4 size classes based on dbh: small (12.5 – 38.0 cm); medium (38.1 – 63.5 cm); large (63.6 – 89.2 cm), and extra large trees (> 89.2 cm). We estimated the percent of plot ground over the entire plot covered by saplings (trees < 12.5 cm dbh), shrubs, ground cover, water, and litter (Bonham 1989).

We measured nest stand characteristics using 5 fixed-radius (12.8 m) plots, 1 plot was centered on the nest tree (nest plot) and 1 plot was centered on the nearest tree 50 m from the nest tree in each cardinal direction (north, east, south, west). We measured the distance to cardinal direction plots using a 100 m tape or by pacing. Variables measured at each nest stand plot were the same as those measured within the nest site plot.

To examine use of riparian areas, we measured distance from each point the nearest stream (fish-bearing stream, Class 1 or 2, USDA Forest Service). To compare that with all points, we generated 458 random points (equal to the number of owl relocations) across the study area and measured the distance of that point to the nearest stream. All values are presented as mean ± standard error, unless otherwise specified.

Movements

We documented screech-owl movements in two ways. First, we examined distance between capture site and settling site (i.e., the general area an owl spent while radio tagged, in this case the nesting area). Additionally, we conducted simultaneous nighttime relocations of owls to document movements, which we presumed to be foraging bouts away from the roost / nest area. Two observers took locations at pre-established time intervals (e.g., every five minutes) over 2 hours. We used these bi-angulations to estimate the location of the owl. We measured distance between consecutive locations only if they were outside of the average error we measured for our telemetry locations (determined above; 132 m). We calculated rate of movement and describe the patterns of movements.

RESULTS

Capture

We captured 10 Western Screech-Owls (7 male, 3 female) during 2005 and 2006. Of these owls, 9 (7 male, 2 female) had ≥ 30 locations during the breeding season, totaling 458 locations (51 ± 4, range = 30 – 67; Table 3.1), including 159 (18 ± 2; range = 10-29) home-in locations; 156 (17 ± 2; range = 11-27) day telemetry location, and 143 (16 ± 2; range = 6-22) night telemetry locations. All owls were captured in unique territories.

Home range

Home range size (95 % contour of adaptive kernel) was 551 ± 148 ha across all Western Screech-Owls (Table 3.2), but male home range (606 ± 186 ha) tended to be larger and more variable than female home range (358 ± 71 ha). Core home ranges (50 % contour of adaptive kernel) were 70.6 ± 24.8 ha (male = 83.2 ± 30.4 ha; female = 26.6 ± 13.4 ha).

Roosts

We located 110 roost trees from 12 different owls (including the mates of radio-tagged birds) in 10 Western Screech-Owl territories (9 ± 2 roost locations / owl; range = 1 - 22). Western Screech-Owls tended to roost in western hemlock trees (49 %), Sitka spruce (25 %), or Alaska yellow-cedar (*Chamaecyparis nootkatensis*; 22 %), but also used unidentified snags (3 %), and red alder (*Alnus rubra*; 2 %). Most roosts were in live trees (79 %) and, of those live trees, most were part of the canopy (dominant or co-dominant; 77 %), while some were intermediate (15 %), or suppressed (7 %). Roost trees were classified mostly as small (dbh < 38.1 cm; 67 %) or extra-large (dbh > 89.1 cm; 21 %) trees but the $\bar{x}$ roost tree dbh (49.1 ± 3.0 cm) was in the medium size class. Roost tree height averaged 22.9 m (SE = 1.2 m). Percent canopy closure at roost sites was 42 ± 3 % (range = 5 – 95%). Roost sites faced Southeast ($\bar{x}$= 150º, angular deviation = 92.8°), had an 18 ± 2 % slope, and an average elevation = 186 ± 21 m (range = 12 – 1745 m). Western Screech-Owls roost height was 10.1 ± 0.6 m, which was half way up the roost tree (48 ± 2 %). Owls perched 53 ± 9 cm from the bole of the tree, however, and as might be expected, the distance to truck was small ($\bar{x}$= 4 cm) in small trees and large ($\bar{x}$= 214 cm) in extra large trees.

Nests

We found 4 nest trees in 4 Western Screech-Owl territories. We found nests in western hemlocks snags (75 %; *n* = 3) or in a dead portion of a live western hemlock tree (25 %; *n* = 1) that was part of the overstory canopy (i.e., dominant or co-dominant). Western Screech-Owl nest trees were large-sized trees (dbh = 68.1 ± 4.7 cm; height = 21.4 ± 3.3 m; Table 3.3), often one of the largest trees in the stand (Table 3.4). Percent canopy closure at roost sites was 43 ± 4 (range = 30 – 60 %). Western Screech-Owls nest cavity height was 11.9 ± 2.7 m. Nests tended to be on relatively flat slopes (16 ± 6 %) with an eastern aspect ($\bar{x}$= 103º, angular deviation = 81.1), and averaged 206 m (SE = 47 m) elevation.

We measured nest site and stand characteristics in the 4 territories where we found nests. Western Screech-Owl nest sites are dominated by western hemlock (83 %; Table 3.4). Trees surrounding the nest tree were relatively small (dbh = 29.9 ± 1.7 cm; Table 3.4). Over half (54 %) of the trees were either partially (i.e., intermediate), or completely (i.e., suppressed) beneath the canopy, suggesting a relatively dense mid-story canopy. The overstory canopy closure was 43 % at the nest site. The forest floor was relatively densely covered with saplings (30 %), shrubs (54 %), and ground (50 %) cover, but had little litter (9 %) or water (2 %) cover. Slope was relatively flat (16 %) and generally, nest sites faced east (77°) but this was variable (angular deviation = 62°). Nest site elevation was 210 ± 66 m (range= 90 – 319). Western Screech-Owl nest sites had 51.3 m^2/ha basal area of live trees, which was mostly made up of small (385 trees/ha) and medium (70 trees/ha) sized trees (Table 3.4).

Western Screech-Owl nest stands were dominated by western hemlock (73 %; Table 3.4). Trees were relatively small (dbh = 31.2 ± 1.5 cm). Over half (54 %) of the trees are either partially (i.e., intermediate), or completely (i.e., suppressed) beneath the canopy, suggesting a relatively dense mid-story canopy. The overstory canopy closure was 47 % in the nest stand.

The forest floor was relatively densely covered with saplings (41 %), shrubs (55 %), and ground (45 %) cover, but had little litter (11 %) or water (5 %) cover. Slope was relatively flat (19 %) and generally, nest stands faced east (30°) but this was highly variable (angular deviation = 106°). Western Screech-Owl nest stands had 49.3 m^2/ha basal area of live trees, which was mostly made up of small (395 trees/ha) and medium (78 trees/ha) sized trees.

We located Western Screech-Owls closer to streams (i.e., Class 1 and 2 = fish-supporting streams) than random points on the landscape. Owl locations were 135.9 ± 14.8 m from fish-supporting streams while random points were 449.7 ± 17.1 m. Males (150.5 ± 8.0 m) were located further from streams than females (91.7 ± 7.5 m) Overall owls, 13 ± 3 % of locations (males = 13 ± 2 %; females = 14 ± 9 %) were within the 30 m of a stream (i.e., corresponded to buffer distances from Tongass Land and Resource Management Plan riparian no-cut buffer meant to protect salmon-bearing streams). At the widest riparian buffer available to fish-bearing streams (i.e., TLMP 150-m buffer for Important Brown Bear Foraging Locations; USDA Forest Service 1997), 68 ± 6 % of all owl locations (males = 63 ± 7 %; females = 80 ± 5 %) were within the 150 m of a stream.

Movements

We documented 3 extraordinary movements during monitoring of Western Screech-Owls (Figure 3.3). One was between capture and subsequent relocation and 2 were during the breeding season. Adult female ws6 was trapped on 4/14/06 (Figure 3.3a). We were unable to locate her for several days until we finally found her on 4/22/06 at a roost, 5.4 km away from the capture site. She subsequently nested 5.6 km from her capture site and was found at that nest first on 4/25/06. All other owls captured remained in the general vicinity of their capture site ($\bar{x}$ = 498 ± 139 m from capture site to first location after capture).

Adult male ws1 was located at a day roost on 1 May 2005 (Figure 3.3b). We next attempted to locate him on 9 May 2005 but were unable to hear his signal. We eventually located him on 5/10/05 at a roost on a nearby ridge (elevation = 532 m), 2.9 km away from his home range where he had been seen repeatedly with another screech-owl (presumably his mate). He was back in his home range the next day and remained in that vicinity until his transmitter failed.

Adult male ws4 was located on 1 June 2006 in the vicinity of his breeding season home range (26 previous locations across 2 months; Figure 3.3c). Four days later he was located 3.5 km away from that location, across a 450 m ridge in a new drainage. He was subsequently located 20 times in the new area, never returning to his previous breeding area where he has been seen repeatedly roosting with his presumed mate. This movement resulted in his unusually large home range (Table 3.2).

We conducted 4 simultaneous location sessions on 3 owls. Sessions took place during June between 2200 hrs and 2400 hrs. During these 2 hour session, owls moved at an average rate of 0.4 m/s during these 2-hr sessions but this was variable (SD = 0.2 m/s). All 3 owls exhibited apparent foraging behavior, spending 10 – 30 min at 1 location (or general location) before moving $\bar{x}$ = 446 m (SD = 177 m) to a new locale.

DISCUSSION

In Southeast Alaska, Western Screech-Owl home ranges were focused on riparian forests associated with larger streams (i.e., streams that support fish population; Stream class 1 or 2; USDA Forest Service 1997) in all cases. While we did not capture and radiotag any owls in higher elevations away from larger stream valleys, we rarely detected screech-owls in such areas during nocturnal surveys (Chapters 1 and 2) and screech-owls have rarely been found at higher elevations in other coastal locations (Cannings and Angell 2001).

No data has been reported on home range size of Western Screech-Owls (Cannings and Angell 2001), but the home range sizes we documented were much larger (by orders of magnitude) than that reported for Eastern Screech-Owls (*M. asio*; Gehlbach 1995). These differences are likely due to very different prey base available to these owls with the large home range sizes in Southeast Alaska reflecting a relatively depauperate prey base (MacDonald and Cook 1996). It is likely that home ranges of Western Screech-Owls that occur south of Alaska would be smaller and more comparable to eastern screech-owls, which do not extend into the northern forests of eastern North America (Gelhbach 1995). However, the forest raptor community in Southeast Alaska is relatively limited, presumably due to the lack of sufficient prey.

Western Screech-Owl male home ranges contained the nest areas, roosts, and presumably, foraging areas. These areas were relatively similar in size, except for one bird that moved from the apparent breeding site to a new area part way through the breeding season. The 2 female home ranges we documented were similar in size to each other. One female (ws3) was mostly located at or near her nest site, and successfully fledged young. The other female (ws8) attempted to nest but no juveniles were ever seen and the female stopped using the presumed nest tree early in the time when nestlings still would have needed her care, suggesting failure. The third female (ws6) we marked was not conducive to good telemetry locations and access was limited so we did not get adequate locations to include her in the analysis. We could not confirm whether her nest succeeded or failed. One dead nestling was found beneath the nest on 20 June but the female remained at the nest area for 1 month before she moved out of the nest area and then disappeared (i.e., we were unable to locate her again).

Western Screech-Owls usually roosted in a medium-sized (38 – 65 cm dbh) trees, but these were some of the larger trees found in nest stands. Male Western Screech-Owls commonly roost near the nest cavity during the breeding season (Cannings and Angell 2001). Roosts were usually near the bottom of the canopy, however exact roost location also seemed to depend on the weather. During rainy days, especially when it had been raining for several hours, owls tended to roost beneath clumps of moss or dwarf mistletoe (*Arceuthobium* spp.) brooms or close to the trunks of trees, presumably for shelter. On sunny days after rains, screech-owls often were found higher in the canopy of the roost tree, in a spot that allowed it to sunbathe while still being concealed.

Owl position relative to the tree varied with tree size. On small (≤ 38 cm dbh) roost trees, owls were usually within a few centimeters of the trunk where their cryptic coloring made them hard to notice. On these roosts, the owls were often close to the ground as well. Other roosts were in very large trees in the stand, and on these trees, owls roosted over 2 m from the trunk. These roosts were often out on a limb where the thick needles or large clumps of moss provided some camouflage.

Screech-owl roosts in Southeast Alaska were similar to those reported for other coastal and near-coastal populations of *kennicottii* subspecies of screech-owl (summarized in COSEWIC 2002). Outside of Victoria, British Columbia, roosts were in western red-cedar (67%), approximately 25 m off the ground (Darling and Hobbs 2001, personal communication, reported in COSEWIC 2002). On southern Vancouver Island and Gulf Islands, screech-owl roosts were in a variety of forest types that bordered marshes, pools, and other wet areas or fields (Hobbs

2001, personal communication reported in COSEWIC 2002). Robertson et al. (2000) found Western Screech-Owls roosting in mixed deciduous-coniferous woods > 50 yrs old but also found numerous roosts in young-growth (25-30 yrs).

We located nests in dead trees or dead portions of live trees, and cavities were in one of the largest trees in the area. The dead trees used here were long dead and riddled with holes and rot. It was difficult to determine which hole was the nest cavity, and all were too high to evaluate with a cavity camera. The other nest was found in a dead trunk of a live tree. The trunk was killed by a high-wind event that formed a long, vertical crack running the length of the dead trunk. We were not able to determine the exact cavity because it was high above the ground and associated with that crack that could have allowed multiple entrances and exits.

The natural-type cavities used in Southeast Alaska are similar to those reported in the literature (Campbell et al. 1990, Cannings and Angell 2001). Southeast Alaska lacks a wide-spread, primary cavity nester (e.g., Pileated Woodpecker; *Dryocopus pileatus*), and thus screech-owls are forced to rely on wind, in concert with other agents of forest disturbance such as insects, fungi, and snow breakage, to create natural cavities (Harris 1989, Nowacki and Kramer 1998).

The majority of trees in screech-owl nest sites and stands (54%) are in the intermediate or suppressed canopy category. Intermediate trees are those that just reach the canopy but usually have the majority of their canopy beneath the overstory canopy. Suppressed trees are those entirely beneath the main canopy. Thus, Western Screech-Owl nest sites and stands tended to be relatively thick beneath the canopy. This could inhibit other aerial predators, such as northern goshawks (*Accipiter gentilis*). It could also be that the limbs associated with these small trees are closer to the ground, and thus facilitate hunting. Western Screech-Owls are ambush predators that hunt from a perch, often relatively close to the ground (personal observation; Cannings and Angell 2001).

In recent forest planning in Southeast Alaska, the importance of riparian forests were highlighted for some species (e.g., Brown Bear, [*Ursus arctos*] and Pacific salmon [*Oncorhynchus* spp.]; Schoen et al. 1994, Titus and Beier 1999). Based primarily on anadromous fish needs, riparian standards and guidelines for the Tongass National Forest prohibit commercial timber harvest within 30 m of streams that contain fish (i.e., Stream Class 1 or 2; USDA Forest Service 1997). Besides providing important habitats for brown bears in coastal forests, riparian zones are rich ecological areas (Naiman et al. 1998, Naiman et al. 2000, Schindler et al. 2003). Gende and Willson (2001) found greater densities of passerines in riparian forests, and perhaps more importantly for Western Screech-Owls, there was an increase in the abundance of terrestrial and aquatic invertebrates (see Chapter 5 for description of diet). We found that while only 13 % of locations were within the 30-m buffer, 68 % of locations were in 150 m of streams. This distance relates to the buffer placed on parts of streams that are deemed "important bear foraging areas" (USDA Forest Service 1997).

It is unclear from our data why Western Screech-Owls are associated with riparian habitats in Southeast Alaska. However, it could be because of increased access to their small mammal and invertebrate prey, similar to that found in eastern screech-owls (Belthoff and Ritchison 1990). Another possible reason could be the abundance of suitable cavities for nesting and roosting in the storm-protected forests in riparian valley bottoms (DeGayner et al. 2005). Heart rot fungi are essential for creation of large cavities and advanced encroachment of this fungi is likely in trees > 200 years old (Hennon 1995), much longer than the rotation length of actively managed stands (USDA Forest Service 1997).

Harvest operations, especially clearcutting, can lower the number of trees with suitable nest and roost cavities. Managers could mitigate this impact by leaving clumps of large and small standing trees within harvest units to ensure persistence and future recruitment of cavity-bearing trees (DeGayner et al. 2005). This may be consistent with timber harvest economic objectives since many of the large old-growth trees that may recruit into suitable nest-cavity trees have little timber value due to their poor form and high degree of wood defect (DeGayner et al. 2005). Because of Western Screech-Owl use of riparian forests and need for trees relatively large and old enough to support natural cavities, continued protection of the valley-bottom forest of Southeast Alaska would benefit Western Screech-Owls in this area.

LITERATURE CITED

Alaback, P. B. 1982. Dynamics of understory biomass in Sitka spruce-western hemlock forests of Southeast Alaska. Ecology 63:1932-1948.

Belthoff, J. R., and G. Ritchison. 1990. Nest-site selection by eastern screech-owls in central Kentucky. Condor 92:982-990.

Bonham, C. D. 1989. Measurement of terrestrial vegetation. John Wiley and Sons, New York, New York, USA.

Campbell, R. W., N. K. Dawe, I. McTaggart-Cowan, J. M. Cooper, G. W. Kaiser, and M. C. E. McNall. 1990. The birds of British Columbia. Volume 2: diurnal birds of prey through woodpeckers. Royal British Columbia Muesum, Vancouver, British Columbia, Canada.

Cannings, R. J., and T. Angell. 2001. Western Screech-Owl (*Otus kennicottii*). *In* The Birds of North America, No. 597 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

COSEWIC. 2002. COSEWIC assessment and update status report on the Western Screech-owl Otus kennicottii in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Canada.

DeGayner, E. J., M. G. Kramer, J. G. Doerr, and M. J. Robertsen. 2005. Windstorm disturbance effects on forest structure and black bear dens in Southeast Alaska. Ecological Applications 15:1306-1316.

Fuller, M. R., J. J. Millspaugh, K. E. Church, and R. E. Kenward. 2005. Wildlife radiotelemetry. Pages 377-417 *in* C. E. Braun, editor. Techniques for wildlife investigations and management. Sixth edition. The Wildlife Society, Bethesda, Maryland, USA.

Gaunt, A. S., L. W. Oring, K. P. Able, D. W. Anderson, L. F. Baptista, J. C. Barlow, and J. C. Wingfield [online]. 1997. Guidelines for the use of wild birds in research. <http://www.nmnh.si.edu/BIRDNET/GuideToUse> (11 November 2004).

Gehlbach, F. R. 1995. Eastern Screech-Owl (*Otus asio*). *In* The Birds of North America, No. 165. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Gende, S. M., and M. F. Willson. 2001. Passerine densities in riparian forests of Southeast Alaska: potential effects of anadromous spawning salmon. Condor 103:624-629.

Hardy, P. C., M. L. Morrison, and R. X. Barry. 1999. Abundance and habitat associations of elf owls and western screech-owls in the Sonoran Desert. Southwestern Naturalist 44:311-323.

Harris, A. S. 1989. Wind in the forests of Southeast Alaska and guides for reducing damage. USDA Forest Service, General Technical Report PNW-GTR-244.

Hayward, G. D., and E. O. Garton. 1988. Resource partitioning among forest owls in the River of No Return Wilderness, Idaho. Oecologia 75:253-265.

Helms, J. A. 1998. The dictionary of forestry. Society of American Foresters, Washington, D.C., USA.

Hennon, P. E. 1995. Are heart rot fungi major factors of disturbance in gap-dynamic forests? Northwest Science 69:284-293.

Horne, J. S. and E. O. Garton. 2006a. Likelihood cross-validation versus least squares cross-validation for choosing the smoothing parameter in kernel home-range analysis. Journal of Wildlife Management 70: 641-648.

Horne, J. S. and E. O. Garton. 2006b. Selecting the best home range model: an information-theoretic approach. Ecology 87:1146-1152.

Horne, J. S., and E. O. Garton. 2007. Animal Space Use 1.2 <http://www.cnr.uidaho.edu/population_ecology/animal_space_use.htm>.

Johnsgard, P. 2002. North American owls. Smithsonian Institute Press, Washington, DC, USA.

Johnson, R. R., B. T. Brown, L. T. Haight, and J. M. Simpson. 1981. Playback recordings as a special avian census technique. Studies in Avian Biology 6:68-75.

Kenward, R. E. 2001. A manual for wildlife radio tagging. Academic Press, San Diego, California, USA.

Landres, P. B., J. Verner, and J. W. Thomas. 1988. Ecological uses of vertebrate indicator species: a critique. Conservation Biology 2:316-328.

MacDonald, S. O., and J. A. Cook. 1996. The land mammal fauna of Southeast Alaska. Canadian Field-Naturalist 110:571–598.

Maser, C., R. G. Anderson, K. Cromack, Jr., J. T. Williams, and R. E. Martin. 1979. Dead and down woody material. Pages 78-95 *in* J. W. Thomas, technical editor. Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington. USDA Forest Service Agricultural Handbook.

Mech, L. D. 1983. Handbook of animal radio-tracking. University of Minnesota Press, Minneapolis, Minnesota, USA.

Naiman, R. J., K. L. Fetherston, S. McKay, and J. Chen. 1998. Riparian forests. Pages 289-323 *in* R. J. Naiman and R. E. Bilby, editors. River ecology and management: Lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York, New York, USA.

Naiman, R. J., R. E. Bilby, and P. A. Bisson. 2000. Riparian ecology and management in the Pacific coastal rain forest. Bioscience 50:996-1011.

Neiland, B. 1971. The forest-bog complex of Southeast Alaska. Vegetation 22:2-63.

Nowacki, G. J., and M. G. Kramer. 1998. The effects of wind disturbance on temperate rainforest structure and dynamics of Southeast Alaska. USDA General Technical Report PNW-GTR-421.

Nowacki, G. J., M. Shephard, P. Krosse, W. H. Pawuk, G. Fisher, J. Baichtal, D. Brew, E. J. Kissinger, and T. Brock. 2001. Ecological subsections of Southeast Alaska and neighboring areas of Canada. USDA Forest Service, Technical Publication R10-TP-75.

Pickett, S. A., and P. S. White. 1985. The ecology of natural disturbance and patch dynamics. Academic Press, New York, New York, USA.

Robertson, I., M. Gebauer, G. Ryder, and R. Toochin. 2000. Observations of two species at risk in mainland southwestern British Columbia: Hutton's Vireo and Western Screech-owl. Pp 267-273 *in* L.M. Darling (ed.), Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, Kamloops, British Columbia, 15-19 February, 1999. Volume 1. British Columbia Ministry of Environment, Lands and Parks, Victoria, British Columbia and College of the Caribou, Kamloops, British Columbia, Canada.

Schindler, D. E., M. D. Scheuerell, J. W. Moore, S. M. Gende, T. B. Francis, and W. J. Palen. 2003. Pacific salmon and the ecology of coastal ecosystems. Frontiers in ecology and the environment 1:31-37.

Schoen, J. W., M. D. Kirchhoff, and J. H. Hughes. 1988. Wildlife and old-growth forests in Southeastern Alaska. Natural Resources Journal 8:138-145.

Schoen, J. W., R. W. Flynn, L. H. Suring, K. Titus, and L. R. Beier. 1994. Habitat-capability model for brown bear in Southeast Alaska. International Conference for Bear Research and Management 9:327-337.

Seaman, D. E., and R. A. Powell. 1996. An evaluation of the accuracy of kernel density estimators for home range analysis. Ecology 77:2075-2085.

Seaman, D. E., J. J. Millspaugh, B. J. Kernohan, G. C. Brundige, K. J. Raedeke, and R. A. Gitzen. 1999. Effects of sample size on kernel home range estimates. Journal of Wildlife Management 63:739-747.

Titus, K. T., and L. R. Beier. 1999. Suitability of stream buffers and riparian habitats for brown bears. Ursus 11:149-156.

USDA Forest Service. 1997. Tongass Land Management Plan Revision. USDA Forest Service, Alaska Region. R10-MB-38a. Juneau, Alaska, USA.

White, G. C. and R. A. Garrott. 1990. Analysis of wildlife radio-tracking data. Academic Press, Inc. San Diego, California, USA.

Worton, B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164-168.

Table 3.1. Description of variables measured or calculated at Western Screech-Owl roosting and nesting areas in Southeast Alaska, 2005-2006.

Variable	Description
Tree Species	Genus species of tree
DBH	Diameter (cm) at breast height of tree
Canopy Class	Canopy classification: 0 = dead; 1 = open-grown or isolated; 2 = dominant; 3 = codominant; 4 = intermediate; 5 = suppressed
Tree Height[a]	Height (m) of nest tree
Owl Height[b]	Height (m) of roosting owl
Cavity Height[c]	Height (m) of cavity opening
Owl Distance[b]	Distance of owl from bole of tree (cm)
Height Ratio[a]	Ratio of owl roost/cavity height to tree height (%)
Concealment[b]	Estimate of owl concealment on roost from top and bottom
Slope	Slope of tree site or nest plot (%)
Aspect	Slope aspect at tree or plot (°)
Elevation[d]	Elevation of nest tree (m)
Canopy	Estimated percent total canopy, over entire plot
Shrub	Estimated percent shrub cover
Saplings	Estimated percent sapling (DBH < 12.5cm) cover
Ground	Estimated percent ground covering (forbs, grasses, moss)
Litter	Estimated percent covering by litter
Water	Estimated percent cover by water
Water Type	Type of water: none, ephemeral, stream, pond
Disturbance	Type of disturbance at plot: none, wind, logging
BA	Basal area (m^2/ha) of trees
Live Trees	Number of live trees per ha
Small Trees	Number of live trees per ha (12.5 – 38.1 cm dbh)
Medium Trees	Number of live trees per ha (38.1-63.5 cm dbh)
LargeTrees	Number of live trees per ha (63.6-89.2 cm dbh)
Extra-large Trees	Number of live trees per ha (> 89.2 cm dbh)
Snags	Number of snags per ha

[a] Variable measured at roost and nest trees only.
[b] Variable measured at roost trees only.
[c] Variable measured at nest tree only.
[d] Variable measured at nest site plot only.

Table 3.2. Summary statistics of Western Screech-Owl home-in and telemetry relocations gathered on Mitkof Island, Alaska during 2005 and 2006.

			Telemetry			Home Range (ha)	
Owl	Sex	Walk-in	Day	Night	Total	99%	50%
ws01	M	10	12	10	32	199.7	27.4
ws02	M	13	11	6	30	67.3	8.5
ws03	F	29	14	18	61	429.6	13.2
ws04	M	13	19	16	48	694.1	253.8
ws05	M	15	27	17	59	619.8	70.4
ws06	F	17	4	5	26	~	~
ws07	M	28	17	22	67	651.4	82.0
ws08	F	23	17	20	60	287.3	40.1
ws09	M	14	23	18	55	623.5	86.9
ws10	M	14	16	16	46	478.9	53.3

Table 3.3. Summary of habitat characteristics measured at Western Screech-Owl roost and nests on Mitkof Island, Southeast Alaska, 2005-2006.

Variable	Roost Tree (n = 110)			Nest Tree (n = 4)		
	Mean	SE	Range	Mean	SE	Range
DBH (cm)	49.1	3.0	4.2-146.5	68.1	4.76	60.0-78.8
Tree height (m)	22.9	1.2	3.5-68.9	21.4	1.6	17.7-25.3
Owl / Cavity Height (m)	11.9	4.6	7.3-16.5	11.9	2.7	7.3-16.5
Height Ratio (%)	48	2	13-96	56	13	42-65
Concealment – Below	42	3	0-100	~	~	~
Concealment – Above	58	4	0-100	~	~	~
Canopy Closure (%)	42	3	5-95	43	4	30-60
Plot Aspect (°)	150	93[a]	~	103	81[a]	~
Plot Slope (%)	17	2	1-85	16	6	1-30
Elevation (m)	186	21	12-1745	206	47	90-319

[a] angular deviation

Table 3.4. Habitat variables measured at Western Screech-Owl nest site and stand plots on Mitkof Island, Southeast Alaska, 2005; $\bar{x} \pm$ SE.

Variable	Nest Site	Nest Stand
Tree Species	83% Western Hemlock 9% Sitka Spruce 8% Unknown	73% Western Hemlock 8% Sitka Spruce 2% Alaska Yellow-cedar 1% Mountain Hemlock 16% Unknown
DBH	29.9 ± 1.7 cm	31.2 ± 1.5 cm
Canopy Class	10% dominant 36% co-dominant 22% intermediate 32% suppressed	6% dominant 40% co-dominant 29% intermediate 26% suppressed
Slope	16 ± 4%	19 ± 5%
Aspect[a]	77° (ang. deviation = 62°)	30° (ang. deviation = 106°)
Elevation	210 ± 66 m	210 ± 66 m
Canopy	43 ± 4%	47 ± 3%
Sapling	30 ± 10%	41 ± 9%
Shrub	54 ± 5%	55 ± 7%
Ground	50 ± 4%	45 ± 5%
Litter	9 ± 2%	11 ± 3%
Water	2 ± 1 %	5 ± 4%
Basal Area	51.3 ± 3.8 m^2/ha	49.3 ± 5.7 m^2/ha
Live Trees	510 ± 57 trees/ha	512 ± 78 trees/ha
Small Trees	385 ± 75 trees/ha	395 ± 80 trees/ha
Med Trees	70 ± 17 trees/ha	78 ± 17 trees/ha
Large Tree	50 ± 21 trees/ha	26 ± 11 trees/ha
Extra Large Trees	5 ± 5 trees/ha	13 ± 8 trees/ha
Snags	85 ± 46 snags/ha	98 ± 22 snags/ha

[a] mean ± angular deviation

Figure 3.1. Map of Western Screech-Owl study area on Mitkof Island in central Southeast Alaska, USA.

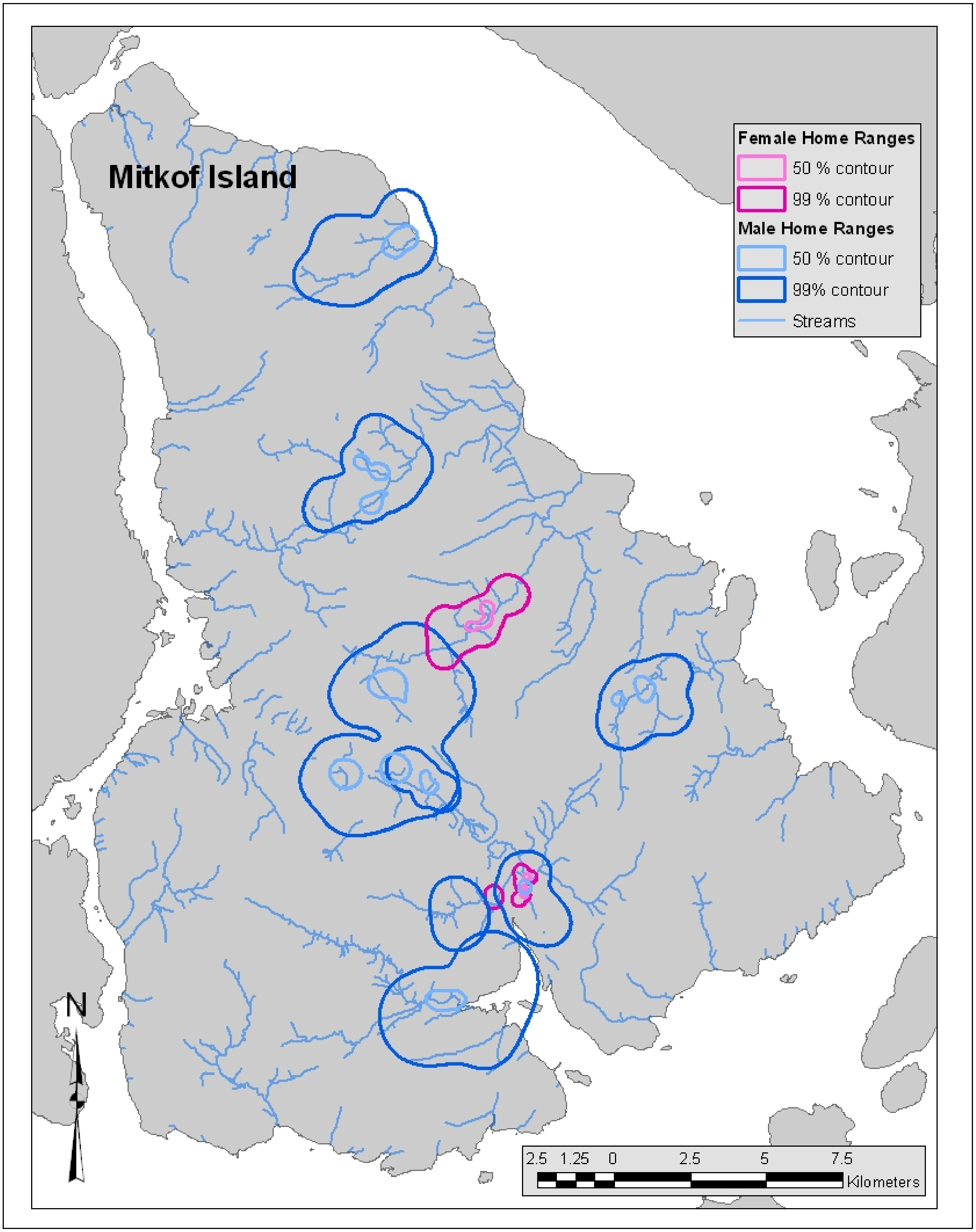

Figure 3.2. Male (blue) and female (pink) Western Screech-Owl home ranges measured on Mitkof Island, Southeast Alaska 2005 – 2006. Light blue is 50 % contour, dark blue is 99 % contour of adaptive kernel estimate.

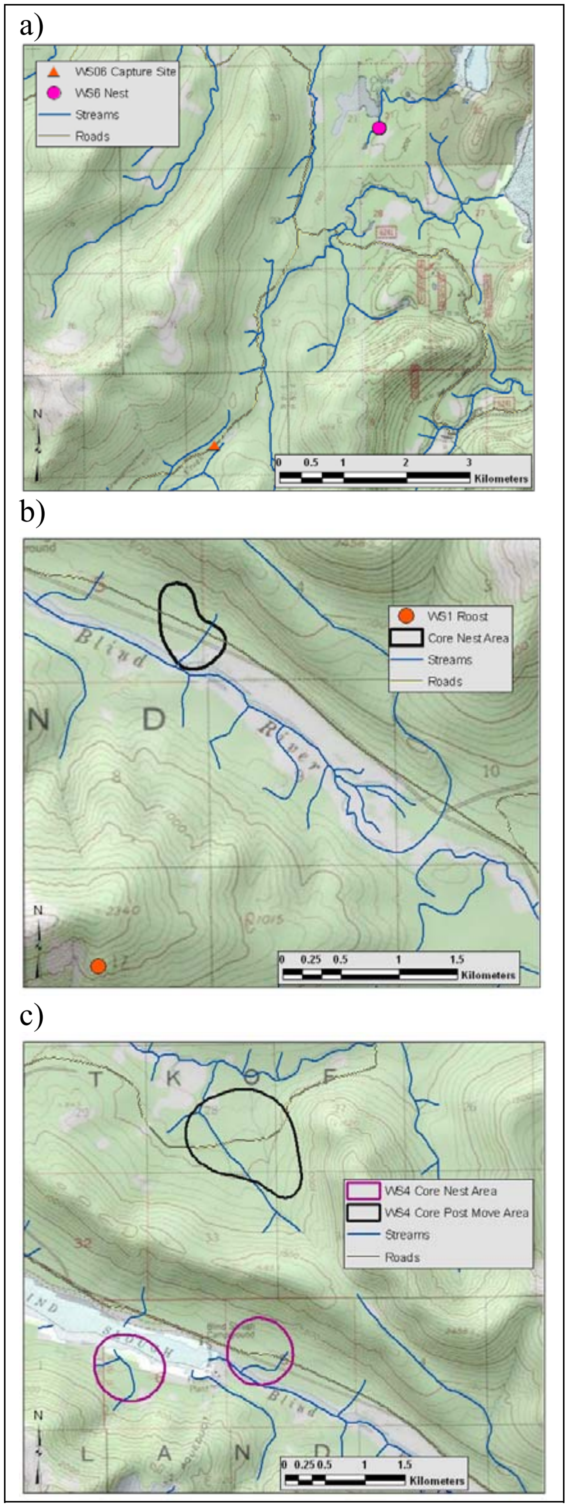

Figure 3.3. Maps showing unusual movements for 3 Western Screech-Owls monitored in Southeast Alaska, 2005 – 2006: a) shows movement of WS6 from capture site to nest site; b) Movement by WS1 from core nest area (presumed) to roost; c) Movement of WS4 from core nest area (presumed) to core area after nest failure (presumed).

CHAPTER 4
WESTERN SCREECH-OWL (*MEGASCOPS KENNICOTTII*) CAPTURE IN SOUTHEAST ALASKA: TECHNIQUE EVOLUTION AND CAPTURE RATES

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ABSTRACT

With little information about Western Screech-Owl ecology in Southeast Alaska, we wanted to radio mark owls to learn about home range, habitat use, and movements. We encountered problems with existing trapping techniques related to the forest and climate of Southeast Alaska that required us to refine techniques. We used a mist-net set along roadways with a broadcast and decoy to attract screech-owls to our trap site, and a mouse-decoy to entice the owl to stoop into the net. We captured 11 screech-owls during 28 responses to broadcasts during 40 attempts. This resulted in a capture rate of 33 birds per 100 net-hours (b/100nh) across all attempts, and 44 b/100nh after the initial response. We discuss some issues we encountered when utilizing this technique and offer suggestions to make this an efficient method to capture small shy owls in locales with thick, moist forest and dense understory.

INTRODUCTION

Little information exists describing distribution and abundance of owls in Southeast Alaska, leading to concerns about their population status (Alaska Department of Fish and Game 2006). The Western Screech-Owl (*Megascops kennicottii*) is a species of special interest because it is closely associated with riparian habitats (Hayward and Garton 1988, Cannings and Angell 2001), is a year-round resident (Cannings and Angell 2001), and has suffered population declines in other locations (e.g., British Columbia; COSEWIC 2002, Elliott 2006). Our initial objective was to develop a survey protocol to monitor populations of Western Screech-Owls in Southeast Alaska and to gather information on their biology and habitat requirements. During development of the survey protocol, we grew concerned that detections histories of Western Screech-Owls at each survey station were not independent. This would violate a critical assumption of the occupancy estimation techniques we intended to use (MacKenzie et al. 2006).

To address this concern, we needed to capture Western Screech-Owls to equip them with radio-transmitters.

Most techniques used to capture small owls start with either knowing the location of a nest area or broadcasting a conspecific call to attract the owl to the trapping location (Bloom et al. 2007). Once the owl is located (either aurally or visually), standard techniques for capturing small owls include: placing a bal-chatri beneath a perched owl (Bub 1995, Smith 1999); luring the owl into a mist net (Smith and Walsh 1981, Reynolds and Linkhart 1984); nest cavity captures by placing a net over the cavity opening (Reynolds and Linkhart 1984); and, grabbing the bird on a perch with a telescoping noose pole (Reynolds and Linkhart 1984).

However, the coastal, temperate rainforest of Southeast Alaska presented unique problems for trapping Western Screech-Owls that required us to adapt existing techniques. The extremely dense forests and moist climate dampened the relatively low volume calls of Western Screech-Owls, making it difficult to attract owls from even reasonable distances. Unlike many locales where Western Screech-Owls have been studied (e.g., southwestern Idaho; Ellsworth and Belthoff 1999, Herting and Belthoff 2001), the forests of Southeast Alaska are extensive and Western Screech-Owls occur at naturally low numbers (Chapter 2), so selecting trapping sites and finding owls to trap requires significant time and effort. After a Western Screech-Owl is located, the bird may leave the trap vicinity before a trap is set up because of their shy and elusive behavior (personal observation). Also, the forest floor layer is densely packed with shrubs, herbs, ferns, and mosses and complex terrain of decaying logs and tipped-up root wads (Alaback 1982, Schoen et al. 1988), making it difficult to approach an owl stealthily to place a bal-chatri trap beneath it or even for the perched owl to see the baited trap. Therefore, we set out to develop a technique that was efficient and portable to capture Western Screech-Owls in the dense rainforests of Southeast Alaska.

METHODS

Study area

We attempted to capture Western Screech-Owls near 3 locations in Southeast Alaska: Juneau, on the mainland (58° 18’ N, -134° 25’ W); Petersburg, on Mitkof Island (56° 48’ N, -132° 56’ W); and, Sitka on Baranof Island (57° 08’ N, -135° 27’ W). The landscape of Southeast Alaska is naturally fragmented by mountainous terrain, wetlands, and forest patches of various sizes. The forests are a coastal, temperate rainforest dominated by western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*), that occur at low elevations as a mosaic with muskegs and other wetlands (Neiland 1971). A cool and wet maritime climate characterizes the region, with average annual precipitation of 288 cm evenly distributed throughout the year.

Capture

We attempted to capture Western Screech-Owls during breeding season when they were defending territories. We located owls during broadcast surveys being conducted for a different portion of this study (Chapters 1 and 2) and by broadcasting in areas we thought would be good screech-owl habitat. Depending on the location and the individual target owl, we either set up the mist net prior to attracting the owl (usually for owls that we previously attempted to trap) or we attracted the owl prior to setting up the net (typically at suspected but not confirmed territories).

To attract owls to the general trap location, we used the main territorial call of Western Screech-Owls, the bouncing ball (BB; Feusier 1989, Cannings and Angell 2001). We broadcast the BB call with a handheld megaphone (PA Genie Amplifier APM-760, Fanon Courier, Irvine, CA) and a portable CD player (CD Walkman D-NS505, Sony, Tokyo, Japan). At first, we would hold the megaphone in hand and play a series of 3 segments of calls, and then listen for a response. Each segment consisted of 30 s of the BB call, followed by 60 s of silence. If nothing was heard after 2 minutes, we would play the 3 segments again. After 4-6 repeats of this sequence and no response from an owl, we put the CD player on repeat of a track that was set up in advance to play a 30 s segment of bouncing ball and 60 s of silence repeated. We would place the megaphone and CD player on the ground and wait quietly nearby to try and detect the responding owl as soon as it came in range of hearing.

To capture birds, we used a mist net (61 mm mesh, 12 m length, 2.6 m height, 4 shelves, black nylon; Association of Field Ornithologists) strung between poles (set contains 3 4'-sections, 1" aluminum poles) stuck into 2 5-gal buckets filled with sand. Most trapping attempts were made on the edge of a roadway or off the road near the forest edge. All trapping took place on smaller forest roads that received little night traffic or, if trapping along a larger road or near a population center, we trapped near a pull-off or on a side road to avoid attracting the owl into the roadway. Once the net was set up, we placed the megaphone and CD player on or near the ground, centered in the net (Figures 4.1, 4.2). We used a small, stuffed-animal owl decoy to draw the attention of the owl, placing it on top of the megaphone.

If the owl did not attempt to stoop the owl-decoy (which was usually the case), we would deploy the mouse-decoy. The mouse-decoy consisted of a small (9 cm) cat-toy mouse attached to a long (10 m) piece of dark twine (Evergrip Hanging Twine, Redden Marine Supply, Inc., Bellingham, WA) or a fishing pole with 20-lb test line. We would quietly approach one net pole and crouch down, using no light. We would throw the mouse across the face of the net, parallel to the length of the net (Figures 4.1, 4.2), so that it was 1-2 m behind the net (opposite the net from the forest where the owl was presumably perching). We would slowly drag the mouse-decoy along the road so that it made a scratchy noise in the gravel, much like a small rodent scratching in the dirt. We would drag the mouse-decoy across the face of the net until it was 1 – 2 m away from us, collect it in hand, and throw it again. In most cases, the owl would stop calling once it detected the mouse-decoy, and often move to get into a better position to see the mouse. When this happened, we would change the pace of pulling the decoy, letting it sit for a few seconds then pulling it rapidly for 15 – 30 cm before letting it sit again. If the owl did not attempt to stoop the mouse-decoy, we would use a small flashlight to illuminate the mouse-decoy as we pulled it along the ground. This almost always elicited a stoop attempt. Typically, we allowed the broadcasting of the conspecific call to continue throughout the trapping event.

Once captured, we removed owls from the nets and placed them in a cotton bird bag for weighing and began processing. We measured wing chord (natural and flat), tail length, bill length, and mass (Pyle 1997). We noted plumage characteristics and prepared molt cards of both primary and secondary feathers. Each captured owls was banded with a U. S. Fish and Wildlife Service band on one leg. We equipped birds with backpack-mounted radio transmitters (Biotrack, Ltd., model # TW-4) using Teflon ribbon. While capturing and handling owls, we followed animal care and use guidelines from the Ornithological Council (Gaunt et al. 1997). We report capture rate as birds per 100 net-hours (b/100nh); a net-hour is defined as one 12-meter net under favorable weather conditions during one nighttime hour.

RESULTS

We attempted to capture Western Screech-Owls on 31 nights from 14 March-15 May, 2005-2007 (Table 4.1). During those nights, we made 40 attempts (i.e., defined as setting up the net either after a Western Screech-Owl response during a survey or at a place with a previous screech-owl response) and had 28 responses (i.e., screech-owls approaching the trapping area in response to our broadcast while trapping). From those responses, Western Screech-Owls stooped towards the decoy and/or hit the net 21 times, resulting in 11 captures (8 males, 3 females). Attempts averaged 50 min overall, but successful attempts averaged only 32 min. Across all years, we had a capture rate of 33 b/100nh. However, after the initial response of the target owl occurred, the rate increased to 44 b/100nh, emphasizing the time required to attract the owl to the trap site.

DISCUSSION

In total, we captured 65% (11 of 17) of the Western Screech-Owls we attempted to capture. In 2005, we captured 2 owls but missed owls at 3 other locations. However, our main objective in 2005 was to conduct owl surveys and attempt a few captures as a pilot effort to determine the feasibility of capture, radiotagging, and relocating Western Screech-Owls in Southeast Alaska. In 2006, when capturing Western Screech-Owls was our main objective, we captured 73% of the owls we targeted. Only at 1 territory did we fail to capture an owl. We tried repeatedly at this location, getting the owl to respond to the broadcast and approach the trap site but could never catch it. Two other failures in 2006 were attempts to capture the mate of a female owl we had captured previously that year. Both of these birds were very shy and we exerted relatively little effort trying to capture them, instead focusing on catching owls in unique territories.

It was important to anticipate where the owl might perch or where the best perch opportunities were for the owl to approach the megaphone and decoy when setting up the net (Figure 4.2). On several occasions, there were opportunities for the owl to perch close to the ground and/or very close to the net, so when the bird dove for the mouse-decoy they hit the net low and were able to escape. We had a few instances where the owl approached the trap site from the opposite side of the road from which we set the net and the owls were usually very tentative to cross the open road, plus they could reach the decoy without hitting the net. Another problem was setting the net in an area with no vegetation close to it for perching (i.e., only larger trees with lowest branches well above the net top). In this case, the owl approached as close as it could but did not seem interested in entering the open space near the net and therefore, was not captured.

It was important to have the mouse-decoy at the right distance from the net so that when the owl stooped at the decoy, it hit the net in the second (or higher) panel; if the mouse-decoy was too far from the net, the bird simply flew over the net to stoop the decoy. We had several attempts foiled when the owl hit the net in the bottom panel but ended up perched on the ground. As we approached, it jumped out and was able to clear the netting and escape. The obvious solution was to make sure the bottom panel was high enough that it did not reach the ground, but then there was a risk that the bird would stoop under the net.

We found that defensive or curious owls (i.e., one attracted by the BB call) usually became silent once the mouse-decoy was presented to them. This appeared to signify a change to predatory behavior and was often accompanied with slight changes in the bird's location. On several occasions during dark nights (i.e., those with no moonlight), the owl seemed interested in the mouse-decoy but would not stoop it until it was illuminated with a headlamp. In these instances, once the mouse-decoy was illuminated, the owl stooped almost immediately.

We attempted to trap owls (e.g., mate of radio tagged females) within their nest stand. We tried to set up the mist net upon locating the owl at a roost. However, the dense understory in the forest here made this difficult and usually resulted in tangled nets. Often, the owl would begin to leave the area before we could get the net set up or seemed shy and disturbed by our presence and would not approach the trap site. We also attempted to put a bal-chatri baited with a live mouse beneath perched owls. However, again the dense understory seemed to conceal the prey enough from the owl that we never had an owl stoop one of these traps. These problems resulted in us spending most of our trapping time along the roadside.

In all cases, we used the BB call to attract the owl to the trap locations. However, in some cases, once the owl arrived it was silent for several minutes, not attempting to "duel" with the decoy-owl and broadcaster. In those cases, we suspected the responding bird was a female and we changed the call to the "double trill" (DT, Herting and Belthoff 2001). The BB was ususally more of a defensive call and often used by males, the DT seemed to be a communication call between mates and often enticed females to fly into the net (Ritchison et al. 1988, Herting and

Belthoff 2001). In one case where it was light enough to see, we attracted an owl with the BB. We thought it was a female so switched the DT call. Soon, this bird began responding very softly in her own DT for several minutes before beginning to stoop high over the decoy, avoiding the net but apparently attempting to alert the decoy-owl to her presence. She eventually hit the net but escaped when we approached to remove her. She left the capture area immediately (or became silent) and we never got another attempt at her.

One caution is to be aware if a larger owl (e.g., Barred Owl [*Strix varia*] or Great Horned Owl [*Bubo virginianus*]) responds to the broadcast of the smaller owl and approaches the capture site. Every time we had a larger owl approach our capture site, any screech-owl that was responding immediately ceased calling and presumably left the area. For this reason, it is important to watch the net closely, without disturbing the target owl, in the event that a larger owl is perched nearby, presumably attracted to the broadcast call. Both Barred Owl and Great Horned Owl are known predators of smaller owls (Houston et al. 1998, Mazur and James 2000).

Techniques to capture owls have been rather standardized for years (Bub 1995, Bloom et al. 2007). However, we found a unique set of circumstance in the forest of Southeast Alaska that required refining some of the existing techniques. A mouse-decoy has been used to attract Great Gray Owls (*Strix nebulosa*) close enough to capture with a dip-net (R. Nero, reported in Bull 1987). We adapted this technique by using a broadcast and owl-decoy to attract owls in a territorial response, followed by presentation of a mouse-decoy to generate a predatory response. The result was an efficient method to capture Western Screech-Owls in Southeast Alaska and other locales with thick, moist forest and dense understory.

LITERATURE CITED

Alaback, P. B. 1982. Dynamics of understory biomass in Sitka spruce-western hemlock forests of Southeast Alaska. Ecology 63:1932-1948.

Alaska Department of Fish and Game. 2006. Our wealth maintained: a strategy for conserving Alaska's diverse wildlife and fish resources. Alaska Department of Fish and Game, Juneau, Alaska, USA.

Bloom, P. H., W. S. Clark, and J. W. Kidd. 2007. Capture techniques. In: Raptor research and management techniques (D.M. Bird and K.L. Bildstein, eds.), pp. 193-219. Hancock House Publishers, Blaine, WA.

Bub, H. 1995. Bird trapping and bird banding: a handbook for trapping methods all over the world. Cornell University Press, Ithaca, New York, USA.

Bull, E. L. 1987. Capture techniques for owls. Pages 291-293 *in* Biology and conservation of northern forest owls (R. W. Nero, R. J. Clark, R. J. Knapton, and R. H. Hamme, eds.). USDA Forest Service General Technical Report RM-142, Fort Collins, Colorado, USA.

Cannings, R. J., and T. Angell [online]. 2001. Western Screech-Owl (*Megascops kennicotti*), The Birds of North America Online (A. Poole, Ed.). Ithica: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.conrell.edu/bna/species/597.

COSEWIC. 2002. COSEWIC assessment and update status report on the Western Screech-Owl *Otus kennicottii* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario, Canada.

Elliott, K. 2006. Declining numbers of Western Screech-Owl in the lower mainland of British Columbia. British Columbia Birds 14:2-11.

Ellsworth, E.A. and J. R. Belthoff. 1999. Effects of social status on the dispersal behavior of juvenile Western Screech-Owls. Animal Behaviour 57:883-892.

Feusier, S. 1989. Distribution and behavior of Western Screech-Owls (*Otus kennicottii*) of the Starr Ranch Audubon Sanctuary, Orange CO., California. M.S. thesis, Humboldt State University, Arcata, CA, USA.

Gaunt, A. S., L. W. Oring, K. P. Able, D. W. Anderson, L. F. Baptista, J. C. Barlow, and J. C. Wingfield [online]. 1997. Guidelines for the use of wild birds in research. <http://www.nmnh.si.edu/BIRDNET/GuideToUse> (11 November 2004).

Hayward, G. D., and E. O. Garton. 1988. Resource partitioning among forest owls in the River of No Return Wilderness, Idaho. Oecologia 75:253-265.

Herting, B. L., and J. R. Belthoff. 2001. Bounce and double trill songs for male and female Western Screech-Owls: characterization and usefulness for classification of sex. Auk 118:1095-1101.

Houston, C. S., D. G. Smith, and C. R. 1998. Great Horned Owl (*Bubo virginianus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/372.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Academic Press, Burlington, MA, USA.

Mazur, K. M., and P. C. James. 2000. Barred Owl (*Strix varia*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/508.

Neiland, B. 1971. The forest-bog complex of Southeast Alaska. Vegetatio 22:2-63.

Pyle, P. 1997. Identification guide to North American birds: part I. Slate Creek Press, Bolinas, California, USA.

Reynolds, R. T., and B. D. Linkhart. 1984. Methods and materials for capturing and monitoring Flammulated Owls. Great Basin Naturalist 44:49-51.

Ritchison, G., P. M. Cavanagh, J. R. Belthoff, and E. J. Sparks. 1988. The singing behavior of Eastern Screech-Owls: seasonal timing and response to playback of conspecific song. Condor 90:648-652.

Schoen, J. W., M. D. Kirchhoff, and J. H. Hughes. 1988. Wildlife and old-growth forests in Southeastern Alaska. Natural Resources Journal 8:138-145.

Smith, D. G. 1999. Eastern Screech-Owl behavior at a bal-chatri trap. Connecticut Warbler 19:38-39.

Smith, D. G., and D. T. Walsh. 1981. A modified bal-chatri trap for capturing Screech-Owls. North American Bird Bander 6:14-15.

Table 4.1. Summary of statistics for Western Screech-Owl trapping conducted in Southeast Alaska, 14 March – 15 May, 2005 – 2007.

Year	Nights	Attempts	Responses	Stoops	Captures	Captures / Attempt[a]	Captures / Response[b]
2005	10	11	6	4	2	0.18	0.33
2006	20	28	21	16	8	0.29	0.38
2007	1	1	1	1	1	1.00	1.00
Total	31	40	28	21	11	0.28	0.39

[a] Attempt defined as setting up the net either after a Western Screech-Owl response during a survey or at a place with a previous screech-owl response.
[b] Trapping response defined as a screech-owl approaching the trapping area in response to our broadcast while trapping.

Figure 4.1. Photograph of roadside mist net used to capture Western Screech-Owls in Southeast Alaska, 2005-2007. The net is strung between to net poles in 5-gal buckets of sand, supported with tie-downs. The megaphone is in center of net with CD player next to it. Owl decoy is out of sight by blaster and mouse-decoy is on ground by far net pole (not visible) in case owl approaches.

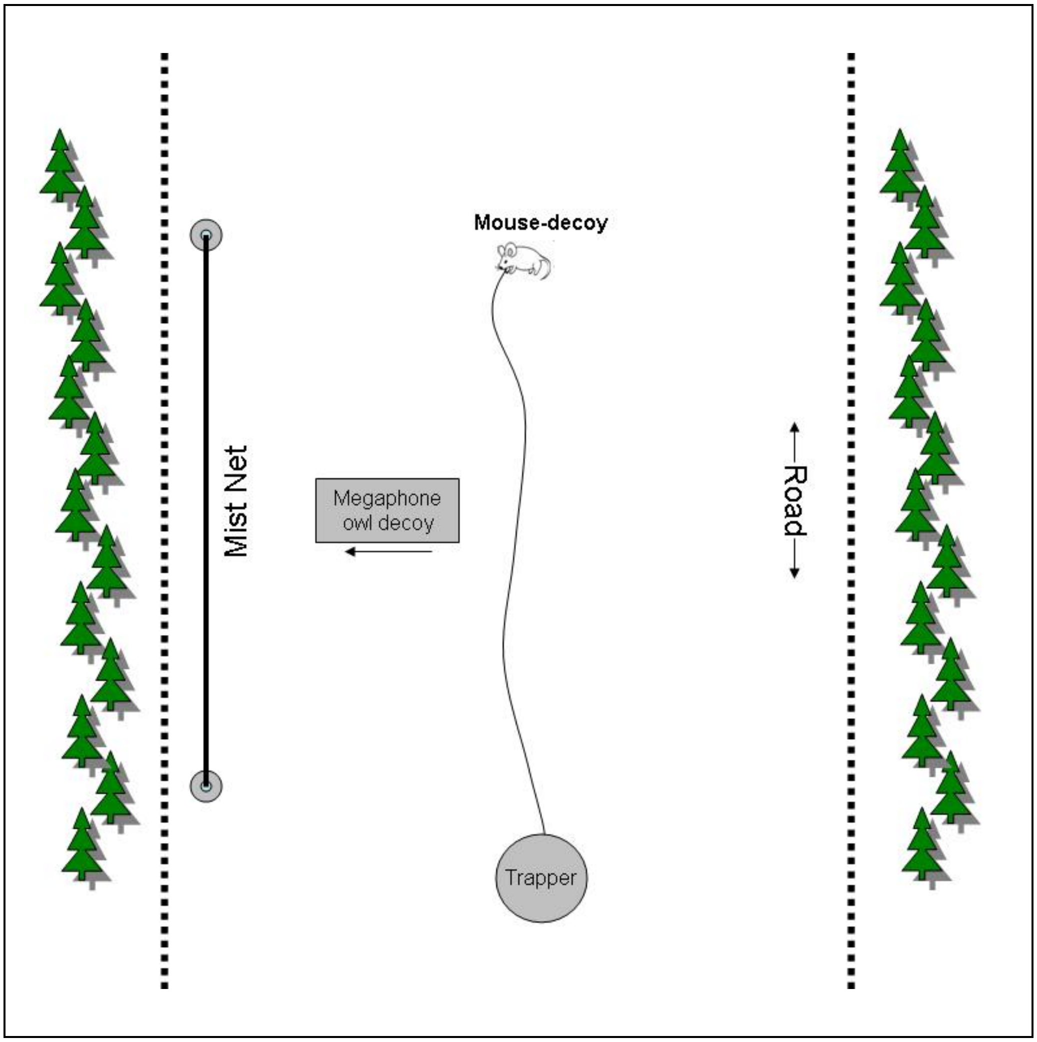

Figure 4.2. Schematic drawing of trapping site showing mist net placement relative to road edge, megaphone and owl decoy relative to mist net, and mouse decoy relative to mist net used to trap Western Screech-Owls in Southeast Alaska, 2005-2006.

CHAPTER 5
DIET OF THE WESTERN SCREECH-OWL (*MEGASCOPS KENNICOTTII*) IN SOUTHEAST ALASKA

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INTRODUCTION

Western Screech-Owls (*Megascops kennicottii*) are well-distributed across western North America, primarily associated with riparian habitats (Johnsgard 2002, Duncan 2003). In the Pacific Northwest, habitat loss in productive riparian areas and predation pressure from the recently-arrived Barred Owl (*Strix varia*) has raised concerns about Western Screech-Owl population status and prompted listing of the *macfarlanei* subspecies as 'endangered' and the *kennicotti* subspecies as that of 'special concern' in British Columbia (Cannings and Angell 2001, COSEWIC 2002, Elliot 2006). Although Western Screech-Owl is one of the more common owl species across their entire range, relatively few data exist concerning their diet (Cannings and Angell 2001, COSEWIC 2002).

Knowledge of a raptor's diet is not only significant to understanding its ecology, but to how it relates to its community (Marti et al. 2007). Lack of sufficient prey is one of the primary factors that can limit a raptor's population growth (Newton 1979, Newton 1998). Therefore, a better understanding of diet can improve management and conservation of a raptor species (e.g., Northern Goshawk [*Accipiter gentilis*]; Reynolds et al. 1992). Western Screech-Owl diet varies tremendously across its range but primarily comprises small mammals, birds, worms, insects, and crayfish (Cannings and Angell 2001). In general, the southern populations consume more invertebrates compared to the northern populations which primarily feed on small mammals, but still supplement their summer diet with insects (Hayward and Garton 1988, Cannings and Angell 2001). However, little information exists on their diet in the northern coastal forests where the mammalian prey base is relatively limited (Lewis et al. 2006).

We studied the diet of Western Screech-Owls at the northern edge of their range, in Southeast Alaska. Our primary objective was to describe and estimate the relative occurrence of prey items in the breeding season diet of Western Screech-Owls. Because of the scarcity of information, we also compiled information on the non-breeding season diet of this species in Southeast Alaska.

METHODS

Study area

We conducted this study near Petersburg on Mitkof Island (56° 48' N, -132° 56' W; Figure 5.1) in Southeast Alaska, a sparsely populated region characterized by steep, rugged topography, costal fjords, and large tracts of temperate rainforest. Mitkof Island is 545 km^2 in size and ranges in elevation from sea level to 3304 m. The island is naturally fragmented by mountainous terrain, wetlands, and various fine-scale disturbances (e.g., wind-throw). Commercial timber harvesting has resulted in extensive, broad-scale clearcutting. The forest is dominated by western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*) and the understory consists primary of blueberry (*Vaccinium* spp.), devil's club (*Oplopanax horridus*), and salmonberry (*Rubus* spp.). Mitkof Island has a cool, wet maritime climate with average annual precipitation of 288 cm evenly distributed throughout the year.

Data collection

We captured 10 Western Screech-Owls using mist nets with an audio lure and mouse decoy from March–May, 2005 and 2006 (Chapter 4). We equipped 3 females and 7 males with backpack-mounted radio transmitters (model TW-4, Biotrack, Ltd) with Teflon ribbon. We located radio-marked birds at roost and nest sites approximately 2 times per week to describe habitat use and nesting areas (Chapter 3). We collected pellets (no prey remains were ever found) from beneath roost trees or nest cavities of radio-marked birds, their mates, or their young. Each pellet was placed into a 6 x 9 cm manila envelope and labeled with date, time, location, and owl identity. We also indicated whether the pellet was in a clustered group with other pellets or it was found alone. We dried, weighed, and dissected pellets in the laboratory. We separated contents into mammalian, avian, and invertebrate categories and weighed the contents of each category. We then identified items to the lowest possible taxon. We identified mammals by dentition and skull characteristics (MacDonald and Cook 2006) and consulted with experts and collections to identify invertebrate remains (P. Atkins, USDA Forest Service, Forestry Sciences Laboratory, Juneau). We were unable to identify birds to species or species group because of the condition of feathers and bones found in pellets.

In addition, we collected carcasses of Western Screech-Owls that were found dead or had died from vehicle or window collisions throughout Southeast Alaska. All carcasses were submitted in good condition from September-February, 2000–2007 and were frozen immediately on arrival. We necropsied 15 carcasses (7 adults and 8 hatch-year owls) to determine cause of death, sex, and to examine stomach contents. Only 12 of these carcasses (6 adult and 6 hatch-year owls) had prey remains in their stomach. We also obtained information from Western Screech-Owl specimens from Southeast Alaska at the University of Alaska Museum of the North, Fairbanks. Only 3 of 19 museum specimens included information about stomach contents; 2 adult birds were collected near Sitka in 1982 (UAM Birds 4180, 4181) and 1 hatch-year bird was sent to the museum from Juneau in August 2004 (date and location of death unknown; UAM Bird 20146). Although there were few carcasses (n=12) and study skins (n=3), these data offer the only information about the non-breeding season diet and eliminate some of the biases associated with pellet data (Lewis et al. 2004).

Data analysis

Pellets collected at the same time and location were analyzed as a group to determine the minimum number of prey items that could have resulted in the observed pellets. We did this to avoid overestimating single prey items that may have been regurgitated in multiple pellets. We collected all pellet parts from beneath roosts to ensure no double counting across groups. We estimated prey biomass for small mammals only; we used the midpoint of the mass range of the prey item (MacDonald and Cook 2006). We assumed that unknown shrews were Cinereus Shrew (*Sorex cinereus*) because these were the only shrews we positively identified and Cinereus Shrew is the most common shrew in Southeast Alaska (MacDonald and Cook 2007; *S. monicolus* also occurs on Mitkof Island). We assumed unknown rodents were proportional to our pellet samples (88% mice and 12% voles or lemmings) and used an average value of 32.0g for their mass (MacDonald and Cook 2006). We did not include unidentified mammals in the frequency or biomass estimation because we were unable to approximate mass reliably.

RESULTS

Pellet analysis

We collected 125 pellets from 48 groups from Western Screech-Owls during 26 April–21 September, 2005–2006. We collected 5 pellet groups per owl (SD=4; range = 1–13). Total pellet mass was 90.3g ($\bar{x}$=0.72g), comprised of mammalian (84.5g; 94%), invertebrate (3.1g; 3%) and avian remains (2.7g; 3%; Table 5.1). The frequency of occurrence in pellet groups was highest for mammals (98%; n=46) and invertebrates (81%; n=39) and lowest for birds (23%; n=11; Table 5.1).

We tallied 115 mammalian prey items, which represent the minimum number that occurred in the pellets. We categorized 110 of these items as either shrews (Family Soricidae; n=38) or rodents (Family Cricetidae; n=72; Table 5.2). We identified 65 mammalian items to 5 different species: Cinereus Shrew (n=3), Northern Bog Lemming (*Synaptomys borealis*; n=2), Meadow Vole (*Microtus pennsylvanicus*; n=5), Long-Tailed Vole (*M. longicaudus*; n=1), and Keen's Deer Mouse (*Peromyscus keeni*; n=60; Table 5.2).

Two pellets were primarily comprised of bird remains, but 9 additional pellets had traces of feathers, possibly from the owl itself. We were unable to identify the birds to species, or species group, but given the density of the feathers and bones in the pellet, we're confident that at least 2 different predation events on birds occurred.

We identified 25 invertebrate prey items (all Class Insecta) to 4 different families in Orders Coleoptera (84%) and Hemiptera (16%; Table 5.3). Coleopteran represented in pellets belonged to Families Caribidae (n=5), Dytiscidae (n=5), and Curculionidae (n=6), and the only family in Hemptera was Belostomatidae (n=4; Table 5.3).

Carcass analysis

Based on 15 Western Screech-Owl carcasses (8 adult and 7 hatch-year owls), mammals (9% of prey items; 5 of 57) did not comprise a large portion of the stomach contents; insects (82% of prey items; 47 of 57) dominated the prey items (Table 5.4). Caterpillars (67%), the larval form of butterflies and moths, constituted a large portion of the stomach contents from the carcasses, particularly for adults (Table 5.4). There was no evidence of mammals in adult stomachs, but 5 (71%; 5 of 7) of the hatch-year birds had mammal hair or bones in their stomachs (Table 5.4). Other soft-bodied invertebrates (e.g., worms, spiders) were represented in the stomach contents along with the Coleoptera species identified in the pellet analysis (Table 5.4).

DISCUSSION

Pellet collection and analysis is an indirect method to studying raptor diet, but is advantageous because there is little disturbance to the bird and a relatively large sample can be collected over time and space (Lewis et al. 2004, Marti et al. 2007). Owls typically swallow their prey whole, allowing highly acidic gastric juices to assist in digestion (Duke et al. 1975). Larger undigested bones and undigested fur and feathers are cast into a pellet which is regurgitated; therefore, pellet analysis can be biased toward prey items that are not fully or easily digested. Studies have shown that mammals, in particular, are overestimated and soft-bodied prey (e.g., earthworms) are underestimated when describing the diet using pellets (Lewis et al. 2004).

We present the first information describing the diet of the Western Screech-Owl in Southeast Alaska. Based on regurgitated pellets, this species consumes primarily small mammals during the breeding season; avian remains were insignificant in the diet. Keen's Deer Mouse, one of the most common and widely-distributed mammals in Southeast Alaska (MacDonald and Cook 2007), dominated the breeding season diet. Although invertebrate remains contributed very little to the total pellet mass, they occurred in nearly all of the pellet groups. All invertebrates that occurred in pellets were insects and nearly all of those were beetles (Order Coleoptera), which have elytron (i.e., hardened forewings) that often persisted in the pellet and therefore, led to positive identification of beetle remains. It is likely that other soft-bodied invertebrates consumed were digested easily and quickly, leaving no evidence in pellets. Invertebrate prey is notoriously difficult to detect with an indirect technique like pellet analysis, and the diet of known insectivores (e.g. Flammulated Owl [*Otus flammeolus*]) are not studied with pellet analysis (McCallum 1994). As such, it is difficult to truly understand the importance of invertebrate prey to Western Screech-Owls in Southeast Alaska. Because both insects and mammals were consistently represented in the pellets, we conclude that, during the breeding season, Western Screech-Owls feed on small mammals, primarily deer mice, but supplement their diet with a relatively high number of invertebrates, many of which were probably underestimated in our analysis.

Our carcass analysis was intended to provide information about Western Screech-Owl diet outside of the breeding season. We collected carcasses opportunistically (except for the male and female topotypes that were included in the museum collection) and therefore, they do not represent an unbiased sample; these birds may have been predisposed to mortality (e.g., due to starvation). We were surprised that relatively few carcasses had mammalian remains in the stomach because deer mice are active year-round. Western Screech-Owls produce a large pellet about 4 hr after eating small mammals and then usually produce a second, smaller pellet (about 1/3 of the size of the first) within an hour; after the second pellet is cast, they are able to immediately begin hunting and feeding again (Cannings and Angell 2001). Therefore, stomach content analysis may positively bias invertebrates because an owl could not cast a pellet without a large amount of undigested material in the stomach. Regardless, the carcass analysis provided information on soft-bodied invertebrates, especially Lepidoptera caterpillars, that appear to constitute an important part of the Western Screech-Owl diet and may provide an alternative food source during the winter months in years that Keen's Deer Mice, and other small mammals, occur at low densities. Caterpillars rank among insects as having the highest fat content, as well as vitamins and minerals (DeFoliart 1992), and have been documented in the Western Screech-Owl diet in other parts of its range (Smith and Wilson 1971, Fraser et al. 1999).

One advantage to using pellet analysis to determine the diet of Western Screech-Owls (and other mammal-eating owls) is the ability it provides to detect rare small mammals. For example, no specimen records for Northern Bog Lemming exist for Mitkof Island (MacDonald and Cook 2007), yet we documented 2 in the diet of Western Screech-Owls. Because these owls were equipped with radio-transmitters, we are confident that the owls were not flying to neighboring islands to hunt (Chapter 3). This is especially important in an island ecosystem where endemism has become a highlighted concern for conservation biologists and managers (Cook et al. 2006). A well designed owl diet study, spread over several islands, could be extremely useful for monitoring different types of small mammal prey, given some basic understanding of owl species food habits and preferences.

Despite some of the limitations and potential biases of our methods, we provide data to characterize the Western Screech-Owl diet in Southeast Alaska. As found elsewhere, their diet is diverse with small mammals, especially deer mice, comprising the majority of the biomass in the diet, but insects also contribute significantly throughout the year (Cannings and Angell 2001 and references therein). Other than Lepidoptera caterpillars, which are presumably only available during the winter months, Keen's Deer Mouse, shrews, and other rodents, and Coleoptera beetles are ubiquitous, available, and active year-round. Therefore, we suspect that the diet does not vary much temporally or spatially across Southeast Alaska, unless there are island-based differences in the prey base. We believe, however, that during the cold winter months when food is scarce, Western Screech-Owls rely heavily on riparian areas with streams that remain unfrozen (Chapter 2). We suggest protecting low gradient streams at low elevations to provide sufficient year-round foraging habitat for Western Screech-Owls in Southeast Alaska.

LITERATURE CITED

Cannings, R. J., and T. Angell. 2001. Western Screech-Owl (*Otus kennicottii*). *In* The Birds of North America, No. 597 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Cook, J. A., N. G. Dawson, and S. O. MacDonald. 2006. Conservation of highly fragmented systems: the north temperate Alexander Archipelago. Biological Conservation 133:1-15.

COSEWIC. 2002. COSEWIC assessment and update status report on the Western Screech-Owl *Otus kennicottii* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 31pp.

DeFoliart, D. 1992. Insects as human food. Crop Protection 11:395-399.

Duke, G. E., A. A. Jegers, G. Loff, and O. A. Evanson. 1975. Gastric digestion in some raptors. Comparative Biochemistry Physiology 50A:649-656.

Duncan, J. R. 2003. Owls of the world: their lives, behavior, and survival. Firefly Books, Buffalo, New York, USA.

Elliott, K. 2006. Declining numbers of Western Screech-Owl in the lower mainland of British Columbia. British Columbia Birds 14:2-11.

Fraser, D. F., W. L. Harper, S. G. Cannings, and J. M. Cooper. 1999. Rare birds of British Columbia. Ministry of Environment, Lands and Parks, Victoria, British Columbia.

Hayward, G. D., and E. O. Garton. 1988. Resource partitioning among forest owls in the River of No Return Wilderness, Idaho. Oecologia 75:253-265.

Johnsgard, P. 2002. North American owls. Smithsonian Institute Press, Washington, DC, USA.

Lewis, S. B., M. R. Fuller, and K. Titus. 2004. A comparison of 3 methods for assessing raptor diet during the breeding season. Wildlife Society Bulletin 32:373-385.

Lewis, S. B., K. Titus, M. R. Fuller. 2006. Northern Goshawk diet during the nesting season in Southeast Alaska. Journal of Wildlife Management 70:1151-1160.

Mccallum, D. A. 1994. Flammulated Owl (*Otus flammeolus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/093.

MacDonald, S. O., and J. A. Cook. 2006. The small mammals of Southeast Alaska: an identification guide to the shrews and small rodents. Museum of Southwestern Biology, University of New Mexico, Albuquerque.

MacDonald, S. O., and J. A. Cook. 2007. Mammals and amphibians of Southeast Alaska. Special Publication Number 8, Museum of Southwestern Biology, University of New Mexico, Albuquerque.

Marti, C. D., M. Bechard, F. M. Jaksic. 2007. Food Habits. In: Raptor research and management techniques (D.M. Bird and K.L. Bildstein, eds.), pp. 129-151. Hancock House Publishers, Blaine, WA.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, South Dakota, USA.

Newton, I. 1998. Population limitation in birds. Academic Press Inc., San Diego, California, USA.

Reynolds, R. T., M. H. Graham, R. L. Reiser, R. L. Bassett, P. L. Kennedy, D.A. Boyce, Jr., G. Goodwin, R. Smith, and E. L. Fisher. 1992. Management recommendations for the Northern Goshawk in the southwestern United States. U.S. Forest Service General Technical Report RM-217, Ft. Collins, Colorado, USA.

Smith, D. G., and C. R. Wilson. 1971. Notes on the winter food of Screech-Owls in central Idaho. Great Basin Naturalist 31:83-84.

Table 5.1. Pellet mass (n=125) and frequency of occurrence in pellet groups (n=48) by prey type based on pellets collected at roost and nest sites of Western Screech-Owls, Southeast Alaska, 2005–2006.

Type of prey	Pellet mass		Frequency of occurrence	
	Total (g)	Percent (%)	Number (n)	Percent (%)
Mammalian	84.5	94	46	98
Avian	2.7	3	11	23
Invertebrate	3.1	3	39	81

Table 5.2. Frequency of occurrence and proportion of biomass of small mammals in pellets regurgitated by Western Screech-Owls, Southeast Alaska, 2005–2006. We did not include unknown mammals (n=5) in the analysis because we were unable to assign an approximate biomass.

Family	Scientific name	Common name	Minimum number	Frequency	Total biomass (g)	% biomass
Soricidae	*Sorex cinereus*	Cinerus Shrew	3	0.03	11.4	0.5
	-	unknown shrew	35	0.32	133.0	5.5
Cricetidae	*Synaptomys borealis*	Northern Bog Lemming	2	0.02	60.8	2.5
	Microtus pennsylvanicus	Meadow Vole	5	0.04	177.5	7.3
	Microtus longicaudus	Long-Tailed Vole	1	0.01	45.0	1.9
	-	unknown rodent	4	0.04	128.0	5.3
	Peromyscus keeni	Keen’s Deer Mouse	60	0.54	1860.0	77.0

Table 5.3. Minimum number of invertebrates found in pellets regurgitated by Western Screech-Owls, Southeast Alaska, 2005–2006.

Order	Family	Genus	Species	Description	Minimum number
Coleoptera	-	-	-	beetles	5
	Caribidae	-	-	ground beetle	2
		Pterostichus	-	woodland ground beetle[1]	3
	Dytiscidae	Dytiscus	-	predacious diving beetle	5
	Curculionidae	-	-	snout and bark beetle	4
		Hylobius	-	snout and bark beetle	2
Hemiptera	Belostomatidae	Lethocerus	americanus	Giant Water Bug	4

[1]based on distribution likely to be a type of common black ground beetle.

Table 5.4. Identification and minimum number of prey items found in carcasses of hatch-year (n=7) and adult (n=8) Western Screech-Owls, Southeast Alaska, 1982–2007. Information was compiled from study skins (n=3) and from recently killed birds (n=12).

Owl age class	Class	Order	Family	Genus	Description	Minimum number
Hatch-year	Mammalia	-	-	-	unknown mammal	4
		Soricomorpha	Soricidae	Sorex	unknown shrew	1
	Insecta	Coleoptera	-	-	unknown beetle	4
		Coleoptera	Caribidae	Pterostichus	Common Black Ground Beetle	3
		Lepidoptera	-	-	larval stage of butterfly or moth	4
Adult	Arachnida	Araneae	Linyphiidae[1]	-	spider	2
	Insecta	Coleoptera	-	-	unknown beetle	2
		Lepidoptera	-	-	larval stage of butterfly or moth	24
		Lepidoptera	Noctuidae	-	larval stage of moth (caterpillar)	10
	Hirudinea	Annelida	-	-	earthworm	3

[1]possibly from Family Pimoidae

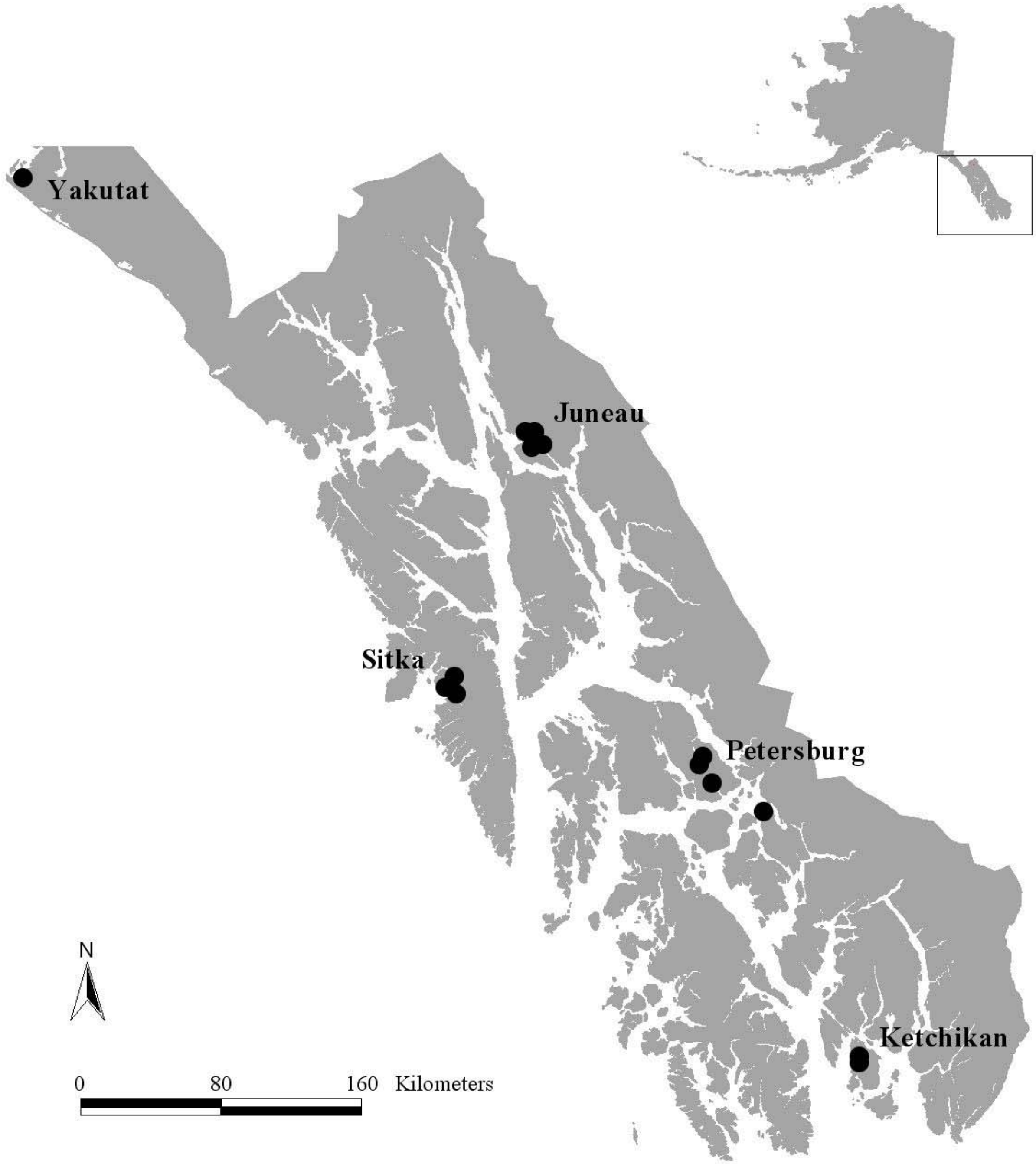

Figure 5.1. Map of study area showing Petersburg area (Mitkof Island) where the pellet collection occurred and the locations of the carcasses examined in this study of Western Screech-Owl diet, Southeast Alaska, 1982–2007.

CHAPTER 6
GENETIC VARIATION AND SEX IDENTIFCATION OF WESTERN SCREECH-OWLS *(MEGASCOPS KENNICOTTII)* IN SOUTHEAST ALASKA

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INTRODUCTION

Western Screech-Owls *(Megascops kennicottii*) inhabit western North American forests and range from Alaska through the Coastal and Rocky Mountains to Mexico (Sibley 2000, Proudfoot et al. 2007). Throughout their range there is evidence that the species is further broken into several distinct populations and perhaps subspecies based on genetic data, differences in color morphology, call patterns, and tagging studies (Cannings and Angell 2001, Proudfoot et al. 2007). It is important to understand the population structure in order to determine the status of this species and to make proper management recommendations.

We used nucleotide sequence data from two mitochondrial DNA (mtDNA) markers to investigate the amount of genetic divergence found within a small sample of Western Screech-Owls collected in Southeast Alaska. We also compared Western Screech-Owls collected in Southeast Alaska to individuals sampled from Washington and California to discern if phylogenetic structure exists among the different geographic regions. We chose to use mtDNA markers for this study because they can provide insight to contemporary population structure that may not be seen using nuclear markers. This is primarily due to the maternal inheritance pattern of mitochondria which creates an overall effective size one fourth as large as autosomal genes (Halliburton 2004). The smaller effective size in mtDNA leads to a faster rate of genetic drift among populations and can be used to describe maternal population structure in a more contemporary time frame than nuclear DNA markers. Recently studies have used mtDNA markers to standardize the categorization and species identification of many North American bird species, including the Western Screech-Owl (Kerr et al. 2007). We chose two specific mtDNA markers so we could add the results of our study to the phylogenetic structure of Western Screech-Owls previously sampled from throughout the western United States (Kerr et al. 2007, Proudfoot et al. 2007). Neither of these studies included Western Screech-Owl samples from Southeast Alaska.

We also investigated the ability of three different nuclear DNA markers to identify the sex of individual Western Screech-Owls. The absence of visually distinguishing sexual characteristics in Western Screech-Owls makes it impossible to determine the sex of an individual animal in the field without careful observation of mating or egg incubating behavior (Cannings and Angell 2001). Prior to this study the only way to determine the sex of a Western Screech-Owl was to witness mating between two birds or to surgically investigate a dead animal to identify an ovary/oviduct or testis. These methods are either very time intensive or require sacrificing the animal to obtain an answer; therefore, it has become desirable to use non-lethal sampling techniques to obtain tissue samples for molecular genetic analysis to determine the sex of Western Screech-Owls.

Molecular DNA techniques have become reliable methods to identify the sex of many non-ratite bird species (Griffiths et al. 1998, Kahn et al. 1998, Fridolfsson and Ellegren 1999). Non-lethal sampling techniques can provide tissue samples that supply relatively good-quality DNA for analysis (Jensen et al. 2003). Blood is the most common tissue sampled in birds and yields large amounts of DNA because avian red blood cells are nucleated. The DNA sexing process using whole blood from Western Screech-Owls is now readily available through commercial laboratories (e.g., Zoogen, Davis, CA). The improvement of DNA extraction techniques in the past few years has led to the ability to extract DNA from some types of feathers; however, the yield of DNA from feathers is much lower than other tissue types such as muscle or blood (Bush et al. 2005).

Female birds have heterogametic sex chromosomes Z and W while male birds have homogametic sex chromosomes ZZ (Ellegren 1996). Regions of genes located on the sex chromosomes have been targeted by molecular primers and amplified using the Polymerase Chain Reaction (PCR). The sex chromosomes in non-ratite birds do not recombine during meiosis and therefore it is possible to identify sex-specific DNA polymorphisms to determine sex of individual animals. The chromo-helicase-DNA-binding gene (CHD) is located on both of the sex chromosomes, Z and W, and has been highly conserved throughout the Class Aves (Griffiths and Tiwari 1995). PCR amplification of intronic regions of this gene produces different base pair lengths between the Z and W chromosomes (Ellegren 1996). Therefore separating these PCR products by electrophoresis yields a single band in males and two distinct bands in females. This technique is a very simple method that can easily distinguish male and female birds in most non-ratite species. However, Both Kahn et al. (1998) and Griffiths et al. (1998) report difficulty in discerning two distinct bands in some of the owl species tested in their studies. There are some owl species that have been successfully sexed using these molecular DNA methods (Table 6.1), but, these techniques have never been used to identify the sex of Western Screech-Owls.

In this paper we describe the use of three different primer pairs designed to amplify different intronic regions of the CHD gene in Western Screech-Owls. We also describe a mtDNA investigation of the phylogenetic structure of Western Screech-Owls collected throughout Southeast Alaska and compare these individuals to Western Screech-Owls from throughout their range.

METHODS

Sample collection

Tissue samples (n=17) were collected from live birds (n=10) and carcasses (n=7) throughout various mainland and island locations in Southeast Alaska, 2005-2006 (Table 6.2; Chapter 4, Appendix III). Live birds were sexed based on morphometric information and carcasses were necropsied to determine sex (Appendix III). We used the 2 known females (WESO15 and WESO16) to compare against other samples to ensure proper identification of sex in unknown birds.

Using the same samples (n=17) we investigated genetic differentiation among individuals collected in Southeast Alaska and between those collected in other parts of the Western Screech-Owl range. We obtained mtDNA sequences from Western Screech-Owls located in the western United States from the Genbank database from the National Center for Biotechnology Information (Kerr et al. 2007, Proudfoot et al. 2007).

DNA extraction

We stored tissue, feather, and blood samples in a -20^{o} C freezer. DNA from blood and tissue was extracted using a Qiagen DNeasy kit (Qiagen, California, USA) or by using a method developed by the Montana Conservation Genetics Laboratory at University of Montana (Spruell and Knudsen pers. comm.). DNA from feather samples was extracted using a modification of the Qiagen DNeasy kit (Bush et al. 2005). The extracted DNA was hydrated in Qiagen AE buffer or Tris-EDTA solution and stored in 1.5 ml tubes at 3^{o} C until analysis was complete and then permanently stored at -20^{o} C.

Identification of sex

We used three different PCR primers to amplify intronic and exonic regions of the CHD gene using an MJ Research PTC-200 thermal cycler and profiles and conditions described by the initial investigator of each primer pair.

The P8/P2 primer sequences, P8 (5'- CTCCCAAGGATGAGRAAYTG-3') and P2 (5'-TCTGCATCGCTAAATCCTTT-3'), were initially described by Griffiths et al. (1998). Fifteen µl PCR mixes for each individual contained: 2 µl of 1:50 (DNA:MiliQ-H2O), 6.72 µl MiliQ-H2O, 1 µl of 25mM $MgCl_2$, 1.5 µl of 10x PCR buffer (Promega, San Luis Obispo, California, USA), 1 µl BSA (1.0 to 1.0 µg/µL final concentration), 1.2 µl of 0.2mM dNTP mix, 0.8 µl of taq polymerase (Garvin and Gharrett 2007), and 0.75 µl of each 10 mM primer.

The 2550/2718 primer sequences, 2550F (5'-GTTACTGATTCGTCTACGAGA-3') and 2718R (5'-ATTGAAATGATCCAGTGCTTG-3'), were initially described by Fridolfsson and Ellengren (1999). Fifteen µl PCR mixes for each individual contained: 2 µl of 1:50 (DNA:MiliQ-H2O), 6.72 µl MiliQ-H2O, 1 µl of 25mM $MgCl_2$, 1.5 µl of 10x PCR buffer (Promega, San Luis Obispo, California, USA), 1 µl BSA (1.0 to 1.0 µg/µL final concentration), 1.2 µl of 0.2mM dNTP mix, 0.8 µl of taq polymerase (units unknown; Garvin and Gharrett 2007), and 0.75 µl of each 10 mM primer.

The 1237L/1272H primer sequences 1237L, (5'GAGAAACTGTGCAAAACAAG-3') and 1272H (5'-CAGAATATCTTCTGCTCC3'), were initially described by Kahn et al. (1998). Fifteen µl PCR mixes for each individual contained: 2 µl of 1:50 (DNA:MiliQ-H2O), 6.72 µl MiliQ-H2O, 1 µl of 25mM $MgCl_2$, 1.5 µl of 10x PCR buffer (Promega, San Luis Obispo, California, USA), 1 µl BSA (1.0 to 1.0 µg/µL final concentration), 1.2 µl of 0.2mM dNTP mix, 0.8 µl of taq polymerase (units unknown; Garvin and Gharrett 2007), and 0.75 µl of each 10 mM primer.

We ran PCR reactions for all three sex identification primer pairs under the following thermal cycle program: 1 min at 94^{o}C, followed by 30 sec at 94^{o}C, 1 min at 56^{o}C, and 2 min at

72°C, followed by 30 cycles of 30 sec at 94°C, 1 min at 56°C, and 2 min at 72°C, and finishing with a 5 min extension at 72°C (Jensen et al. 2003).

We separated the amplified product on a 1.5% or 3% agarose gel and stained with ethidium bromide, Gelstar™ (Cambrex, Rockland, Maine, USA) or Gelred™ (Biotium Inc., Hayward, California, USA). The stained gels were illuminated with a UV light box and photographed with a Kodak DC290 zoom digital camera. Amplified PCR product from two primer pairs, P8/P2 and 1237L/1272H, were subsequently separated on a 7 % acrylamide gel and visualized using a LI-COR model 4300 DNA analyzer (LI-COR, Lincoln, Nebraska, USA). Known female Western Screech-Owls were included on each gel to insure consistent scoring of individuals across all gels.

Mitochondrial DNA

We amplified two different regions of Western Screech-Owl mtDNA to explore for sequence differences among individuals. We used the Mk-PS2-COI primer sequences (Mk-PS2-COI-F [TTCTCCAACCACAAAGACATTGGCAC] and Mk-PS2-COI-R [ACGTGGGAGATAATTCCAAATCCTGG]) to amplify the cytocrome *c* oxidase I (COI) mitochondrial gene (Kerr et al. 2007). The Mk-Mkk-*Cytb* primer sequences (Mkk-*Cytb*-F [CAAATCATCACAGGCCTCCT] and Mkk-*Cytb*-R [GGGTTTGCTGGTGTGAAGTT]), were used to amplify cytochrome *b* (*Cytb*) mitochondrial gene (Proudfoot et al. 2006). Both primer pairs were found using GenBank using accession numbers DQ433788 for PS2-COI and DQ190851 for Mkk-*Cytb*. Primers were designed to amplify each gene from the website Primer3 (www.primer3.sourceforge.net). The 10 µl PCR mixes for each individual contained: 2 µl of 1:50 (DNA:MiliQ-H2O), 2.42 µl MiliQ-H2O, 1 µl of 25mM $MgCl_2$, 1 µl of 10x PCR buffer (Promega, San Luis Obispo, California, USA), 1 µl BSA (1.0 to 1.0 µg/µL final concentration), 1 µl of 0.2mM dNTP mix, 0.8 µl of taq polymerase (Garvin and Gharrett 2007), and 0.75 µl of each 10 mM primer.

We amplified the COI and the *Cytb* mitochondrial genes using an MJ Research PTC-200 or PTC-225 thermal cycler. We ran PCR reactions under the following thermal cycle program: 1 min at 94°C followed by six cycles of 1 min at 94°C, 1.5 min at 45°C, and 1.5 min at 72°C, followed in turn by 35 cycles of 1 min at 94°C, 1.5 min at 55°C, and 1.5 min at 72°C, and finishing with a 5 min extension at 72°C (Kerr et al. 2007).

To ensure successful amplification, we separated the PCR product on a 1.5% agarose gel and stained with Gelred^{TM} (Biotium Inc., Hayward, California, USA). We illuminated the stained gels with an ultra-violet lightbox and photographed each stain with a Kodak DC290 zoom digital camera. The amplified gene product was sent via overnight airmail to the High-Throughput Genomics Unit at the University of Washington (Seattle, Washington, USA) for sequencing.

We examined forward and reverse sequences of the PS2-COI and *Cytb* mtDNA gene segments for congruence and aligned them using Genious Pro (v3.0.6; Drummond et al. 2007). We saved high-quality forward sequences in Fasta file format and imported the files into ClustalX (v2.0; Thompson et al. 1997). We calculated unique haplotypes from a 508 base pair segment of the PS2-COI gene and a 511 base pair segment of the *Cytb* gene using DNAcollapser (v1.0; Villesen 2007). We compared individual sequences for both mtDNA markers BLAST, the Genbank taxonomy identification computer program. This method compares the mtDNA sequence from each Western Screech-Owl sample to 6,128,933 known species sequences submitted to Genbank and then calculates percent sequence divergence from the nearest found species. UPGMA dendrograms based on a Kimura 2-parmameter genetic distance (Kimura 1980) was created using PHYLIP (Felsenstein 1993) and visualized using TREEVIEW (Page 1996).

RESULTS

Extraction of DNA from feathers

Feathers were the only tissue sampled from 3 of 17 Western Screech-Owls (Table 6.2). Unfortunately, we had no success in amplifying DNA from the feather samples of these individuals, whereas all other individuals provided adequate DNA for PCR amplification. This is mostly likely due to the absence of skin or fleshy pulp from the base of the feather tip. Therefore, 14 individuals were used for the subsequent analysis.

Identification of sex

The identification of sex for all 3 primer pairs used was inconclusive on agarose gels. Two of the primer pairs, P8/P2 and 1237L/1272H, produced a single band across all individuals (Figures 6.1 and 6.2). Polymorphism was detected in the third primer pair, 2550/2718, but, instead of showing two bands for female and one single band for males, there were cases where an alternate homozygote amplified in some individuals (Figure 6.3). These results indicate that there was recombination occurring for the segment of the CHD gene amplified by this marker, and therefore, it is not a useful marker to determine sex in this species.

PCR products from the primer pairs, P8/P2 and 1237L/1272H, were separated on a 7 % acrylamide gel to increase the resolution and to distinguish separate banding patterns. However, both sets of primers amplified only a single band across all individuals including putative known females. Therefore, these markers can not be used to identify sex in this species.

Mitochondrial DNA

For the 16 Western Screech-Owl samples that were successfully sequenced at the *PS2_COI* mtDNA gene segment, we found 5 unique haplotypes (Table 6.3). Three individuals from Washington and 4 individuals from Southeast Alaska shared a unique haplotype (Table 6.3, Figure 6.4). For the 12 Western Screech-Owls that were successfully sequenced at the *Cytb* mtDNA gene segment we found 9 unique haplotypes (Table 6.4, Figure 6.5). The individual from California (*M. k. bendierei*) and the individual from Washington (*M. k. kennicottii*) shared a unique haplotype with two birds from Southeast Alaska (Table 6.4, Figure 6.5).

All of the Western Screech-Owls collected in Southeast Alaska had less than 1% sequence divergence from animals submitted to Genbank and classified as *M. k. kennicottii-provisional species 2* at the *PS2_COI* mtDNA mitochondrial marker. At the *Cytb* marker nearly all Western Screech-Owls had less than 2% sequence divergence from the animals submitted to Genbank (*M. k. bendierei* and *M. k. kennicottii*; Proudfoot et al. 2007) and therefore are considered to be part of *M. k. kenicottii-provisional species 2*. One owl (WESO13) from Southeast Alaska showed a 3% sequence divergence from the owls submitted to Genbank and classified as *M. k. kenicottii-provisional species 2* at the *Cytb* marker; however, this individual had < 1% sequence divergence at the *PS2_COI* marker.

When phylogenetic divergence is visualized on a UPGMA dendrogram (Figures 6.4 and 6.5) there does not appear to be a geographic-specific pattern that arises at either mtDNA marker to support population structure in the maternal linage of Western Screech-Owls sampled from Southeast Alaska compared to owls sampled in Washington and California. This finding is congruent with our results indicating that Western Screech-Owls from Washington and California share unique haplotypes with owls sampled in Southeast Alaska (Tables 6.3 and 6.4).

DISCUSSION

Identification of sex

We were unable to determine the sex of individual owls using nuclear markers that targeted regions of the CHD gene on the sex chromosomes, Z and W, of Western Screech-Owls. All of the initial investigators that developed sex identification primers described having difficulty in identifying the sex of some owl species (Griffiths et al. 1998, Kahn et al. 1998, Fridolfsson and Ellegren 1999). Two of the primer pairs, P8/P2 and 1237L/1272H, produced a single band across all individuals (Figures 6.1 and 6.2). A 2-band polymorphism was detected in the third primer pair, 2550/2718, but, instead of showing 2 bands for female and 1 single band for males, there were cases where an alternate homozygote amplified in some individuals and a case where a single band was amplified in a known female (Figure 6.3). These results indicate that there was likely recombination occurring for the segment of the CHD gene amplified and this marker can not be used to determine sex in this species.

We tried to increase the resolution of the 2 markers (P8/P2 and 1237L/1272H) that produced only one band on agarose gels by using fluorescently-labeled forward primers and running the amplified PCR product on a 7% poly acrylamide gel. Unfortunately, the results conclusively showed that only one band was amplified in the PCR reaction. The next step toward resolving whether either of these 2 markers can be used for sexing Western Screech-Owls would be to sequence the amplified product and look for sex specific nucleotide divergence.

Mitochondrial DNA

The UPGMA dendrograms show a very small amount of genetic divergence found within and among the samples collected from Southeast Alaska, Washington, and California. In fact some of the Western Screech-Owls collected from Washington and California cluster together in the same clade on both of the UPGAMA dendrograms with individuals collected from Southeast Alaska. There does not appear to be a geographic-specific pattern that arises at either mtDNA marker used in this study to support population structure in the maternal linage of Western Screech-Owls sampled from Southeast Alaska compared to owls from Washington and California. These results suggest that the Western Screech-Owls from Southeast Alaska are members of the subspecies *M. k. kennicotii-provisional species 2* that ranges from coastal Southeast Alaska to California. The results from the *Cytb* marker suggest that the animals collected from Southeast Alaska have approximately 2.5% sequence divergence from owls collected in Idaho (*M. k. macfarlanei*) and the Sierra Nevada Mountains (*M. k. aikeni*). This finding is similar to Proudfoot et al. (2007), who suggested that there are greater latitudinal barriers to gene flow than longitudinal in the western range of this species. These results do not rule out the possibility of geographic groups of *M. k. kennicotii-provisional species 2* being further subdivided into distinct populations, especially given the very small sample size we used in this study. Because these Western Screech-Owls are residents of Southeast Alaska and are known to hold territories year-round (Cannings and Angell 2001), we recommend further investigation of the population structure of this species. We suggest collecting samples from Prince of Wales Island, Ketchikan, Kuiu Island, Admiralty Island, Wrangell Island, and the mainland of Southeast Alaska (including Yakutat). Our small effort described in this paper constitutes a useful pilot study, but we lacked a sufficient sample from the region to evaluate genetic differentiation of Western Screech-Owls in Southeast Alaska. We also recommend exploring the use of nuclear genetic markers, such as microsatellite loci, in future analyses.

LITERATURE CITED

Bush, K. L., M. D. Vinsky, C. L. Aldridge, and C. A. Paszkowski. 2005. A comparison of sample types varying in invasiveness for use in DNA sex determination in an endangered population of Greater Sage-Grouse (*Centrocercus uropihasianus*). Conservation Genetics 6:867-870.

Cannings, R. J., and T. Angell. 2001. Western Screech-Owl (*Otus kennicottii*). *In* The Birds of North America, No. 597 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Drummond A.J., B. Ashton, M. Cheung, J. Heled, M. Kearse, R. Moir, S. Stones-Havas, T. Thierer, A. Wilson. 2007. Geneious v3.0.6. Available from http://www.geneious.com/

Ellegren, H. 1996. First gene on the avian W chromosome (CHD) provides a tag for universal sexing of non-ratite birds. Proceedings of the Royal Society of London Series, B-Biological Sciences 263:1635-1641.

Felsenstein, J. 1993. PHYLIP, Phylogeny Inference Package, v3.5c. Department of Genetics, University of Washington, Seattle.

Fridolfsson, A. K., and H. Ellegren. 1999. A simple and universal method for molecular sexing of non-ratite birds. Journal of Avian Biology 30:116-121.

Garvin, M. R., and A. J. Gharrett. 2007. DEco-TILLING: an inexpensive method for single nucleotide polymorphism discovery that reduces ascertainment bias. Molecular Ecology Notes 7: 735–746.

Griffiths, R., M. C. Double, K. Orr, and R. J. G. Dawson. 1998. A DNA test to sex most birds. Molecular Ecology 7:1071-1075.

Griffiths, R., and B. Tiwari. 1995. Sex of the last wild Spix's Macaw (*Cyanopsitta spixii*). Nature 375:454-454.

Halliburton, R. 2004. Introduction to population genetics. Pearson Prentice Hall, Upper Saddle River, NJ, USA.

Jensen, T., F. M. Pernasetti, and B. Durrant. 2003. Conditions for rapid sex determination in 47 avian species by PCR of genomic DNA from blood, shell-membrane blood vessels, and feathers. Zoo Biology 22:561-571.

Kahn, N. W., J. St. John, and T. W. Quinn. 1998. Chromosome-specific intron size differences in the avian CHD gene provide an efficient method for sex identification in birds. Auk 115:1074-1078.

Kerr, K. C. R., M. Y. Stoeckle, C. J. Dove, L. A. Weigt, C. M. Francis, and P. D. N. Hebert. 2007. Comprehensive DNA barcode coverage of North American birds. Molecular Ecology Notes 7:535-543.

Kimura, M. 1980. A simple model for estimating evolutionary rates of base substitutions through comparative studies of nucleotide sequences. Journal of Molecular Evolution 16:111-120.

Page, R. D. M. 1996. TreeView: an application to display phylogenetic trees on personal computers. Computer Applications in the Biosciences 12:357-358.

Proudfoot, G. A., F. R. Gehlbach, and R. L. Honeycutt. 2007. Mitochondrial DNA variation and phylogeny of the Eastern and Western Screech-Owls. Condor 109:617-627.

Proudfoot, G. A., R. L. Honeycutt, and R. D. Slack. 2006. Mitochondrial DNA variation and phylogeography of the Ferruginous Pygmy-Owl (*Glaucidium brasilianum*). Conservation Genetics 7:1-12.

Sibley, D, A. 2000. The Sibley Guide to Birds. Random House Books, New York, NY, USA.

Thompson J. D, T. J. Gibson, F. Plewniak, F. Jeanmougin, and D. G. Higgins. 1997. Nucleic Acids Research 25: 4876-4882.

Villesen, P. 2007. FaBox: an online toolbox for fasta sequences. Molecular Ecology Notes 7:965-968.

Table 6.1. Members of the family Strigidae that have been successfully sexed using molecular genetic analysis of the CHD gene on the Z and W chromosomes.

Common name	Scientific name	PCR primers	Electrophoretic method	Reference
Boreal Owl	*Aegolius funereus*	2550/2718	Agarose	Fridolfsson and Ellengren 1999
Great Grey Owl	*Strix nebulosa*	2550/2718	Agarose	Fridolfsson and Ellengren 1999
Morepork	*Ninox novaseelaniiae*	P2/P8	Acrylamide	Griffiths et al. 1998
Tawny Owl	*Strix aluco*	P2/P8	Acrylamide	Griffiths et al. 1998
Great Horned Owl	*Bubo virginianus*	1237/1272	Acrylamide	Kahn et al. 1998

Table 6.2. Source information for Western Screech-Owls (n=24) used in this study. Individuals with band numbers were live owls; the remainder were carcasses or were owls located in the Genbank database. Sex followed by "?" indicates that sex was determined based on morphometric information (Appendix III); otherwise, sex was determined by reproductive organs during necropsy.

Bird ID	mtDNA Analysis Code	Date Collected	Location Collected	Band Number	Sample Type	Tissue Type	Genbank Accession Number	Sex
WESO03	-	3/17/2006	Mitkof Island, AK	894-57371	Live bird	Feather	-	F?
WESO04	-	3/27/2006	Mitkof Island, AK	934-17861	Live bird	Feather	-	M?
WESO05	-	4/3/2006	Mitkof Island, AK	894-57372	Live bird	Feather	-	M?
WESO06	SEAK06	4/14/2006	Mitkof Island, AK	894-57373	Live bird	Blood	-	F?
WESO07	SEAK07	4/22/2006	Mitkof Island, AK	934-17862	Live bird	Blood	-	M?
WESO08	SEAK08	4/24/2006	Mitkof Island, AK	894-57374	Live bird	Blood	-	F?
WESO09	SEAK09	5/11/2006	Mitkof Island, AK	894-57375	Live bird	Blood	-	M?
WESO10	SEAK10	5/11/2006	Mitkof Island, AK	934-17863	Live bird	Blood	-	M?
WESO12	SEAK12	11/16/2006	Sitka, AK	894-57356	Live bird	Blood	-	-
WESO13	SEAK13	12/4/2006	Sitka, AK	-	Live bird	Blood	-	-
WESO14	SEAK14	11/17/2006	Sitka, AK	-	Carcass	Muscle	-	-
WESO15	SEAK15	11/30/2006	Juneau, AK	-	Carcass	Muscle	-	F
WESO16	SEAK16	9/2/2006	Mitkof Island, AK	-	Carcass	Muscle	-	F
WESO17	SEAK17	6/20/2006	Mitkof Island, AK	-	Carcass	Muscle	-	-
WESO18	SEAK18	11/30/2006	Kupreanof Island, AK	-	Carcass	Muscle	-	M
WESO19	SEAK19	12/11/2006	Ketchikan, AK	-	Carcass	Muscle	-	M
WESO20	SEAK20	9/6/2005	Ketchikan, AK	-	Carcass	Muscle	-	M
WASH01	WASH01	-	King County, WA	-	-	-	DQ433788	-
WASH02	WASH02	-	King County, WA	-	-	-	DQ433787	-
WASH03	WASH03	5/14/1999	Skagit County, WA	-	-	-	DQ433786	-
WASH04	WASH04	-	Kittitas County, WA	-	-	-	DQ43008	-
WASH05	WASH05	-	Kitsap County, WA	-	-	-	DQ433007	-
WASH Mkk	WASH Mkk	-	Washington State	-	-	-	DQ190851	-
CAL Mkb	CAL Mkb	-	California State	-	-	-	DQ190850	-

Table 6.3. Haplotypes found at the *PS2_COI* mtDNA marker in 11 Western Screech-Owls from Southeast Alaska and 5 Western Screech-Owls from western Washington. For all owls, 508 base pairs were used.

Haplotype	Frequency	Individual Haplotypes
1	31.3%	SEAK06 SEAK08 SEAK09 SEAK10 SEAK18
2	43.8%	SEAK12 SEAK13 SEAK19 SEAK20 WASH01 WASH05 WASH04
3	6.3%	WASH03
4	6.3%	WASH02
5	12.5%	SEAK14 SEAK17

Table 6.4. Haplotypes found at the *Cytb* mtDNA marker in 10 Western Screech-Owls from Southeast Alaska, 1 Western Screech-Owl from western Washington, and 1 Western Screech-Owl from western California . For all owls, 511 based pairs were used.

Haplotype	Frequency	Individual Haplotypes
1	8.3%	SEAK09
2	8.3%	SEAK10
3	8.3%	SEAK06
4	8.3%	SEAK13
5	8.3%	SEAK07
6	8.3%	SEAK14
7	8.3%	SEAK19
8	8.3%	SEAK20
9	33.3%	SEAK16 SEAK18 CAL Mkb WASH Mkk

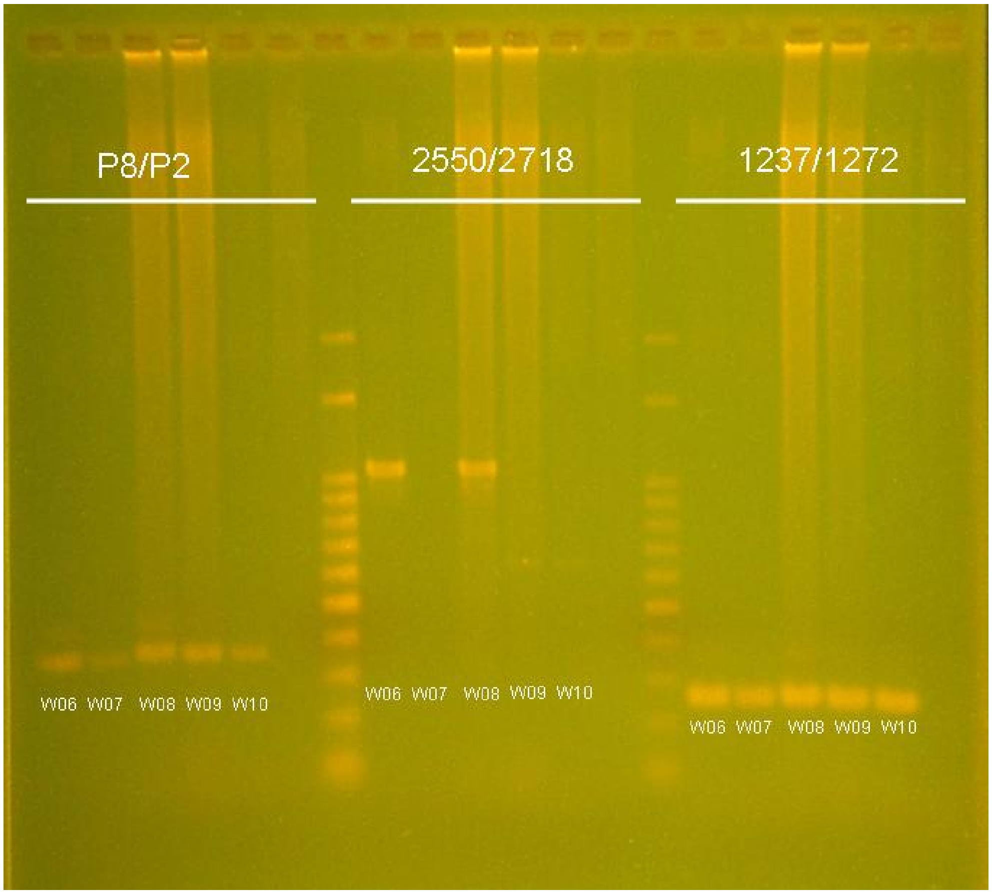

Figure 6.1. A 3% agarose gel stained with ethidium bromide showing 3 primer pairs used to identify sex in Western Screech-Owls.

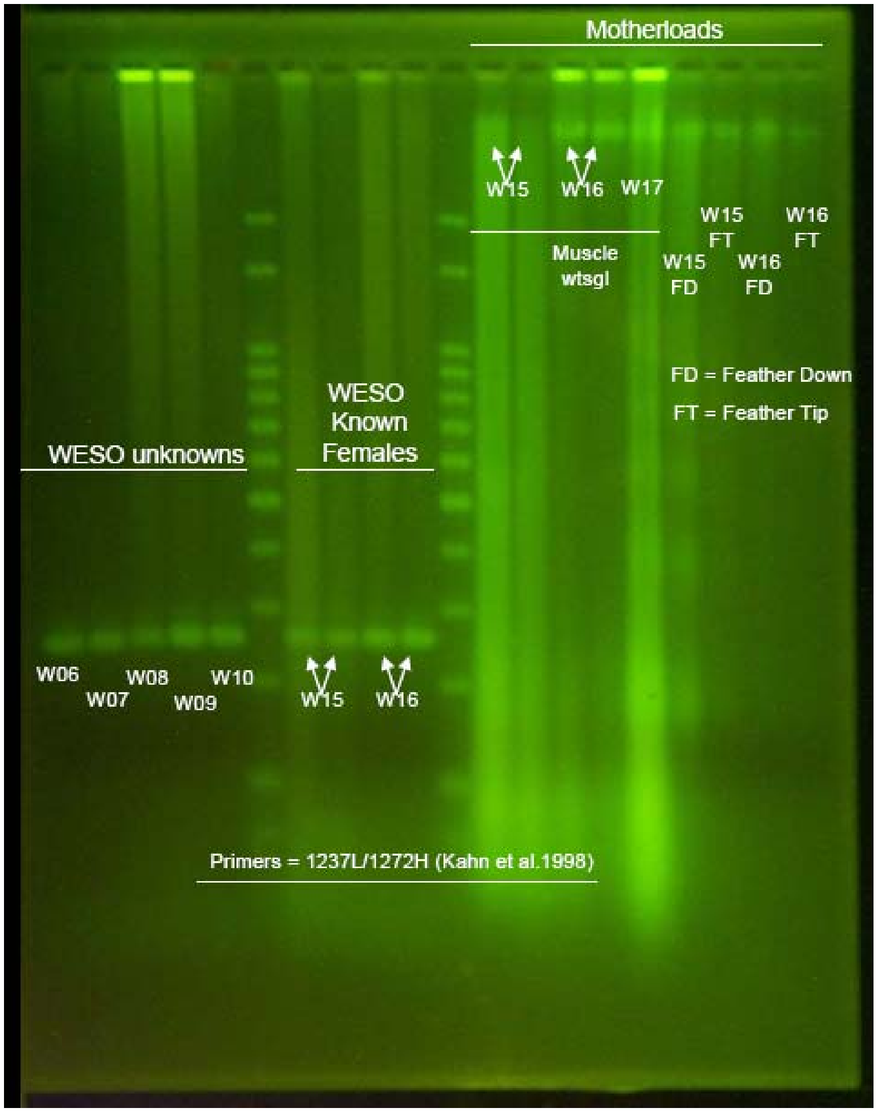

Figure 6.2. A 3% agarose gel with unknown Western Screech-Owls and known female Western Screech-Owls amplified with 1237L/11272H primers and DNA stock to verify success of amplifying feathers. The gel was stained with Gel Star and visualized using an ultra-violet lightbox. The known female samples do not show two distinct bands, suggesting that the product should be separated on a 7% acrylamide gel.

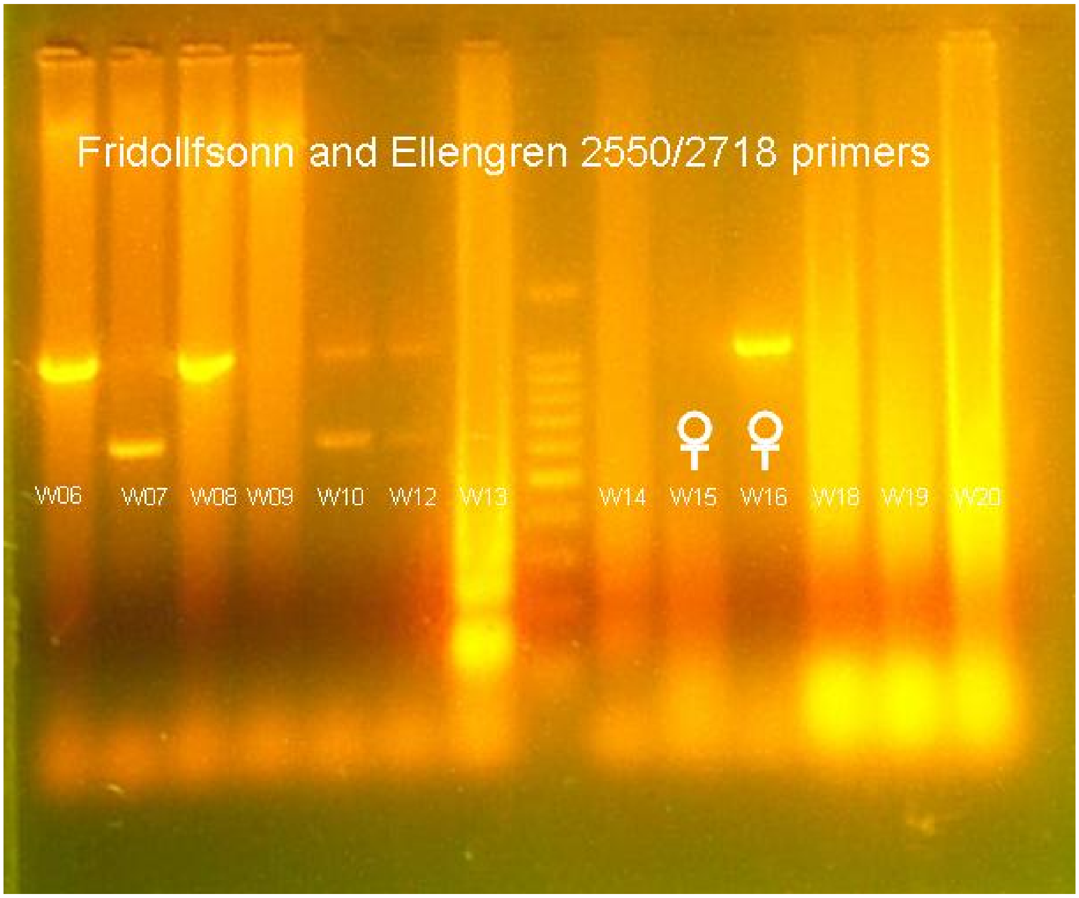

Figure 6.3. A 3% agarose gel with unknown Western Screech-Owls and known female Western Screech-Owls amplified with 2550/2718 primer pairs. The gel was stained with Gel Red and visualized using an ultra-violet lightbox. Known female samples do not have two distinct bands, and single band or double bands show up for the unknown birds. There are also alternate homozygotes for this primer pair suggesting that there is recombination between this region of the sex chromosome during meiosis. Therefore, this marker can not be used to distinguish sex in this species.

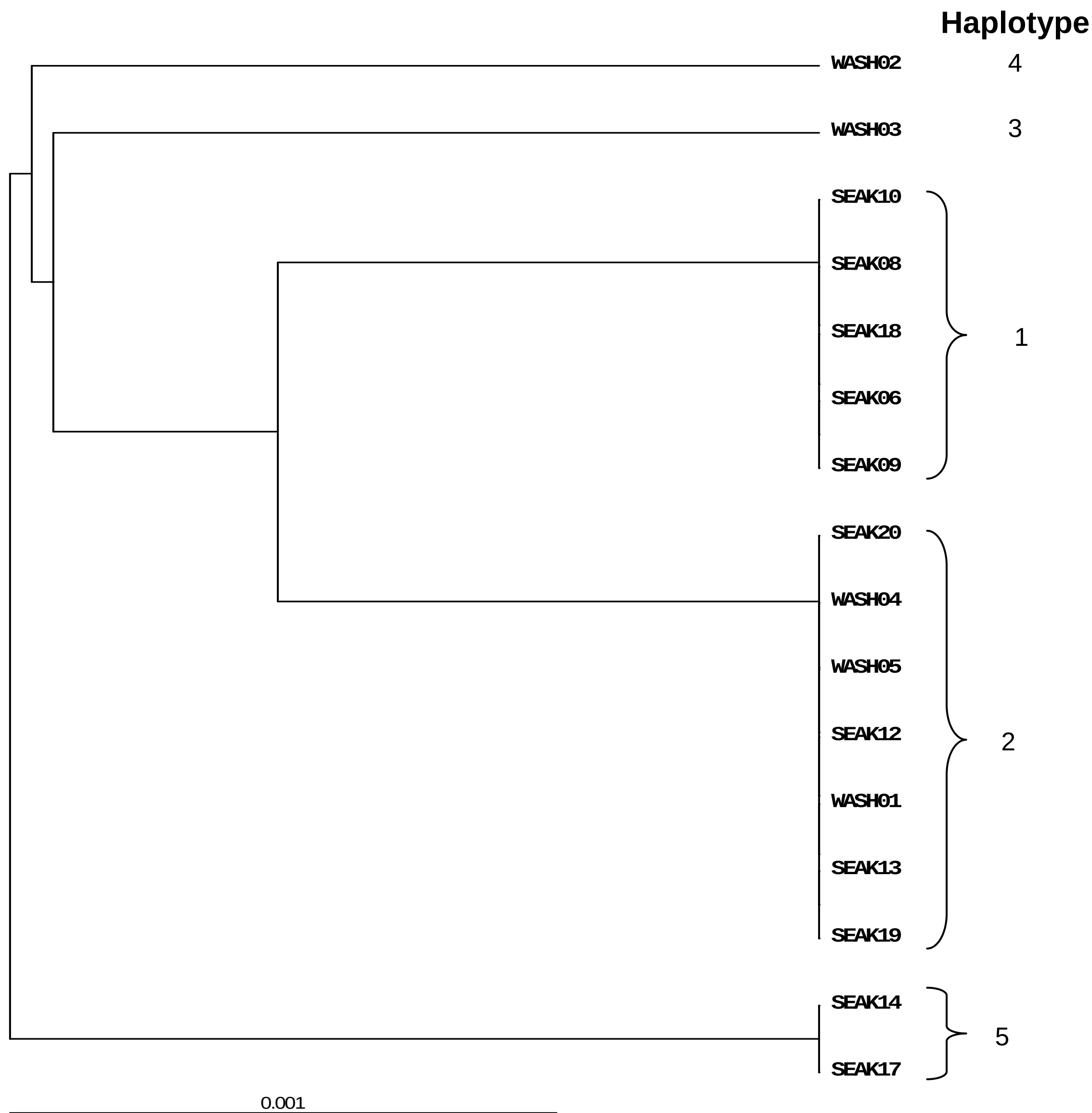

Figure 6.4. A UPGMA dendrogram constructed using Kimura 2-parameter genetic distance from the mtDNA *PS2-COI* marker sequence data from Western Screech-Owls. The dendrogram branch labels denote individual birds from different sample locations (Table 6.2). The haplotype numbers denote unique sequences shared among individuals (Table 6.3).

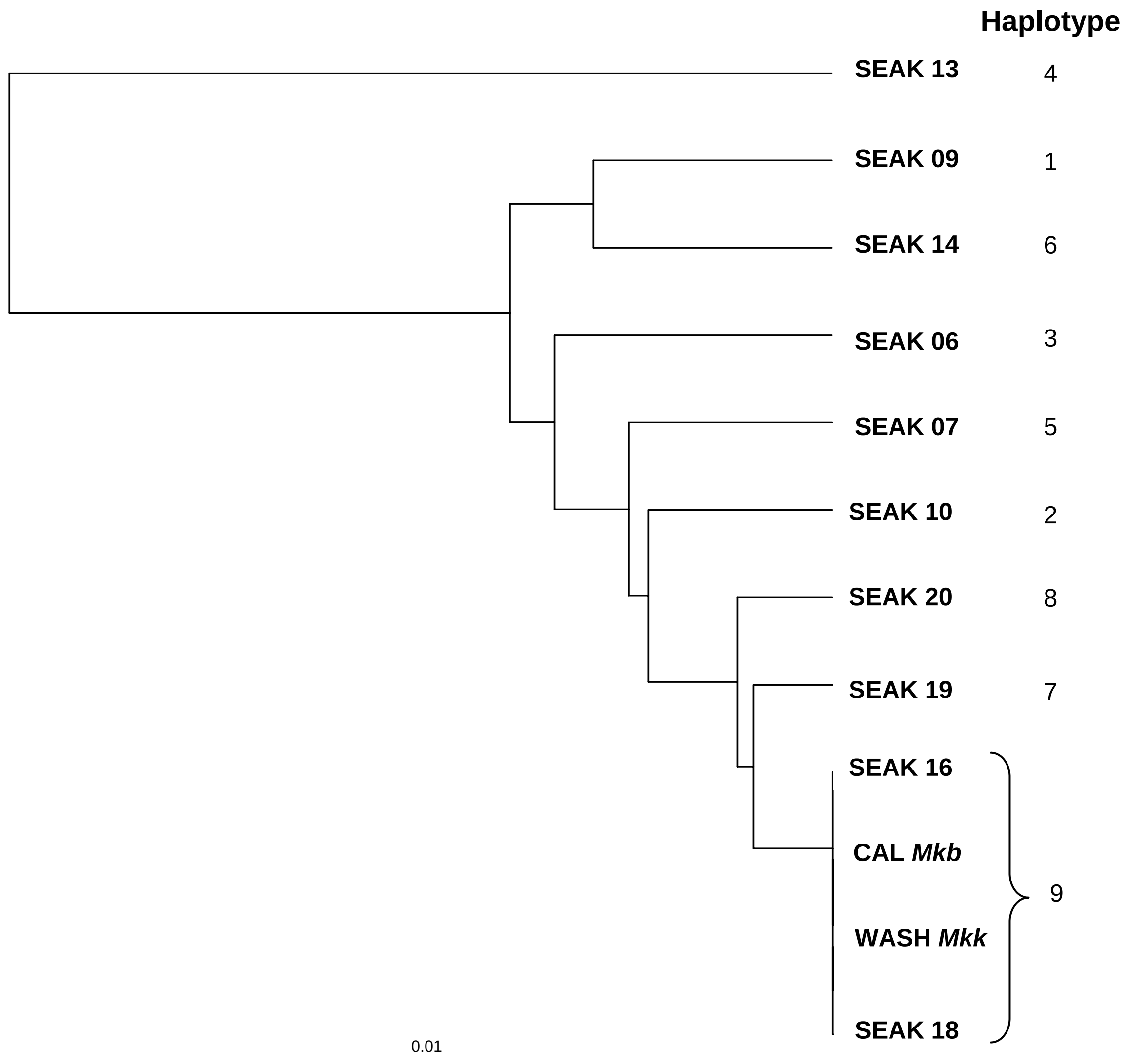

Figure 6.5. A UPGMA dendrogram constructed using Kimura 2-parameter genetic distance from the mtDNA *Cytb* marker sequence data from Western Screech-Owls. The dendrogram branch labels denote individual birds from different sample locations (Table 6.2). The haplotype numbers denote unique sequences shared among individuals (Table 6.4).

OVERALL DISCUSSION

Nocturnal owls are a difficult group of birds to study. Most species are primarily active at night when working conditions can be challenging at best. In addition, they occur in relatively low densities, making it difficult to reach sufficient sample sizes for population-level monitoring. For these reasons, relatively little has been learned about owl distribution, abundance, and ecology, especially in Alaska where distances are large and access is limited. The lack of knowledge about this unique species group in Alaska prompted them to be highlighted in the recently drafted Comprehensive Wildlife Conservation Strategy (Alaska Department of Fish and Game 2006). In response to that strategy, we aimed to learn about nocturnal forest owls in Southeast Alaska.

Southeast Alaska Owl Network

To assist us in documenting owl occurrence throughout the year and across the entire region, we created the Southeast Alaska Owl Network (hereafter, SEAKON). Working with the Juneau Raptor Center (JRC), we recruited members of the public with an interest in owls and wildlife. We made public presentations in 6 communities (Juneau, Petersburg, Sitka, Ketchikan, Wrangell, and Craig) around Southeast Alaska to generate interest in owl conservation, explain the need to gain information on owls, and identify potential volunteers. We enlisted 46 volunteers and agency personnel from 14 Southeast Alaskan communities to conduct owl surveys over 4 years (2005-2008). Using our JRC SEAKON Coordinator, we distributed training materials, protocols, datasheets, and equipment to volunteers. We used these survey data to estimate site occupancy and changes in occupancy of 3 common owl species (Northern Saw-Whet Owl, Western Screech-Owl, and Barred Owl; Chapter 2). An additional 134 individuals submitted owl sightings to SEAKON; these sightings assisted in documenting seasonal variation of all owl species in Southeast Alaska (Appendix II).

The SEAKON proved to be an extremely valuable resource for completion of the region-wide survey. Most of our volunteers were exemplary, but, as with most volunteer-based programs (e.g., Breeding Bird Survey), there were inherent challenges to overcome. Coordinating the SEAKON was time-consuming at some times of the year and, at those times, required more time than a partially-volunteer coordinator could afford. Some volunteers were unavailable during part or all of the survey period (e.g., other commitments, travel) or had permanently moved without informing the SEAKON Coordinator, leaving us scrambling to find a new volunteer before surveys were scheduled to begin. A few volunteers were unwilling to participate in broadcast surveys because of potential disturbance to the owls; we worked directly with these volunteers on a survey protocol that would still collect valuable data without compromising their principles. On occasion, we received incomplete datasheets from volunteers, which prevented us from using some of the data in our final analyses. Similarly, many volunteers failed to document survey hours in the timesheet format required by the State Wildlife Grant Program and therefore, we estimate that roughly 30% of non-federal match (required for the grant that supported this project) was lost because of documentation issues. We received feedback that this step was an excessive burden and only reduced enthusiasm to participate in SEAKON and some volunteers ceased participating in surveys because of the extra steps required of them. Overall, the benefits of the SEAKON exceeded the drawbacks, particularly in terms of generating interest in owls, educating the public and school groups on the conservation of owls in Southeast Alaska, surveying relatively remote areas that otherwise we would not have been able to reach, and providing data for a region-wide survey.

Owl surveys

We developed an efficient survey protocol for monitoring populations of nocturnal forest owls. We dedicated our entire first year of study to evaluating survey methods and design, considering the allocation of survey effort, and identifying sources of variation in detection probabilities (Chapter 1). We were particularly concerned with imperfect detection of owls at survey stations; information is lost when a site is surveyed but no owl is detected because it is not clear if the site is not occupied by an owl or if it is occupied but the owl was not detected. Because we expected owls to occur in relatively low densities in Southeast Alaska, we wanted to design a survey protocol that maximized detection probabilities. Therefore, we tried to estimate and incorporate detection probabilities into the survey protocol to ensure unbiased results and to get the most out of our survey effort.

At the conclusion of the first field season, we developed a survey protocol that was appropriate for the landscape and weather conditions of Southeast Alaska (Appendix I). We did not explicitly broadcast for Northern Saw-Whet Owls in order to maximize efficiency; we expected owls to be rare on the landscape and therefore, we believed it was more productive to spend less time at each station and more time surveying additional stations. Furthermore, detection rates of Northern Saw-Whet Owls during surveys conducted in British Columbia were relatively high (D. Cannings, pers. comm.). We may have detected a few more Northern Saw-Whet Owls during our surveys if we had broadcast for them specifically, but we do not think that the additional time required at each station would have outweighed the benefit of surveying additional stations. Nor do we believe that our results would have been different. We broadcast for owls in order of increasing size (i.e., Western Screech-Owl was always followed by Barred Owl calls). Although one could argue that broadcasting the calls in random order would be more statistically valid, our results demonstrate that the presence of larger owls negatively affects the detection probability of smaller owls. It is illogical to think that the reverse would be true, but we did not explicitly test this. The final protocol used in this study is compatible with owl surveys that have been conducted across Canada and a few select areas in the United States since 2000 (Takats et al. 2001).

During the early stages of this study, a derivative of mark-recapture methodology was being refined to estimate occupancy probabilities while accounting for imperfect detectability. The proportion of sites occupied can be a surrogate for abundance of owls in the region (MacKenzie et al. 2006) and because it has a measure of the variability in the data, can be repeated to learn if site occupancy is changing over time. After careful evaluation, we concluded that this approach has several advantages for monitoring populations of nocturnal owls in Southeast Alaska. First, occupancy modeling incorporates heterogeneity in detection probabilities. Second, this technique provides a measure of confidence on the occupancy estimates. Third, occupancy modeling relies on presence-absence data and therefore, it is realistic to achieve adequate sample sizes to estimate occupancy of rare species. We believe this approach offers an efficient and economical method for monitoring nocturnal owls in Southeast Alaska and elsewhere.

We estimated occupancy of the 3 most common owl species (Northern Saw-Whet Owl, Western Screech-Owl, and Barred Owl) in Southeast Alaska using methods developed by MacKenzie et al. (2006). In addition, we identified habitat features associated with occupancy and factors influencing detectability of these species (Chapter 2). During the course of the study, we learned of an owl survey designed and conducted by L. Suring (USFS) in the late 1980s and early 1990s in Southeast Alaska. Suring agreed to share his data with us to evaluate trends in owl numbers over the 2 time periods (1986-1992 and 2005-2008). Although survey techniques differed slightly, we were able to model site occupancy and trend across the time periods by making several realistic assumptions. Most notably, we were unable to estimate detection probabilities directly for the historical data; instead we applied detection probabilities from our study to the historical data and assumed that we encountered similar conditions (e.g., weather) during our surveys. After close examination of our protocol with that used during the historical surveys, we believe this was a reasonable assumption. Our collaborative effort with Suring resulted in valuable information on the status of 3 owl species in Southeast Alaska by utilizing previously-gathered data that would otherwise have not been reported.

The biggest roadblock to completion of owl surveys throughout the region was weather conditions, specifically snowfall and the resulting closure of roads. Due to record snowfall during the winter of 2006-2007, we were not able to complete surveys at many sites that had been accessible during previous years and few sites were repeatedly surveyed within that winter. In fact, above average snowfall over the last 3 years resulted in fewer sites being surveyed overall. This affected our ability to run a multi-season analysis to estimate occupancy, colonization, and extinction rates. Ultimately, this would be the most valuable information to have in order to evaluate the status of forest owls in Southeast Alaska.

We evaluated techniques to conduct owl surveys without having to rely on roads. We considered using skiffs to survey forests adjacent to the shoreline and snow machines to access snow-covered areas (mostly in higher elevations). We quickly concluded that trying to survey at night from a skiff was not only too dangerous, but also that it would be difficult to hear owls over the noise of the water and boat. Snow machines are used to conduct surveys in other locations (e.g., Rocky Mountains, Yukon-Charley National Park). However, snow machines are not readily available throughout Southeast Alaska (as they are in other regions) and it would be cost-prohibitive to transport individual machines throughout the region. We considered walking to survey stations along trails accessed from the road system, but it would be difficult to survey more than a few stations in a night and would still require using a road system for access. New technology with automated recording systems (e.g., “frogloggers”) may provide a technique for estimating occupancy of owls at random or remote stations.

Owl ecology

In an effort to learn about Western Screech-Owl detectability in relation to breeding stage, we captured 10 screech-owls over 2 years. We refined existing techniques for capture of owls to conditions in Southeast Alaska's temperate rainforest. Using those radio marked birds, we provide some of the first data on Western Screech-Owl roosts, nests, and nest sites. Similar to other areas, Western Screech-Owls are found near valley bottoms with larger streams in Southeast Alaska. These are the types of forests important for other wildlife (e.g., bears and salmon). Their use area size is larger than other conspecifics, likely reflecting the depauperate prey base of the area.

While locating screech-owl roosts and nests, we collected pellets and analyzed them to describe their diet in Southeast Alaska. Small mammals make up a large portion of the screech-owl diet, which is supplemented with invertebrates and the occasional bird. Using owl pellet collections has some biases regarding the type of prey that are often found with it but is useful for describing the general prey that are important. In addition, pellets can be useful for documenting rare small mammals in an area. For example, 2 Northern Bog Lemmings were detected in screech-owl pellets from Mitkof Island. While it is not surprising to detect this species on Mitkof Island, no specimens of this small mammal had been recorded here (MacDonald and Cook 2007). On islands where potentially rare, endemic small mammals might occur, studying owl diet could be used to detect and possibly monitor small mammals.

Outreach

We presented information about owls and preliminary results of our study in 6 communities in Southeast Alaska over the 4 years (2005-2008). We conducted 2 demonstrations with school groups (Petersburg, Sitka) to teach children about owl biology and conservation. We participated in the production of 3 radio programs (Petersburg, Sitka, Juneau) about this study and have written 2 articles for the Juneau Empire and 1 for the Alaska Science Forum in Fairbanks (N. Rozell). We produced 3 Southeast Alaska Owl Network Newsletters to update members on our results and keep interest in owls alive. In collaboration with Dick Cannings, we also wrote an article for the Bird Studies Canada Nocturnal Owl Survey Program annual newsletter.

We presented results of this study at several professional ornithological meetings, including the IV North American Ornithological Conference in 2006, the Alaska Chapter of The Wildlife Society in 2007, the 11th and 13th Alaska Bird Conferences (2006 & 2008), as well as at annual Boreal Partners-in-Flight meetings. Finally, we participated in an owl working group with Boreal Partners-in-Flight.

OVERALL RECOMMENDATIONS

Long-term monitoring of forest owl populations in Southeast Alaska

We designed and conducted a region-wide survey for nocturnal owls in Southeast Alaska. We recommend that this survey be repeated annually to estimate colonization and extinction rates because these values would be most useful for management purposes. If annual surveys are cost-prohibitive, we recommend repeating surveys at 2- or 3-year intervals to monitor trends in occupancy of the more common owls of Southeast Alaska's forests. This survey could involve collaboration between ADF&G's Nongame Program, the USDA Forest Service, and the U.S. Fish and Wildlife Service, as well as volunteers from SEAKON.

1. We provide a protocol for conducting surveys for nocturnal owls (see Appendix I), specifically Western Screech-Owls and Barred Owls. If other owls are of interest, the protocol could easily be modified to accommodate them. If broadcast segments for additional species are included, we recommend broadcasting calls in the order of increasing owl size (i.e., smallest to largest owl) and using the same time intervals (i.e., 30 sec-60 sec-30 sec-60 sec). Examples of possible modifications to the existing protocol may include:
    a. Northern Saw-Whet Owls could be specifically surveyed for by adding a broadcast segment for them. We suggest that this extra effort would be warranted only if this species is the primary study subject.
    b. Detection rates of Northern Pygmy-Owls might increase if surveys were conducted during hours around sunset and sunrise, as has been found in other studies (Holt and Petersen 2000). In total, we detected 12 Northern Pygmy-Owls during our study and those individuals were detected evenly throughout the night (ranging from 52 min to 5 hrs 2 min after sunset) and therefore, Northern Pygmy-Owl behavior may be different in northern latitudes.

   c. Great Horned Owls would require surveys to start much earlier (i.e., February) because these owls begin breeding attempts then (Houston et al. 1998).

2. To maximize efficiency in occupancy surveys, we recommend increasing detection probabilities of target species. In our protocol, we provide advice on conditions to avoid during surveys (e.g., adverse weather conditions, loud noise) and variables to measure during surveys to account for detectability issues in the occupancy-modeling process. All data sheets should be completed properly, including all weather and noise variables and coordinates from a GPS unit.
3. We recommend a minimum of 200 stations across the region to monitor occupancy of target owl species. These sites should be visited 3 times during the survey season. There is a trade-off between number of sites that can be visited and the number of visits at each site. The survey we executed was designed based on using volunteers from various communities across the region to conduct the bulk of the surveys. Thus, most surveys were located close to cities or towns. Future surveys, utilizing agency personnel, could incorporate additional sites further away from population centers (i.e., sites requiring greater logistics to reach). In addition, if an understanding of owl occupancy was desired at a smaller scale than the region (e.g., a FS District), additional sites could be added at that level of spatial resolution to resolve finer scale differences in site occupancy.
4. Despite some of the hurdles we encountered with the SEAKON, we believe that a volunteer-based program for monitoring owls in Southeast Alaska could be successful with a few minor improvements. Compared to other species groups in Southeast Alaska, owls are by far the easiest to employ volunteer surveyors. First, only a few species (<5) are regularly encountered and those species have fairly distinct calls that are difficult to confuse, especially with training. Second, because road-based surveys are the standard method, nearly everyone can participate (e.g., all age groups). We recommend the following if a volunteer-based owl monitoring program is implemented in Southeast Alaska:
   a. Create a web-based data submission platform that allows volunteers to enter and submit survey data. We collaborated with Bird Studies Canada (contact: Denis Lepage) on several proposals to fund a data entry system and database for monitoring nocturnal owl populations across North America. Bird Studies

Canada led the effort and we wrote letters of support committing to use the system should it be funded. Unfortunately, only a portion of the proposal was funded, supporting the design of the website and database, which is now part of the Avian Knowledge Network. For a small annual fee, Bird Studies Canada will customize the system to meet regional needs. We recommend working with Bird Studies Canada to incorporate any owl survey efforts and data into this system, which will allow for broad-scale analysis of owl populations and status.

   b. Serve information on training, protocols, datasheets, and frequently asked questions on a website for volunteers and other surveyors. We had preliminary discussions with a web designer (Laura Haywood, Juneau) to work towards this goal but eventually dropped the effort when money began to run short. Disseminating information in a timely manner to surveyors was time-consuming and challenging. A project website that was locally-served (or had consistent support) would be extremely beneficial.
   b. Hire 2-4 technicians to rotate around Southeast Alaska during surveys. This will help to fill in gaps when volunteers are unavailable and to ensure that the protocol is properly followed. We suggest that each new volunteer be required to survey first with a seasoned volunteer or hired technician before leading surveys on their own.
   c. Hire a coordinator to communicate with volunteers, update information on the website regularly, present survey results, and manage the volunteer database.

5. Populations of nocturnal owls are also monitored successfully at migration stations using mist-nets. The Rocky Point Bird Observatory in coastal British Columbia has been banding migrating owls at multiple stations since 2002. We recommend investigating the feasibility of working with Rocky Point Bird Observatory on the long-term monitoring of nocturnal owl populations at migration stations.
6. We suggest continued monitoring of owl populations in Southeast Alaska in order to determine any effects of Barred Owls on other owl species, which has been documented elsewhere (Olson et al. 2005, Elliott 2006). Similarly, information on the status of owl populations, especially if combined with diet studies, would complement small mammal

investigations and potentially serve as a surrogate to documenting the status of some small mammal species in Southeast Alaska.

7. We recommend investigating the use of automated recording systems (e.g., "frogloggers") to collect information on the distribution and occupancy of owls in unroaded areas. This approach could be used to validate roadside surveys or to address specific hypotheses related to owl occupancy. We suggest considering the influence of rainfall on the ability to detect owl calls on the digital files, but these units have been used successfully to monitor amphibians across North America. We are not aware of their use for owl surveys.

Ecology and conservation of forest owls in Southeast Alaska

The Owl Expert Panel convened for ADF&G's CWCS recommended several conservation objectives and actions, including learning more about owl habitat associations and diet. We recommend the following studies and considerations to address conservation concerns for forest owls in Southeast Alaska.

1. The relatively recent range expansion of Barred Owls (Livezey 2009) and the resulting effects on resident raptors (e.g., Northern Spotted Owls; Kelly et al. 2003, Olson et al. 2005) has garnered much attention in the literature lately. We recommend further evaluation of several aspects of Barred Owl ecology in Southeast Alaska and points further north.
    a. We recommend a detailed study of Barred Owl food habits involving video documentation of deliveries to nests. Understanding the diet of Barred Owls would be an important component of its ecology to learn because 1) Barred Owls may compete with smaller owls (e.g., screech-owls) for prey; 2) Barred Owls might be active predators of smaller owl species; and 3) Barred Owls are large enough that, in a prey-depauperate region such as Southeast Alaska, they may be food competitors with other resident raptors (e.g., northern goshawk).
    b. We recommend that in conjunction with the diet study above, it would be useful to learn about habitat use of Barred Owls. This would give insight into the potential habitats important for this expanding bird and, perhaps most importantly, those habitats that are avoided. A better understanding of habitat use

(including nesting habitat) would provide information on the potential for Barred Owls to compete with other comparably-sized and smaller raptors.

2. Vehicle collisions with owls appear to be a noteworthy source of mortality, especially for Western Screech-Owls (Appendix IV). Relatively open (compared to the forest) and grassy roadsides probably offer owls good hunting opportunities. Of the known sources of mortality of owls in Southeast Alaska, starvation and trauma are the primary causes of owl deaths. Starvation is the natural outcome of reduced food resources, but trauma events (e.g., vehicle collisions) could be reduced. In Canada, Australia, and France, road signs are used to alert motorists of high concentrations of owls and reduced speed limits are implemented along specific stretches of road (Duncan 2003). We recommend conducting a risk assessment in a few select communities of Southeast Alaska, including an attempt to quantify owl deaths along relatively busy roads. Based on our cursory evaluation, we think that a fairly large number of both resident and migratory owls are killed in vehicle collisions each year, especially in the fall when young birds are learning to hunt.
3. In Southeast Alaska, Western Screech-Owl home ranges were focused on riparian forests associated with larger, fish-bearing streams in all cases. While we did not capture and radiotag any owls in higher elevations away from larger stream valleys, we rarely detected screech-owls in such areas during nocturnal surveys (Chapters 1 & 2). Riparian zones are rich ecological areas, providing critical habitats for many wildlife species and the food they depend on (e.g., bears and Pacific salmon; Naiman et al. 2000, Schindler et al. 2003). Based primarily on anadromous fish needs, riparian standards and guidelines for the Tongass National Forest prohibit commercial timber harvest within 30 m of streams that contain fish (i.e., Stream Class 1 or 2; USDA Forest Service 1997). We found that while only 13 % of locations were within the 30-m buffer, 68 % of locations were in 150 m of streams. This distance relates to the buffer placed on parts of streams that are deemed "important bear foraging areas" (USDA Forest Service 1997) and should be applied to all fish-bearing streams to benefit bears as well as the other species that use these riparian forests.
4. Harvest operations, especially clearcutting, can lower the number of trees with suitable nest and roost cavities for owls. Managers could mitigate this impact by leaving clumps

of large and small standing trees within harvest units to ensure persistence and future recruitment of cavity-bearing trees (DeGayner et al. 2005). This may be consistent with timber harvest economic objectives since many of the large old-growth trees that may recruit into suitable nest-cavity trees have little timber value due to their poor form and high degree of wood defect (DeGayner et al. 2005). Because of Western Screech-Owl use of riparian forests and need for trees relatively large and old enough to support natural cavities, continued protection of the valley-bottom forest of Southeast Alaska would benefit Western Screech-Owls in this area.

5. We recommend further evaluation of genetic variation among and between populations of forest owls in Southeast Alaska and western North America. We suggest prioritizing resident owl species, such as Western Screech-Owl and Barred Owl, over migratory species (e.g., Northern Saw-Whet Owl), although the latter could be helpful at identifying important overwintering sites of some species. Tissue samples could be collected from carcasses prior to museum submission (as in this study) and from live, injured birds admitted to the Juneau Raptor Center and Alaska Raptor Center (Sitka). Data gaps could be filled by trapping live owls in under-represented areas (e.g., Prince of Wales Island, Kuiu Island, Admiralty Island). Although owls are able to fly and therefore disperse across islands of Southeast Alaska, our results indicate that dispersal is limited and resident species likely hold territories year-round. Given the relatively high degree of endemism of some species groups in Southeast Alaska (e.g., small mammals; MacDonald and Cook 2007), we believe that extending genetic studies to other taxa would be valuable in identifying landscape barriers to genetic flow and in managing forest resources for all species.
6. Although Short-Eared Owl (*Asio flammeus*) is not a forest owl, we recommend a study of the migration and stopover ecology of this species. This species is not surveyed by traditional nocturnal owl surveys as we recommended in Appendix I and thus, additional techniques will need to be used to learn about their ecology in this region. It has been documented in the past that waves of Short-Eared Owls appear during fall migration in large wetland and tidal grassflat areas (e.g., Gustavus Forelands, Mendenhall Forelands). Capturing and marking Short-Eared Owls with satellite tags could help to elucidate their habitat use and stopover ecology in Southeast Alaska.

Owls are a fascinating part of the avifauna of Southeast Alaska. The relative ease of monitoring forest owls and their value as indicators of environmental condition support continued efforts to study and monitor trends in occupancy of this unique group of birds. Overall, we conclude that forest owl populations in Southeast Alaska are stable (Northern Saw-Whet Owl and Western Screech-Owl) or increasing (Barred Owl), but conservation concerns for this species group exist. With an efficient survey protocol and design, data on habitat associations, and information on the natural history of the most common owls, we hope that forest owl populations are considered in future conservation and management decisions in Southeast Alaska.

LITERATURE CITED

Alaska Department of Fish and Game. 2006. Our wealth maintained: a strategy for conserving Alaska's diverse wildlife and fish resources. Alaska Department of Fish and Game, Juneau, Alaska, USA.

DeGayner, E. J., M. G. Kramer, J. G. Doerr, and M. J. Robertsen. 2005. Windstorm disturbance effects on forest structure and black bear dens in Southeast Alaska. Ecological Applications 15:1306-1316.

Duncan, J. R. 2003. Owls of the world: their lives, behavior, and survival. Firefly Books, Buffalo, New York, USA.

Elliott, K. 2006. Declining numbers of Western Screech-Owl in the lower mainland of British Columbia. British Columbia Birds 14:2-11.

Holt, Denver W. and Julie L. Petersen. 2000. Northern Pygmy-Owl (*Glaucidium gnoma*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/494.

Houston, C. Stuart, Dwight G. Smith and Christoph Rohner. 1998. Great Horned Owl (*Bubo virginianus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/372.

Kelly, E. G., E. D. Forsman, and R. G. Anthony. 2003. Are Barred Owls displacing spotted owls? Condor 105:45-53.

Livezey, K. B. 2009. Barred Owl range expansion, Part I: chronology and distribution. American Midland Naturalist 161:49-56.

MacDonald, S. O., and J. A. Cook. 2007. Mammals and amphibians of Southeast Alaska. Special Publication Number 8, Museum of Southwestern Biology, University of New Mexico, Albuquerque.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Academic Press, Burlington, MA, USA.

Naiman, R. J., R. E. Bilby, and P. A. Bisson. 2000. Riparian ecology and management in the Pacific coastal rain forest. Bioscience 50:996-1011.

Olson, G. S., R. G. Anthony, E. D. Forsman, S. H. Ackers, P. J. Loschl, J. A. Reid, K. M. Dugger, E. M. Glenn, and W. J. Ripple. 2005. Modeling of site occupancy dynamics for Northern Spotted Owls, with emphasis on the effects of Barred Owls. Journal of Wildlife Management 69:918-932.

Schindler, D. E., M. D. Scheuerell, J. W. Moore, S. M. Gende, T. B. Francis, and W. J. Palen. 2003. Pacific salmon and the ecology of coastal ecosystems. Frontiers in ecology and the environment 1:31-37.

Takats, L. D., C. M. Francis, G. L. Holroyd, J. R. Duncan, K. M. Mazur, R. J. Cannings, W. Harris, D. Holt. 2001. Guidelines for nocturnal owl monitoring in North America. Beaverhill Bird Observatory and Bird Studies Canada, Edmonton, Alberta. 32pp.

USDA Forest Service. 1997. Tongass Land Management Plan Revision. USDA Forest Service, Alaska Region. R10-MB-38a. Juneau, Alaska, USA.

APPENDIX I
SOUTHEAST ALASKA OWL NETWORK SURVEY PROTOCOL

Survey objective: To monitor trend in occupancy of nocturnal forest owls throughout Southeast Alaska.

Survey preparation

Number of surveyors and training: Each survey should be conducted by 2 trained observers. Prior to the first survey, review the enclosed training presentation (PowerPoint format). If you do not have PowerPoint, please inform the survey coordinator immediately and you will be sent a hard copy. We recommend review of all owl calls before each survey and have included a representative call of each owl species that occurs in Southeast Alaska on the "Broadcast Survey CD".

Station selection: We have selected survey stations based on previous surveys completed for the SE AK Owl Network, historical owl research, and other avian monitoring programs (e.g., Breeding Bird Survey). The sample unit of the survey is a station; an independent point where you will listen for territorial calls from owls and solicit responses from Western Screech-Owls and Barred Owls. For ease of logistics, we have grouped stations into routes of typically 5 or 10 stations. Stations must be ≥ 1 mile apart. Stations should be located in areas with a) low ambient noise (e.g., stream, barking dogs, and airplanes), b) low traffic levels, and c) at least 25% forest within 500 m of the station. Be sure to maintain a unique station number throughout all surveys. The same stations should be surveyed throughout the entire survey period (1 April – 15 May; see 'Survey date' below) and will be surveyed repeatedly across years.

Survey timing: Conduct at least 3 surveys at each station on different nights over a 3-week period starting 1 April until 15 May. It is acceptable to survey the same station on consecutive nights, but not in the same nights. Examples: (1) You may conduct surveys on 11 April, 13 April, and 30 April. All 3 surveys are within the 3-week period. (2) You may not conduct surveys on 11 April, 13 April, and 5 May. Surveys between 11 April and 5 May exceed 3 weeks.

The survey protocol is designed to allow flexibility for the surveyor, annual events (e.g., heavy snowfall), and geographic location (e.g., Ketchikan versus Yakutat). If a route (or part of a route) is not accessible due to snow, it is best (but not always possible) to wait until the entire route can be surveyed. While providing flexibility, the protocol also adheres to important assumptions about the survey itself.

Time of night: Surveys should begin ≥30 minutes after sunset and continue until the survey is complete. To determine the official time of sunset, either use local tide book or go to <http://aa.usno.navy.mil/data/docs/RS_OneDay.html> and enter the date and nearest community. Record time in Alaska Daylight Time.

Acceptable survey conditions: Surveys should not be conducted or should be discontinued if (a) wind exceeds 20 km/hr, which can be described as raises dust/loose paper and/or small branches move (Beaufort 4), or (b) precipitation in the form of drizzle, showers, rain, or sleet (precipitation codes=2-5) occur.

Materials needed for survey: datasheet, map, clipboard, compass, watch, CD player, powerhorn or megaphone, CD with owl calls, extra batteries.

Survey information

Community: Write name of community or area of survey (e.g., Juneau, Sitka).

Description of route: Write name of route (e.g., North Douglas, Green Lake Rd).

Surveyors: Write first and last name of both surveyors; do not record initials.

Date: Record the actual date of the night of the survey. For example, if you begin a survey at 20:45 on 11 April, you would record 11 April as the survey date. If you begin the survey at 00:30 on 12 April, you would still record 11 April as the survey date.

Moon phase: Write the fraction of the moon available; this can be found at <http://aa.usno.navy.mil/data/docs/MoonFraction.php>.

Time of sunset: Write the time of sunset in Alaska Daylight Time; this can be found at <http://aa.usno.navy.mil/data/docs/RS_OneDay.html>

Station information

Point ID: Write the unique letter code for route name and station (e.g., ND01).

Survey start: Write the military time (e.g., 22:10) in Alaska Daylight Time that the survey began; this is the beginning of the silent listening period.

Temperature: Record temperature in ∘C at start of survey. If you do not have a way to determine temperature (many vehicles have external thermometers), leave this section blank.

Precipitation code: Record precipitation code at beginning of survey. Codes are: 0 = None; 1 = Fog; 2 = Drizzle; 3 = Showers; 4 = Rain; 5 = Sleet; 6 = Snow.

Snow cover: Visually estimate the percent (to the nearest 5%) of ground covered by snow within a 300-m radius of the station.

Cloud cover: Visually estimate percent (to the nearest 5%) of cloud cover at the start the survey.

Beaufort wind: Record Beaufort wind code at beginning of survey. Codes are as follows:

Beaufort code	Wind speed in km/hr (mph)	Indicators of wind speed
0 =	<2 (<1)	Air calm, smoke rises vertically
1 =	2 to 5 (1 to 3)	Slight show of wind direction by smoke drift
2 =	6 to 12 (4 to 7)	Wind felt on face, leaves rustle
3 =	13 to 19 (8 to 12)	Leaves and small twigs in constant motion
4 =	20 to 29 (13 to 18)	Raises dust; loose paper, small branches move
5 =	30 to 38 (19 to 24)	Small trees in leaf begin to sway

External noise: Record noise code at end of survey. Codes are as follows: 1 = Quiet; 2 = Some noise, but not distracting (e.g., dogs barking); 3 = Significant noise that may have reduced owl detectability (e.g., stream, surf); 4 = Constant noise (e.g., heavy traffic, roaring creek, constant crashing surf).

# of cars passed: Count and record the number of cars that pass on the road that the station is located during the (a) silent, and (b) broadcast period separately.

Owls heard?: Record a 'Y' for yes, if an owl is detected during the survey, and a 'N' for no, if an owl is not detected during the survey.

Comments: Record any additional information in this section. Relevant information would include (but not limited to) changes in conditions during the survey, a description of external noise, etc.

<u>Survey methods</u>

Each station will consist of three time periods: (a) a settling period, (b) a silent listening period, and (c) a broadcast survey period.

a) One (1) minute settling period: On arrival at each station, wait <u>quietly</u> for one (1) minute to allow the area to settle before beginning survey. This settling period can be used to record station number, % snow cover, wind, precipitation, etc. Time this period using a watch.
b) Two (2) minute silent listening period: As soon as the settling period ends, begin the silent listening period; note start time on datasheet. Time this period using a watch. If an owl is detected, record all data described below and include any other relevant comments regarding the detection.
c) Seven (7) minute broadcast calling period: After the silent listening period, broadcast calling for Western Screech-Owl and Barred Owl will begin. Each species' song will be broadcast for 30 seconds while rotating a megaphone (e.g., RadioShack Musical Powerhorn) 360°, followed by a one-minute silent count period. This will be repeated once, so that each species broadcast series will be 30-60-30-60 seconds. The broadcast rotation will begin with western-screech owl and end with Barred Owl. After the last Barred Owl call segment, wait 2 additional minutes (this final 2 minutes <u>must</u> be timed using a watch) before ending the calling station.

- If one of the TARGET species (i.e., Western Screech-Owls and Barred Owls) is heard during the silent listening period, do not play that species call rotation. Instead, silently listen for that portion of the 'broadcast calling period'.
- During the broadcast calling period, if one of the TARGET species responds stop broadcasting that species' call. However, maintain the timing of the count at that station. For example, if a Western Screech-Owl responds at 45 seconds into the broadcast period for Western Screech-Owl, discontinue the western-screech owl broadcast and wait 2:25 before starting the Barred Owl hoots. (**IMPORTANT NOTE**: Barred Owls can be aggressive. If a Barred Owl responds to the Barred Owl broadcast segment, immediately stop the CD from playing. This is to protect both the surveyor and the owl(s). Indicate any aggressive birds on the datasheet in the *Comments* field.)
- If species of owl other than the TARGET species calls during the broadcast period, note it on the datasheet but continue the entire calling station. The short duration of the broadcast segment of the survey is not harassment to owls.

The total duration of a survey at each station is 10 minutes. The CD labeled "Broadcast Survey CD" was recorded with the owl calls and silent listening periods are timed in advance. Typical calls of owls known to occur in Southeast Alaska are included on the CD for reference. If an owl is detected but identification is uncertain, wait until after the survey period at that station has ended to listen to the CD and attempt to identify the owl. If the owl species is still unknown, record a description of the call (pitch, cadence, verbal description) in the *Comments* section.

<u>Detection information</u>
Point ID: Write the unique letter code for route name and station that the owl was detected (e.g., ND01).

Species: Record the 4-letter species code of the owl detected. Codes are:

Code	Species	Code	Species
BDOW	Barred Owl (*Strix varia*)	LEOW	Long-Eared Owl (*Asio otus*)
NSWO	Northern Saw-Whet Owl (*Aegolius acadicus*)	GGOW	Great Grey Owl (*Strix nebulosa*)
WESO	Western Screech-Owl (*Megascops kennicottii*)	BOOW	Boreal Owl (*Aegolius funereus*)
GHOW	Great Horned Owl (*Bubo virginianus*)	SNOW	Snowy Owl (*Bubo scandiacus*)
NOPO	Northern Pygmy-Owl (*Glaucidium gnoma*)		
SEOW	Short-Eared Owl (*Asio flammeus*)		
NHOW	Northern Hawk Owl (*Surnia ulula*)		

Silent: Circle 'silent' if the owl is detected at any time during the initial 2-minute silent listening period.

Elapsed time: If the owl is detected during the silent period, record the minutes and seconds that have elapsed since the 2-minute silent listening period began. Record *0:00* if owl was calling before count started.

Direction: Use the compass to estimate the direction (◦) that the owl was first detected during the 2-minute silent listening period.

Distance: Estimate the distance (m) from the station to the owl where it was first detected during the 2-minute silent listening period.

Broadcast: Circle 'broadcast' if the owl is detected at any time during the 7-minute broadcast survey period. NOTE: circle both 'silent' and 'broadcast' if the owl is detected during both periods.

Segments: Circle all segments in which the owl is detected. For example, if a Western Screech-Owl (WESO) is heard after the 2nd 30s segment of WESO hoots and it continues to respond until the 2nd segment of Barred Owl (BDOW) hoots begins, circle segments 2 and 3 on the datasheet. If the owl stopped vocalizing during the 1-minute silent listening period in between calls, circle only segment 2 on the datasheet. Segment numbers are:

1 = during 1st 30s segment of WESO hoots or silent period after 1st 30s segment of WESO hoots;
2 = during 2nd 30s segment of WESO hoots or silent period after 2nd 30s segment of WESO hoots (i.e., between WESO and BDOW);
3 = during 1st segment of BDOW hoots or silent period after 1st segment of BDOW hoots;
4 = during 2nd segment of BDOW hoots or silent period after 2nd segment of BDOW hoots.

Direction: Use the compass to estimate the direction (◦) that the owl was first detected during the 7-minute broadcast survey period.

Distance: Estimate the distance (m) from the station to the owl where it was first detected during the 7-minute broadcast survey period.

Comments: Record unusual observations about the owl detection (e.g., visual detection). Note if the owl detected is the same as an owl detected at a previous station.

Conclusion of survey

Review datasheet for accuracy and completeness and submit to survey coordinator immediately. If field activities prevent immediate submission, make copy of the datasheet(s) and keep copy separate from original until submission occurs.

SOUTHEAST ALASKA OWL NETWORK – FOREST OWL SURVEY FORM

Community:______________________________ Description of route: ______________________________

Surveyors: ____

Date: ______________________ Moon Phase:__________ Time of Sunset :__________________

Point ID	Survey start	Temp. (°C)	Precip Code	Snow Cover (%)	Cloud Cover (%)	Beaufort wind	External Noise	# Cars Passed		Owls Heard?
								silent	broadcast	

Comments:

SOUTHEAST ALASKA OWL NETWORK – FOREST OWL DETECTION FORM

CIRCLE ALL SEGMENTS THAT YOU HEAR AN OWL.

Point ID : ____________ **Species :**________________ **Comments:**

SILENT **Elapsed Time :**___________ **Direction (°) :**________ **Distance (m) :**______

BROADCAST **Segments: 1 2 3 4** **Direction (°) :**________ **Distance (m) :**______

Point ID : ____________ **Species :**________________ **Comments:**

SILENT **Elapsed Time :**___________ **Direction (°) :**________ **Distance (m) :**______

BROADCAST **Segments: 1 2 3 4** **Direction (°) :**________ **Distance (m) :**______

Point ID : ____________ **Species :**________________ **Comments:**

SILENT **Elapsed Time :**___________ **Direction (°) :**________ **Distance (m) :**______

BROADCAST **Segments: 1 2 3 4** **Direction (°) :**________ **Distance (m) :**______

Point ID : ____________ **Species :**________________ **Comments:**

SILENT **Elapsed Time :**___________ **Direction (°) :**________ **Distance (m) :**______

BROADCAST **Segments: 1 2 3 4** **Direction (°) :**________ **Distance (m) :**______

Point ID : ____________ **Species :**________________ **Comments:**

SILENT **Elapsed Time :**___________ **Direction (°) :**________ **Distance (m) :**______

BROADCAST **Segments: 1 2 3 4** **Direction (°) :**________ **Distance (m) :**______

Point ID : ____________ **Species :**________________ **Comments:**

SILENT **Elapsed Time :**___________ **Direction (°) :**________ **Distance (m) :**______

BROADCAST **Segments: 1 2 3 4** **Direction (°) :**________ **Distance (m) :**______

Point ID : ____________ **Species :**________________ **Comments:**

SILENT **Elapsed Time :**___________ **Direction (°) :**________ **Distance (m) :**______

BROADCAST **Segments: 1 2 3 4** **Direction (°) :**________ **Distance (m) :**______

Comments:____

SURVEY DATASHEET

Point ID: Letter code for route name and number of point (e.g., ND01).

Precipitation Codes: 0 = None; 1 = Fog; 2 = Drizzle; 3 = Showers; 4 = Rain; 5 = Sleet; 6 = Snow.

Wind Speed: Record Beaufort code;

Beaufort code	Wind speed in km/hr (mph)	Indicators of wind speed
0 =	<2 (<1)	Air calm, smoke rises vertically
1 =	2 to 5 (1 to 3)	Slight show of wind direction by smoke drift
2 =	6 to 12 (4 to 7)	Wind felt on face, leaves rustle
3 =	13 to 19 (8 to 12)	Leaves and small twigs in constant motion
4 =	20 to 29 (13 to 18)	Raises dust; loose paper, small branches move
5 =	30 to 38 (19 to 24)	Small trees in leaf begin to sway

External Noise: 1 = Quiet;
2 = Some noise, but not distracting (e.g., dogs barking);
3 = Significant noise that may have reduced owl detectability (e.g., stream, surf);
4 = Constant noise (e.g., heavy traffic, roaring creek, constant crashing surf).

Owls Heard? Yes or No depending if any owls were detected at this point.

OWL DETECTION DATASHEET

Owl Species Codes:

Code	Species	Code	Species
BDOW	Barred Owl (*Strix varia*)	LEOW	Long-Eared Owl (*Asio otus*)
NSWO	Northern Saw-Whet Owl (*Aegolius acadicus*)	GGOW	Great Grey Owl (*Strix nebulosa*)
WESO	Western Screech-Owl (*Megascops kennicottii*)	BOOW	Boreal Owl (*Aegolius funereus*)
GHOW	Great Horned Owl (*Bubo virginianus*)	SNOW	Snowy Owl (*Bubo scandiacus*)
NOPO	Northern Pygmy-Owl (*Glaucidium gnoma*)		
SEOW	Short-Eared Owl (*Asio flammeus*)		
NHOW	Northern Hawk Owl (*Surnia ulula*)		

Circle period type when owl was detected (e.g., circle SILENT if heard before or during silent period; circle BROADCAST if heard during or after broadcast period; circle both if heard during both).

Elapsed Time = Time since beginning of silent count period when owl detected; *0:00 if heard before count started***.**

Segments: What segment of the listening period did the owl vocalize? **Circle all segments that you hear the owl.** For example, if you hear a WESO after the 2nd 30s segment of WESO hoots and it continues to respond until the 2nd segment of BDOW hoots begins, you would circle segments 2 and 3 on the datasheet. If the owl stopped vocalizing as soon as you broadcasted the 1st segment of BDOW hoots, you would circle only segment 2 on the datasheet.

1 = during 1st 30s segment of WESO hoots or silent period after 1st 30s segment of WESO hoots;
2 = during 2nd 30s segment of WESO hoots or silent period after 2nd 30s segment of WESO hoots (i.e., between WESO and BDOW);
3 = during 1st segment of BDOW hoots or silent period after 1st segment of BDOW hoots;
4 = during 2nd segment of BDOW hoots or silent period after 2nd segment of BDOW hoots.

Comments: Note any unusual observations made of owl in question; note here if this is same owl as previously detected (e.g., at a different point)

APPENDIX II
MONTLY VARIATION IN OWL OCCURRENCE IN SOUTHEAST ALASKA, 2005-2008

We compiled owl detections during standard surveys (see Chapter 2) and opportunistic sightings of owls reported by community members in Southeast Alaska, 2005-2008. We simply tallied survey detections and owl sightings by species, month, and community; we did not account for different years. These data do not represent a statistical survey, but they do provide information on rare or accidental species that occur in the region and on occurrence of all species during all months of the year.

Tables are arranged by community, beginning at Hyder in the south and extending to Yakutat in the north. We include a final table summarizing all of Southeast Alaska. In addition to the 12 communities, we received five owl sightings from Pelican and Kake. In Pelican, 2 Western Screech-Owls (January, September), 1 Boreal Owl (March), and 1 Northern Saw-Whet Owl (March) were observed. One Barred Owl (January) was reported from Kake.

Table 1. Owl occurrence (n=1) by species and month in Hyder, Southeast Alaska, 2005-2008. In total, surveys were conducted on 3 nights at 15 stations tallying 1 detection; 0 owl sightings were submitted from this community.

	OWL SPECIES											
MONTH	*Barred Owl*	*Boreal Owl*	*Great Gray Owl*	*Great Horned Owl*	*Long-Eared Owl*	*Northern Hawk-Owl*	*Northern Pygmy-Owl*	*Northern Saw-whet Owl*	*Short-Eared Owl*	*Snowy Owl*	*Western Screech-Owl*	*unidentified owl species*
January	0	0	0	0	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0	0	0	0	0	0
April	1	0	0	0	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0	0	0	0
September	0	0	0	0	0	0	0	0	0	0	0	0
October	0	0	0	0	0	0	0	0	0	0	0	0
November	0	0	0	0	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0	0	0
Species total	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Table 2. Owl occurrence (n=18) by species and month in Ketchikan, Southeast Alaska, 2005-2008. In total, surveys were conducted on 4 nights at 15 stations tallying 4 detections; 14 owl sightings were submitted from this community.

	OWL SPECIES											
MONTH	*Barred Owl*	*Boreal Owl*	*Great Gray Owl*	*Great Horned Owl*	*Long-Eared Owl*	*Northern Hawk-Owl*	*Northern Pygmy-Owl*	*Northern Saw-whet Owl*	*Short-Eared Owl*	*Snowy Owl*	*Western Screech-Owl*	*unidentified owl species*
January	0	0	0	0	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0	0	0	0	0
March	1	0	0	0	0	0	0	0	0	0	0	0
April	1	0	0	0	0	1	0	0	1	0	0	0
May	3	0	0	0	0	0	0	1	0	0	3	0
June	0	0	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0	0	0
August	1	0	0	0	0	0	0	0	0	0	0	0
September	1	0	0	0	0	0	0	0	0	0	4	0
October	0	0	0	0	0	0	0	0	0	0	0	0
November	0	0	0	0	0	0	0	0	0	0	0	0
December	1	0	0	0	0	0	0	0	0	0	0	0
Species total	**8**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**1**	**0**	**7**	**0**

Table 3. Owl occurrence (n=82) by species and month on Prince of Wales Island, Southeast Alaska, 2005-2008. In total, surveys were conducted on 26 nights at 159 stations tallying 66 detections; 16 owl sightings were submitted from this community.

	OWL SPECIES											
MONTH	*Barred Owl*	*Boreal Owl*	*Great Gray Owl*	*Great Horned Owl*	*Long-Eared Owl*	*Northern Hawk-Owl*	*Northern Pygmy-Owl*	*Northern Saw-whet Owl*	*Short-Eared Owl*	*Snowy Owl*	*Western Screech-Owl*	*unidentified owl species*
January	0	0	0	0	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0	0	0	0	0
March	3	0	0	1	0	0	1	7	1	0	3	0
April	4	0	1	0	0	0	0	14	0	0	1	0
May	3	1	0	1	0	0	0	22	0	0	9	2
June	0	0	0	0	0	0	0	1	0	0	0	0
July	0	0	0	1	0	0	0	0	0	0	1	0
August	0	0	0	0	0	0	0	0	0	0	0	0
September	0	1	0	1	0	0	0	0	0	0	0	0
October	0	0	0	0	0	0	0	0	0	0	0	0
November	0	0	0	2	0	0	0	1	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0	0	0
Species total	**10**	**2**	**1**	**6**	**0**	**0**	**1**	**45**	**1**	**0**	**14**	**2**

Table 4. Owl occurrence (n=10) by species and month in Wrangell, Southeast Alaska, 2005-2008. In total, surveys were conducted on 22 nights at 101 stations tallying 2 detections; 8 owl sightings were submitted from this community.

	OWL SPECIES											
MONTH	*Barred Owl*	*Boreal Owl*	*Great Gray Owl*	*Great Horned Owl*	*Long-Eared Owl*	*Northern Hawk-Owl*	*Northern Pygmy-Owl*	*Northern Saw-whet Owl*	*Short-Eared Owl*	*Snowy Owl*	*Western Screech-Owl*	*unidentified owl species*
January	0	0	0	0	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0	0	0	1	0
March	1	0	0	0	0	0	0	0	0	0	0	0
April	0	0	0	2	0	0	1	0	0	0	0	0
May	0	0	0	2	0	0	0	0	0	0	0	0
June	1	0	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0	0	0	0
September	2	0	0	0	0	0	0	0	0	0	0	0
October	0	0	0	0	0	0	0	0	0	0	0	0
November	0	0	0	0	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0	0	0
Species total	**4**	**0**	**0**	**4**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**

Table 5. Owl occurrence (n=114) by species and month in Petersburg, Southeast Alaska, 2005-2008. In total, surveys were conducted on 45 nights at 605 stations tallying 113 detections; 1 owl sightings were submitted from this community.

	OWL SPECIES											
MONTH	*Barred Owl*	*Boreal Owl*	*Great Gray Owl*	*Great Horned Owl*	*Long-Eared Owl*	*Northern Hawk-Owl*	*Northern Pygmy-Owl*	*Northern Saw-whet Owl*	*Short-Eared Owl*	*Snowy Owl*	*Western Screech-Owl*	*unidentified owl species*
January	0	0	0	0	0	0	0	0	0	1	0	0
February	0	0	0	0	0	0	0	0	0	0	0	0
March	4	0	0	2	0	0	0	3	0	0	8	0
April	12	0	0	3	0	0	0	21	0	0	13	0
May	10	0	0	1	0	0	1	24	0	0	11	0
June	0	0	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0	0	0	0
September	0	0	0	0	0	0	0	0	0	0	0	0
October	0	0	0	0	0	0	0	0	0	0	0	0
November	0	0	0	0	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0	0	0
Species total	**26**	**0**	**0**	**6**	**0**	**0**	**1**	**48**	**0**	**1**	**32**	**0**

Table 6. Owl occurrence (n=44) by species and month in Sitka, Southeast Alaska, 2005-2008. In total, surveys were conducted on 39 nights at 172 stations tallying 18 detections; 26 owl sightings were submitted from this community.

	OWL SPECIES											
MONTH	*Barred Owl*	*Boreal Owl*	*Great Gray Owl*	*Great Horned Owl*	*Long-Eared Owl*	*Northern Hawk-Owl*	*Northern Pygmy-Owl*	*Northern Saw-whet Owl*	*Short-Eared Owl*	*Snowy Owl*	*Western Screech-Owl*	*unidentified owl species*
January	0	0	0	0	0	0	1	0	0	0	1	0
February	0	0	0	0	0	0	0	0	0	0	3	0
March	0	0	0	0	0	1	1	0	0	0	5	0
April	0	0	0	0	0	0	0	0	0	0	8	0
May	2	0	0	0	0	0	0	0	0	0	5	0
June	0	0	0	0	0	0	0	0	0	0	9	0
July	0	0	0	0	0	0	0	0	0	0	3	0
August	0	0	0	0	0	0	0	0	0	0	1	0
September	0	0	0	0	0	0	0	0	0	0	2	0
October	0	0	0	0	0	0	0	0	0	0	0	0
November	0	0	0	0	0	0	0	0	0	0	2	0
December	0	0	0	0	0	0	0	0	0	0	0	0
Species total	**2**	**0**	**0**	**0**	**0**	**1**	**2**	**0**	**0**	**0**	**39**	**0**

Table 7. Owl occurrence (n=203) by species and month in Juneau, Southeast Alaska, 2005-2008. In total, surveys were conducted on 113 nights at 723 stations tallying 128 detections; 75 owl sightings were submitted from this community.

	OWL SPECIES											
MONTH	*Barred Owl*	*Boreal Owl*	*Great Gray Owl*	*Great Horned Owl*	*Long-Eared Owl*	*Northern Hawk-Owl*	*Northern Pygmy-Owl*	*Northern Saw-whet Owl*	*Short-Eared Owl*	*Snowy Owl*	*Western Screech-Owl*	*unidentified owl species*
January	0	0	0	0	0	0	3	1	0	0	0	0
February	0	0	0	1	0	0	4	0	0	0	1	0
March	7	0	1	1	0	0	9	18	0	0	7	0
April	11	0	0	8	0	0	2	24	2	1	5	1
May	15	0	0	1	1	0	2	32	0	0	2	0
June	2	1	0	1	0	0	0	3	0	0	0	0
July	3	0	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	1	3	0	0	0	5
September	3	0	1	3	0	0	0	0	0	0	0	0
October	0	1	0	0	0	0	0	0	0	0	1	0
November	0	1	0	1	0	0	2	0	7	2	0	0
December	0	0	0	0	0	1	0	0	0	0	1	0
Species total	**41**	**3**	**2**	**16**	**1**	**1**	**23**	**81**	**9**	**3**	**17**	**6**

Table 8. Owl occurrence (n=1) by species and month in Hoonah, Southeast Alaska, 2005-2008. In total, surveys were conducted on 2 nights at 18 stations tallying 1 detection; 0 owl sightings were submitted from this community.

	OWL SPECIES											
MONTH	*Barred Owl*	*Boreal Owl*	*Great Gray Owl*	*Great Horned Owl*	*Long-Eared Owl*	*Northern Hawk-Owl*	*Northern Pygmy-Owl*	*Northern Saw-whet Owl*	*Short-Eared Owl*	*Snowy Owl*	*Western Screech-Owl*	*unidentified owl species*
January	0	0	0	0	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0	0	0	1	0
June	0	0	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0	0	0	0
September	0	0	0	0	0	0	0	0	0	0	0	0
October	0	0	0	0	0	0	0	0	0	0	0	0
November	0	0	0	0	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0	0	0
Species total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**

Table 9. Owl occurrence (n=466) by species and month in Gustavus, Southeast Alaska, 2005-2008. In total, surveys were conducted on 33 nights at 162 stations tallying 21 detections; 445 owl sightings were submitted from this community.

	OWL SPECIES											
MONTH	*Barred Owl*	*Boreal Owl*	*Great Gray Owl*	*Great Horned Owl*	*Long-Eared Owl*	*Northern Hawk-Owl*	*Northern Pygmy-Owl*	*Northern Saw-whet Owl*	*Short-Eared Owl*	*Snowy Owl*	*Western Screech-Owl*	*unidentified owl species*
January	2	0	0	1	0	1	15	2	6	4	0	3
February	0	5	0	19	0	0	15	10	9	2	3	10
March	5	2	0	3	0	0	20	31	11	2	4	3
April	1	0	0	2	0	0	1	19	10	0	2	2
May	0	0	0	0	0	0	2	13	1	0	0	1
June	1	0	0	2	0	0	2	5	0	0	0	0
July	1	0	0	16	0	0	0	1	3	0	0	0
August	2	0	0	25	0	0	0	1	1	0	2	0
September	0	0	0	4	0	1	7	2	3	0	4	1
October	0	0	0	4	0	1	8	11	15	0	0	3
November	8	0	0	4	0	3	10	5	28	8	1	4
December	3	0	0	2	0	1	4	0	9	8	0	0
Species total	**23**	**7**	**0**	**82**	**0**	**7**	**84**	**100**	**96**	**24**	**16**	**27**

Table 10. Owl occurrence (n=23) by species and month in Skagway, Southeast Alaska, 2005-2008. In total, surveys were conducted on 19 nights at 195 stations tallying 14 detections; 9 owl sightings were submitted from this community.

	OWL SPECIES											
MONTH	*Barred Owl*	*Boreal Owl*	*Great Gray Owl*	*Great Horned Owl*	*Long-Eared Owl*	*Northern Hawk-Owl*	*Northern Pygmy-Owl*	*Northern Saw-whet Owl*	*Short-Eared Owl*	*Snowy Owl*	*Western Screech-Owl*	*unidentified owl species*
January	0	0	0	0	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0	0	0	0	0
March	2	1	0	0	0	0	2	1	0	0	0	0
April	4	2	0	0	0	0	3	2	1	0	0	0
May	1	1	0	0	0	0	1	0	0	0	0	0
June	0	0	0	0	0	0	0	1	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0	0	0	0
September	0	0	0	0	0	0	0	0	0	0	0	0
October	0	0	0	0	0	0	0	0	0	0	0	0
November	0	0	0	0	0	0	0	0	0	0	0	0
December	0	1	0	0	0	0	0	0	0	0	0	0
Species total	**7**	**5**	**0**	**0**	**0**	**0**	**6**	**4**	**1**	**0**	**0**	**0**

Table 11. Owl occurrence (n=39) by species and month in Haines, Southeast Alaska, 2005-2008. In total, surveys were conducted on 18 nights at 132 stations tallying 24 detections; 15 owl sightings were submitted from this community.

	OWL SPECIES											
MONTH	*Barred Owl*	*Boreal Owl*	*Great Gray Owl*	*Great Horned Owl*	*Long-Eared Owl*	*Northern Hawk-Owl*	*Northern Pygmy-Owl*	*Northern Saw-whet Owl*	*Short-Eared Owl*	*Snowy Owl*	*Western Screech-Owl*	*unidentified owl species*
January	0	0	0	2	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	2	0	0	0	0	0
March	4	0	0	0	0	0	1	1	0	0	0	0
April	0	0	0	4	0	0	0	3	0	0	0	1
May	0	0	0	1	0	0	1	0	0	0	0	0
June	0	0	0	0	0	0	0	1	1	0	1	0
July	1	0	0	1	0	0	1	0	0	0	1	0
August	0	0	0	0	0	0	0	0	0	0	1	0
September	0	0	0	0	0	0	0	0	0	0	0	0
October	0	0	0	3	0	0	0	1	0	0	2	0
November	0	1	0	0	0	0	1	0	0	0	1	0
December	0	0	0	0	0	0	1	0	0	0	0	1
Species total	**5**	**1**	**0**	**11**	**0**	**0**	**7**	**6**	**1**	**0**	**6**	**2**

Table 12. Owl occurrence (n=29) by species and month in Yakutat, Southeast Alaska, 2005-2008. In total, surveys were conducted on 8 nights at 78 stations tallying 27 detections; 2 owl sightings were submitted from this community.

	OWL SPECIES											
MONTH	*Barred Owl*	*Boreal Owl*[1]	*Great Gray Owl*	*Great Horned Owl*	*Long-Eared Owl*	*Northern Hawk-Owl*	*Northern Pygmy-Owl*	*Northern Saw-whet Owl*	*Short-Eared Owl*	*Snowy Owl*	*Western Screech-Owl*	*unidentified owl species*
January	0	0	0	0	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0	0	0	0	0
March	0	0	0	0	0	0	0	0	0	0	0	0
April	0	0	0	0	0	0	0	0	0	0	0	0
May	2	12	0	0	0	0	1	10	0	1	3	0
June	0	0	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0	0	0	0
September	0	0	0	0	0	0	0	0	0	0	0	0
October	0	0	0	0	0	0	0	0	0	0	0	0
November	0	0	0	0	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0	0	0
Species total	**2**	**12**	**0**	**0**	**0**	**0**	**1**	**10**	**0**	**1**	**3**	**0**

[1]One surveyor expressed concern that boreal owls may not have identified correctly due to confusion with winnowing Common Snipes (*Gallinago gallinago*). All detections are included in the table, but should be interpreted with caution.

APPENDIX III
NOTES ON MORPHOLOGY OF OWLS IN SOUTHEAST ALASKA

We collected information on the morphology of owls that occur in Southeast Alaska. We initially began to gather morphology data on Western Screech-Owl to assist us in determining sex of live birds in hand at the time of capture and radio-marking (see Chapters 1 and 3). The Western Screech-Owl is perhaps one of the least sexually dimorphic owls in North America and there is considerable geographic variation in both size and plumage (Cannings and Angell 2001). Because one of our objectives was to estimate detection probabilities for Western Screech-Owls, it was important to know the sex of the radio-marked bird because females are the sole incubators and would not be "available" for detection if the bird was sitting on eggs.

We compiled information on morphology from three sources: (1) museum specimens, (2) carcasses found opportunistically, and (3) captured birds (see Chapters 1 and 3). We examined Western Screech-Owl specimens at the University of Alaska Museum. We took advantage of access to the collection by also examining Northern Saw-Whet Owl specimens. We also collected carcasses that were found dead by community members and submitted to us, Juneau Raptor Center, Alaska Raptor Center, or the local Alaska Department of Fish and Game office. We asked local state and federal offices to review the contents of their freezers and send any owl carcasses that they found. We agreed to take responsibility to voucher specimens and send them to the University of Alaska Museum, Fairbanks or the collection located at the University of Alaska, Anchorage. We encouraged everyone to send all owl species because it can be difficult to determine species of carcasses, particularly if trauma occurred or the bird is only partially intact. We then measured and performed necropsies on each carcass to determine sex (by locating testes or ovaries) and stomach contents (see Appendix IV for summary and Chapter 5 for analysis of Western Screech-Owl diet). Finally, we include the morphometric data from Western Screech-Owls and Northern Saw-Whet Owls that we captured and released during the course of this study. It is important to note that the carcasses and museum specimens examined due not represent a statistical survey and therefore, do not represent an unbiased sample.

Below we summarize these data by species beginning with the smallest owl and include any relevant notes about the morphology and plumage of the specimen, carcass, or live bird. Records are organized by year and can be cross-referenced with those in Appendix IV. In addition to the owls described below, one long-eared owl was found dead in Wrangell, November 2006. The U.S. Forest Service retained this carcass.

Definitions are as follows: date indicates the month/day/year the bird was found; location is the general location; type=live bird (captured or injured bird that was released), carcass (dead bird submitted for necropsy), and specimen (University of Alaska Museum collection); age=hatch-year (HY) or after-hatch-year (AHY); sex=male (M) or female (F); mass=mass (carcasses were weighed after thawing, specimen mass was indicated on voucher); hallux=dorsal surface of the claw at the junction with the skin to the top of the claw; tarsus width=width at the midpoint of the tarsometatarsal; culmen=exposed culmen, from bill-skin junction to the top of the mandible; tail length=center tail length, from the feather-skin junction of the central pair of retrices to their tips; and wing chord=length of wing from the front of the folded wrist to the tip of the longest primary with the feather flattened.

Table 1. Morphometric measurements of Northern Pygmy-Owls (n=3), Southeast Alaska. Average estimates for each sex do not include hatch-year birds or birds of unknown sex or age class.

Date	Location	Type	Age	Sex	Mass (g)	Hallux length (mm)	Tarsus width (mm)	Culmen (mm)	Tail length (mm)	Wing chord (mm)
4/29/03	Douglas Island	Carcass	AHY	F	76	9.2	3.9	11.2	70	96
8/15/06	Yakutat	Carcass	HY	-	54	8.1	4.3	10.8	65	92
2/13/07	Juneau	Carcass	AHY	-	71	7.7	5.9	12.0	66	95
	Average ($\bar{x}$; SD) for males (n=0)				-	-	-	-	-	-
	Average ($\bar{x}$; SD) for females (n=1)				76	9.2	3.9	11.2	70	96

Table 2. Morphometric measurements of Northern Saw-Whet Owls (n=25), Southeast Alaska. Average estimates for each sex do not include hatch-year birds or birds of unknown sex or age class. See Figures 3 and 4 below.

Date	Location	Type	Age	Sex	Mass (g)	Hallux length (mm)	Tarsus width (mm)	Culmen (mm)	Tail length (mm)	Wing chord (mm)
8/28/1973	Chickamin River	specimen	HY	-	72	-	-	-	67	134
1/10/1978	Etolin Island	specimen	-	F	79	-	-	-	62	132
1/18/1985	Juneau	specimen	AHY	M	71	-	-	-	71	139
1/27/1985	Craig	specimen	-	F	89	-	-	-	73	135
8/21/1990	Mitkof Island	specimen	HY	M	-	-	-	-	76	133
12/1/1991	Mitkof Island	specimen	HY	M	-	-	-	-	69	135
10/18/1992	Coffman Cove	specimen	HY	M	-	-	-	-	70	133
12/1/1995	Ketchikan	specimen	-	M	60	-	-	-	68	134
1/3/1996	Ketchikan	specimen	-	M	-	-	-	-	72	132
12/15/1997	Admiralty Island	specimen	-	M	76	-	-	-	70	131
2/14/1999	Ketchikan	specimen	AHY	F	-	-	-	-	80	136
11/1/1999	Ketchikan	specimen	AHY	M	55	-	-	-	70	133
1/18/2000	Juneau	carcass	AHY	M	79	7.8	3.7	11.4	67	137
2/15/2002	Juneau	specimen	AHY	M	57	-	-	-	72	130
4/24/2005	Mitkof Island	live capture	AHY	M	82	7.4	4.3	11.8	70	135
4/29/2005	Mitkof Island	live capture	AHY	M	75	6.6	3.9	12	70	130
3/4/2006	Wrangell	carcass	AHY	M	55	8.5	3.9	11.6	71	136
11/23/2006	Gustavus	carcass	-	F	69	9.4	3.5	12	71	141
11/24/2006	Juneau	carcass	-	F	98	8.5	4.5	11.2	77	142
3/19/2007	Gustavus	carcass	AHY	F	65	9	4.6	11.1	70	140
4/7/2007	Gustavus	carcass	AHY	M	60	8.2	4.8	12.8	73	143
4/16/2007	Gustavus	carcass	-	-	65	8.4	4.5	12.1	77	140
unknown	Pelican	carcass	AHY	M	49	8.6	4.6	12.6	69	135
unknown	Wrangell	carcass	AHY	M	60	7.9	3.5	11.1	72	129
unknown	Southeast Alaska	specimen	-	F	47	-	-	-	67	137
	Average ($\bar{x}$; SD) for males (n=10)				64 (11)	7.9 (0.7)	4.1 (0.5)	11.9 (0.6)	71 (2)	135 (4)
	Average ($\bar{x}$; SD) for females (n=2)				-	-	-	-	75 (7)	138 (3)

Table 3. Morphometric measurements of Western Screech-Owls (n=43), Southeast Alaska. Average estimates for each sex do not include hatch-year birds or birds of unknown sex or age class. See Figures 5 and 6 below.

Date	Location	Type	Age	Sex	Mass (g)	Hallux length (mm)	Tarsus width (mm)	Culmen (mm)	Tail length (mm)	Wing chord (mm)
4/28/1982	Sitka	specimen	AHY	M	183	-	-	-	80	171
4/28/1982	Sitka	specimen	AHY	F	212	-	-	-	90	182
8/9/1987	Mitkof Island	specimen	HY	-	183	-	-	-	86	172
1/1/1988	Juneau	specimen	AHY	M	227	-	-	-	81	168
10/1/1989	Kupreanof Island	specimen	-	M	-	-	-	-	88	163
3/23/1990	Mitkof Island	specimen	AHY	M	-	-	-	-	81	-
10/15/1992	Ketchikan	specimen	-	M	166	-	-	-	87	172
3/13/1993	Petersburg	specimen	AHY	M	210	-	-	-	91	175
3/14/1994	Mitkof Island	specimen	-	M	125	-	-	-	85	169
12/9/1994	Petersburg	specimen	-	M	126	-	-	-	94	176
12/23/1994	Ketchikan	specimen	AHY	M	208	-	-	-	91	172
7/31/1995	Prince of Wales	specimen	-	M	174	-	-	-	54	168
11/30/1996	Mitkof Island	specimen	AHY	F	282	-	-	-	97	176
12/11/2000	Wrangell	carcass	AHY	M	212	11.7	3.8	15.1	94	180
10/1/2003	Yakutat	carcass	HY	M	117	11.2	3.7	14.5	90	179
11/30/2004	Juneau	carcass	AHY	-	210	11.5	4.2	15.3	90	168
4/3/2005	Mitkof Island	live bird	AHY	M	186	10.6	5.4	14.6	55	174
4/27/2005	Mitkof Island	live bird	AHY	M	178	5.9	2.0	10.4	95	176
9/6/2005	Ketchikan	carcass	HY	M	117	9.1	4.4	15.2	94	167
3/17/2006	Mitkof Island	live bird	AHY	F	244	12.7	5.4	15.8	94	188
3/27/2006	Mitkof Island	live bird	AHY	M	174	8.5	4.1	16.2	95	173
4/2/2006	Mitkof Island	live bird	AHY	M	172	9.2	3.8	15.0	90	174
4/14/2006	Mitkof Island	live bird	AHY	F	234	11.8	4.7	17.2	108	188
4/22/2006	Mitkof Island	live bird	AHY	M	174	10.1	4.1	13.6	91	178
4/26/2006	Mitkof Island	live bird	AHY	F	249	11.3	4.9	15.5	101	173
5/11/2006	Mitkof Island	live bird	AHY	M	168	10.1	3.9	13.9	91	175
5/11/2006	Mitkof Island	live bird	AHY	M	168	10.4	5.3	18.7	88	171
6/20/2006	Mitkof Island	carcass	HY	-	-	-	-	-	-	-

Date	Location	Type	Age	Sex	Mass (g)	Hallux length (mm)	Tarsus width (mm)	Culmen (mm)	Tail length (mm)	Wing chord (mm)
9/2/2006	Mitkof Island	carcass	HY	F	127	10.2	4.0	16.5	98	188
10/17/2006	Wrangell	carcass	-	F	192	11.4	4.2	15.1	95	182
11/9/2006	Juneau	live bird	HY	M	148	10.2	4.6	15.7	80	182
11/16/2006	Sitka	live bird	HY	-	184	11.1	5.0	14.5	91	178
11/17/2006	Sitka	live bird	-	-	190	-	-	-	91	175
11/30/2006	Kupreanof Island	carcass	HY	M	124	10.2	4.0	14.6	91	175
12/4/2006	Sitka	live bird	-	-	150	-	-	-	92	173
12/11/2006	Ketchikan	carcass	-	M	258	12.8	4.0	16.3	92	180
2/1/2007	Sitka	carcass	AHY	F	283	10.9	5.6	15.0	101	178
4/20/2007	Sitka	live bird	AHY	M	176	11.2	4.6	15.9	100	182
5/12/2007	Sitka	carcass	AHY	M	139	11.2	6.6	15.4	95	176
9/1/2007	Wrangell	carcass	HY	M	162	11.2	4.8	14.4	89	177
9/13/2007	Juneau	carcass	HY	-	160	11.6	4.6	15.7	94	175
12/18/2007	Douglas Island	carcass	AHY	M	149	11.7	4.6	-	98	177
unknown	Southeast Alaska	specimen	HY	M	127	-	-	-	84	168
	Average ($\bar{x}$; SD) for males (n=16)				182 (24)	10.1 (1.7)	4.4 (1.2)	14.9 (2.1)	89 (11)	175 (4)
	Average ($\bar{x}$; SD) for females (n=6)				251 (28)	11.7 (0.8)	5.2 (0.4)	15.9 (0.9)	99 (6)	181 (6)

Table 4. Morphometric measurements of Boreal Owls (n=3), Southeast Alaska. Average estimates for each sex do not include hatch-year birds or birds of unknown sex or age class.

Date	Location	Type	Age	Sex	Mass (g)	Hallux length (mm)	Tarsus width (mm)	Culmen (mm)	Tail length (mm)	Wing chord (mm)
10/1/1999	Juneau	carcass	-	-	88	11.3	6.5	15.3	104	185
9/23/2000	Shelter Island	carcass	-	-	151	11.1	4.9	14.6	167	181
3/19/2007	Juneau	carcass	AHY	F	97	10.3	5.3	14.8	122	182
	Average ($\bar{x}$; SD) for males (n=0)				-	-	-	-	-	-
	Average ($\bar{x}$; SD) for females (n=1)				97	10.3	5.3	14.8	122	182

Table 5. Morphometric measurements of Short-Eared Owls (n=6), Southeast Alaska. Average estimates for each sex do not include hatch-year birds or birds of unknown sex or age class.

Date	Location	Type	Age	Sex	Mass (g)	Hallux length (mm)	Tarsus width (mm)	Culmen (mm)	Tail length (mm)	Wing chord (mm)
9/25/2003	Juneau	carcass	AHY	-	335	16.9	6.2	16.3	143	304
11/4/2005	Juneau	carcass	AHY	M	188	15.1	5.9	17.9	148	308
11/20/2005	Juneau	carcass	HY	M	-	15.2	5.4	14.8	166	289
1/31/2007	Sitka	carcass	-	-	195	16.1	5.0	16.1	159	298
unknown	Southeast Alaska	carcass	-	M	155	15.8	6.1	19.0	157	300
unknown	Southeast Alaska	carcass	-	M	222	14.5	6.7	21.4	155	321
	Average ($\bar{x}$; SD) for males (n=1)				188	15.1	5.9	17.9	148	308
	Average ($\bar{x}$; SD) for females (n=0)				-	-	-	-	-	-

Table 6. Morphometric measurements of Barred Owls (n=2), Southeast Alaska. Average estimates for each sex do not include hatch-year birds or birds of unknown sex or age class.

Date	Location	Type	Age	Sex	Mass (g)	Hallux length (mm)	Tarsus width (mm)	Culmen (mm)	Tail length (mm)	Wing chord (mm)
10/25/2001	Ketchikan	carcass	HY	M	412	18.5	8.0	23.3	237	320
4/16/2007	Gustavus	carcass	AHY	F	414	18.7	7.5	24.8	240	355
	Average ($\bar{x}$; SD) for males (n=0)				-	-	-	-	-	-
	Average ($\bar{x}$; SD) for females (n=1)				414	18.7	7.5	24.8	240	355

Table 7. Morphometric measurements of Great Horned Owls (n=2), Southeast Alaska. Average estimates for each sex do not include hatch-year birds or birds of unknown sex or age class.

Date	Location	Type	Age	Sex	Mass (g)	Hallux length (mm)	Tarsus width (mm)	Culmen (mm)	Tail length (mm)	Wing chord (mm)
12/21/2001	Haines	carcass	-	-	1520	25.5	12.0	33.0	250	400
unknown	Southeast Alaska	carcass	-	M	1020	28.6	12.0	31.6	235	390
	Average ($\bar{x}$; SD) for males (n=0)				-	-	-	-	-	-
	Average ($\bar{x}$; SD) for females (n=0)				-	-	-	-	-	-

Figure 1. Stephen Lewis (one of the authors) performing a necropsy on a short-eared owl in the laboratory, December 2007.

Figure 2. Owl carcasses arranged from smallest to largest (left to right): northern pygmy-owl, Northern Saw-Whet Owl, Western Screech-Owl, boreal owl, short-eared owl, Barred Owl, and great-horned owl.

Figure 3. Northern Saw-Whet Owl specimens at the University of Alaska Museum, Fairbanks. The top row of specimens (n=4) are the *brooksi* subspecies endemic to the Queen Charlotte Island, British Columbia. The second bird from the right in the top row is a juvenile. The bottom row of specimens (n=2) are from Southeast Alaska and are the more common subspecies *acadicus*.

Figure 4. Northern Saw-Whet Owl trapped on Mitkof Island, 24 April 2005, as part of this study. This bird was processed and released.

Figure 5. Museum specimens of hatch-year Western Screech-Owls (ventral side) from Southeast Alaska (University of Alaska Museum). Note the horizontal barring on the breast.

Figure 6. Western Screech-Owl (WS2) captured, radio-marked, and released on Mitkof Island, 27 March 2006. Note the antenna from the transmitter extending from the back of the owl.

APPENDIX IV
SOURCES OF MORTALITY FOR OWLS IN SOUTHEAST ALASKA

We compiled information on sources of mortality from two sources: (1) museum specimens, and (2) carcasses found opportunistically. We examined Western Screech-Owl and Northern Saw-Whet Owl specimens at the University of Alaska Museum. We recorded standard morphometric measurements (see Appendix III) and noted relevant information (e.g., stomach contents, collection location, cause of death, etc.) included on the voucher. We also collected carcasses that were found dead by community members and submitted to us, Juneau Raptor Center, Alaska Raptor Center, or the local Alaska Department of Fish and Game office. We asked local state and federal offices to review the contents of their freezers and send any owl carcasses that they found. We agreed to take responsibility to voucher specimens and send them to the University of Alaska Museum, Fairbanks or the collection located at the University of Alaska, Anchorage. We encouraged everyone to send all owl species because it can be difficult to determine species of carcasses, particularly if trauma occurred or the bird is only partially intact. We then performed necropsies on each carcass to determine sex, stomach contents (see Chapter 5 for analysis of Western Screech-Owl diet), and, if possible, confirm cause of death. We acknowledge that the carcasses and museum specimens examined due not represent a statistical survey and therefore, do not represent an unbiased sample; these birds may have been predisposed to mortality. Additionally, relatively few owls that die due to starvation are located, while owls killed by vehicle or window collision are more likely to be retrieved and submitted to researchers or museums.

Below we summarize these data by species beginning with the smallest owl and include any relevant notes about the specimen or carcass (n=68). Records are organized by year and can be cross-referenced with those in Appendix III. In addition to the owls described below, one long-eared owl was found dead in Wrangell, November 2006, presumably due to starvation. The U.S. Forest Service retained this carcass. We conclude with a summary of sources of mortality across all species (Figure 1).

Definitions are as follows: date indicates the month/day/year the bird was found; location is the general location; type= carcass (dead bird submitted for necropsy) or specimen (University of Alaska museum collection); age=hatch-year (HY) or after-hatch-year (AHY); sex=male (M) or female (F); stomach contents=identifiable prey remains found in stomach; cause of death=known cause of death indicated on voucher (museum specimens only) or determined during necropsy (or reported from person that located the carcass; carcasses only), trauma=window or vehicle collision; current location=carcasses were sent to UAM (University of Alaska Museum, Fairbanks; unique ID included if prepared museum specimen), UAA (University of Alaska, Anchorage), or were discarded; notes=additional relevant information.

Table 1. Sources of mortality and other relevant information on the Northern Pygmy-Owl (n=3) based on museum specimens and carcasses collected opportunistically, Southeast Alaska.

Date	Location	Type	Age	Sex	Stomach contents	Cause of death	Current location	Notes
4/29/03	Douglas Island	Carcass	AHY	F	Fully-formed pellet; unknown small mammal	Unknown	UAM	Lots of fat around abdominal cavity
8/15/06	Yakutat	Carcass	HY	-	None	Unknown	UAA	Carcass had been partially scavenged; date was August 2006
2/13/07	Juneau	Carcass	AHY	-	Fully-formed pellet; unknown small mammal	window strike	UAM	Found dead next to building; unable to sex due to injuries

Table 2. Sources of mortality and other relevant information on the Northern Saw-Whet Owl (n=23) based on museum specimens and carcasses collected opportunistically, Southeast Alaska.

Date	Location	Type	Age	Sex	Stomach contents	Cause of death	Current location	Notes
8/28/1973	Chickamin River	specimen	HY	-	parts of little brown bat (*Myotis lucifugus*)	collected	UAF	
1/10/1978	Etolin Island	specimen	-	F	*Sorax* spp	mammal trapline	UAF	
1/18/1985	Juneau	specimen	AHY	M	-	unknown	UAF	no fat
1/27/1985	Craig	specimen	-	F	-	vehicle collision	UAF	
8/21/1990	Mitkof Island	specimen	HY	M	-	unknown	UAF	light fat
12/1/1991	Mitkof Island	specimen	HY	M	-	unknown	UAF	light fat
10/18/1992	Coffman Cove	specimen	HY	M	-	window strike	UAF	moderate fat
12/1/1995	Ketchikan	specimen	-	M	-	unknown	UAF	no fat
1/3/1996	Ketchikan	specimen	-	M	-	unknown	UAF	no fat
12/15/1997	Admiralty Island	specimen	-	M	-	mammal trapline	UAF	light fat
2/14/1999	Ketchikan	specimen	AHY	F	-	unknown	UAF	no fat
11/1/1999	Ketchikan	specimen	AHY	M	invertebrates	unknown	UAF	no fat
1/18/2000	Juneau	carcass	AHY	M	whole *Sorax* spp	window strike	UAF	
2/15/2002	Juneau	specimen	AHY	M	dark, digested matter	vehicle collision	UAF	no fat
3/4/2006	Wrangell	carcass	AHY	M	empty	starvation	UAF	
11/23/2006	Gustavus	carcass	-	F	Coleoptera larvae; 40-50 nematode parasites	starvation	UAA	
11/24/2006	Juneau	carcass	-	F	empty	window strike	discarded	heavy fat
3/19/2007	Gustavus	carcass	AHY	F	mammal hair; 10 nematode parasites	starvation	UAA	alive 3/18/07
4/7/2007	Gustavus	carcass	AHY	M	traces of mammal hair	unknown	UAF	found dead in landfill structure
4/16/2007	Gustavus	carcass	-	-	dark, digested matter	unknown	UAA	parasites
unknown	Pelican	carcass	AHY	M	empty	starvation	UAA	
unknown	Wrangell	carcass	AHY	M	nearly a full pellet of grasses and bark	starvation	UAA	
unknown	Southeast Alaska	specimen	-	F	empty	trauma	UAF	no fat

Table 3. Sources of mortality and other relevant information on the Western Screech-Owl (n=28) based on museum specimens and carcasses collected opportunistically, Southeast Alaska.

Date	Location	Type	Age	Sex	Stomach contents	Cause of death	Current location	Notes
4/28/1982	Sitka	specimen	AHY	M	10 Lepidoptera caterpillars	collected	UAF	topotype
4/28/1982	Sitka	specimen	AHY	F	10 Lepidoptera caterpillars	collected	UAF	topotype
8/9/1987	Mitkof Island	specimen	HY	-	-	vehicle collision	UAF	
1/1/1988	Juneau	specimen	AHY	M	-	window hit	UAF	heavy fat
10/1/1989	Kupreanof Island	specimen	-	M	empty	unknown	UAF	little fat
3/23/1990	Mitkof Island	specimen	AHY	M	-	gillnet	UAF	found 3/16/90; moderate fat
10/15/1992	Ketchikan	specimen	-	M	-	vehicle collision	UAF	
3/13/1993	Petersburg	specimen	AHY	M	-	unknown	UAF	
3/14/1994	Mitkof Island	specimen	-	M	-	starvation	UAF	
12/9/1994	Petersburg	specimen	-	M	empty	starvation	UAF	
12/23/1994	Ketchikan	specimen	AHY	M	-	vehicle collision	UAF	heavy fat
7/31/1995	Prince of Wales	specimen	-	M	-	vehicle collision	UAF	
11/30/1996	Mitkof Island	specimen	AHY	F	-	vehicle collision	UAF	heavy fat
12/11/2000	Wrangell	carcass	AHY	M	4 Lepidoptera caterpillars	vehicle collision	UAF	heavy fat
10/1/2003	Yakutat	carcass	HY	M	1 Caribidae species	unknown	discarded	
11/30/2004	Juneau	carcass	AHY	-	1 Arachnid, Araneae Linyphiidae	unknown	discarded	
9/6/2005	Ketchikan	carcass	HY	M	1 Caribidae species and 1 Caribidae Pterostichus	unknown	UAA	
6/20/2006	Mitkof Island	carcass	HY	-	*Sorex* spp	unknown	discarded	found dead beneath nest tree (WS6)

Date	Location	Type	Age	Sex	Stomach contents	Cause of death	Current location	Notes
9/2/2006	Mitkof Island	carcass	HY	F	empty	starvation	discarded	body lice
10/17/2006	Wrangell	carcass	-	F	1+ Caribidae Pterostichus; 1 small mammal	vehicle collision	UAF	
11/30/2006	Kupreanof Island	carcass	HY	M	empty	starvation	discarded	
12/11/2006	Ketchikan	carcass	-	M	10 Lepidoptera caterpillars	trauma	ADFG, Ketchikan	body lice
2/1/2007	Sitka	carcass	AHY	F	3 Annelida earthworms	vehicle collision	discarded	
5/12/2007	Sitka	carcass	AHY	M	invertebrates	starvation	UAF	radio-marked
9/1/2007	Wrangell	carcass	HY	M	mammal hair; 1+ Caribidae Pterostichus	unknown	UAA	
9/13/2007	Juneau	carcass	HY	-	4 Lepidoptera caterpillars	trauma	UAF	
12/18/2007	Douglas Island	carcass	AHY	M	empty	trauma	ADFG, Ketchikan	tip of culmen broken; light fat
unknown	Southeast Alaska	specimen	HY	M	mammal hair	unknown	UAF	

Table 4. Sources of mortality and other relevant information on the Boreal Owl (n=3) based on museum specimens and carcasses collected opportunistically, Southeast Alaska.

Date	Location	Type	Age	Sex	Stomach contents	Cause of death	Current location	Notes
10/1/1999	Juneau	carcass	-	-	empty	unknown	UAF	carcass was desiccated; found at mouth of Gold Creek, roughly 300ft elevation
9/23/2000	Shelter Island	carcass	-	-	-	unknown	UAF	carcass was desiccated; necropsy not attempted
3/19/2007	Juneau	carcass	AHY	F	empty	unknown	discarded	

Table 5. Sources of mortality and other relevant information on the Short-Eared Owl (n=6) based on museum specimens and carcasses collected opportunistically, Southeast Alaska.

Date	Location	Type	Age	Sex	Stomach contents	Cause of death	Current location	Notes
9/25/2003	Juneau	carcass	AHY	-	empty	trauma; struck by plane	UAF	carcass was badly damaged
11/4/2005	Juneau	carcass	AHY	M	empty; nematode parasites	unknown	UAA	
11/20/2005	Juneau	carcass	HY	M	fully-formed pellet; *Sorex* spp	starvation	discarded	
1/31/2007	Sitka	carcass	-	-	1 unknown feather	unknown	UAF	
unknown	Southeast Alaska	carcass	-	M	-	unknown	USFS, Wrangell	
unknown	Southeast Alaska	carcass	-	M	empty; nematode parasites	starvation	UAF	no documentation

Table 6. Sources of mortality and other relevant information on the Barred Owl (n=2) based on museum specimens and carcasses collected opportunistically, Southeast Alaska.

Date	Location	Type	Age	Sex	Stomach contents	Cause of death	Current location	Notes
10/25/2001	Ketchikan	carcass	HY	M	whole *Sorex cinereus*	unknown	discarded	emaciated despite shrew in stomach
4/16/2007	Gustavus	carcass	AHY	F	empty	starvation	UAF	

Table 7. Sources of mortality and other relevant information on the Great Horned Owl (n=2) based on museum specimens and carcasses collected opportunistically, Southeast Alaska.

Date	Location	Type	Age	Sex	Stomach contents	Cause of death	Current location	Notes
12/21/2001	Haines	carcass	-	-	-	unknown	UAF	carcass was desiccated; necropsy not attempted
unknown	Southeast Alaska	carcass	-	M	empty; nematode parasites	starvation	UAF	no documentation

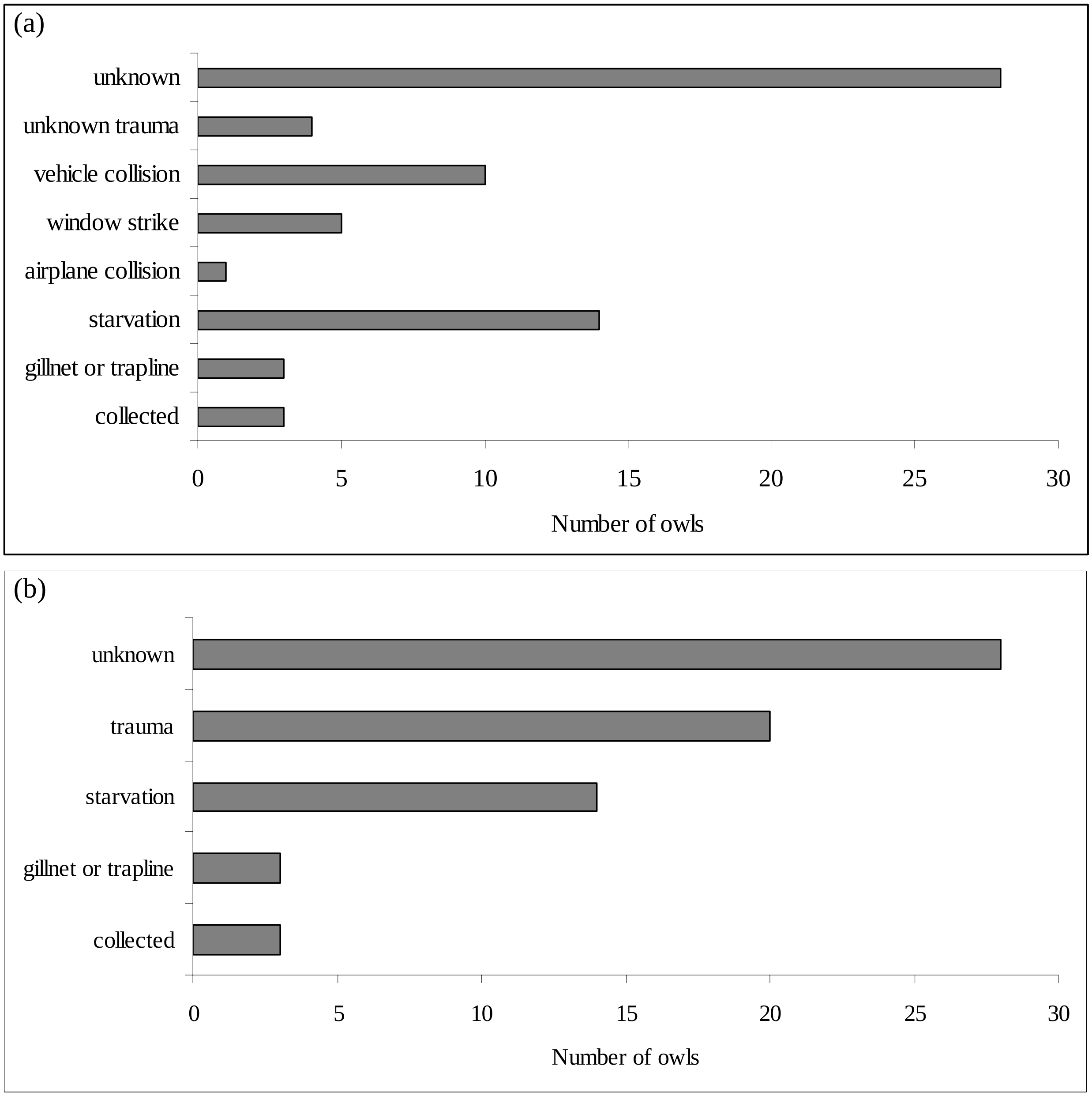

Figure 1. Sources of mortality of owls in Southeast Alaska with (a) causes of trauma separated into categories, and (b) causes of trauma combined.

APPENDIX V
NOTES ON (*AEGOLIUS ACADICUS*) NORTHERN SAW-WHET OWL CAPTURE AND MONITORING

During 2005, we conducted a pilot study to determine the feasibility of capture, radiotagging, and monitoring of Northern Saw-Whet Owls (*Aegolius acadicus*). The purpose of radio-marking owls was to learn more about the relationship between breeding status and singing behavior, and to use that information to refine our survey protocol (see Chapter 1). Because Northern Saw-Whet Owls have never been captured and radio-marked in Southeast Alaska prior to our study, we summarize our results below.

In 2005, as part of a pilot effort, we attempted to capture Northern Saw-Whet Owls during the breeding season when they were defending territories. We trapped owls opportunistically during silent surveys (see Chapter 1). When we detected an owl, we set up a mist net along the road edge and used the Northern Saw-Whet Owl territorial call (Canning 1993) to attract the owl. We broadcast the call with a handheld megaphone (PA Genie Amplifier APM-760, Fanon Courier, Irvine, CA) and a portable CD player (CD Walkman D-NS505, Sony) placed on the ground, centered in the net (Chapter 4). We used a small, stuffed-animal owl decoy to draw the attention of the owl, placing it on top of the megaphone. See Chapter 4 for details on handling procedures.

We attempted to capture Northern Saw-Whet Owls on 4 nights from 22 March–5 May 2005, resulting in 2 captures (2 males). On 24 April, we captured #NS1 approximately 45 min after beginning to broadcast the owl call. On 30 April, we captured #NS2 roughly 12 minutes after beginning to broadcast a saw-whet call.

We monitored Northern Saw-Whet Owls using techniques outlined in Chapter 3. We gathered 27 locations (NS1 = 19; NS2 = 8; Figure 1) which included 4 home-ins locations (2 per owl), 19 day telemetry locations (NS1 = 13; NS2 = 6), and 4 night telemetry locations (NS1 = 4; NS2 = 0). We were able to find 1 owl at its day roost on 2 occasions to measure habitat characteristics (Table 1). During the other 2 home-in locations, the owl flushed before we could find its actual roost so no measurements could be made.

While we found these owls to be relatively easy to capture, locating and monitoring them proved time-consuming and difficult. Both owls appeared to be singing territorially when first encountered and captured but after monitoring, neither seemed to be holding a territory. Both bird's locations were never centralized and seemed to move around the landscape through time (Figures 2, 3). As opposed to Western Screech-Owls which were very approachable, the Northern Saw-Whet Owls were very shy and retreating, often flushing from a roost when we were many meters (>100 m) away through heavy second-growth trees. Additionally, as the breeding season progressed, both owls moved higher up the mountain sides (Figures 1–3). This made them virtually unreachable by foot because of the steep and rugged terrain of Southeast Alaska and the need to conduct other parts of the study (i.e., repeat nightly surveys). After our experience monitoring these 2 owls, we concluded that we could not monitor Northern Saw-Whet Owls in a fashion that would provide us with data to answer questions about their behavior relative to timing of the breeding season and their habitat requirements. Therefore, we did not attempt to capture any more during the subsequent years of the study.

Table 1. Summary of habitat characteristics measured at Northern Saw-Whet Owl roosts on Mitkof Island, Southeast Alaska, 2005 (n = 2 roosts, 1 owl; $\bar{x} \pm$ SE).

	Characteristic	Category	Value
Tree	Species (%)	Sitka Spruce	100
	DBH (m)		13.6 ± 7.8
	Height (m)		7.4 ± 4.0
	Status (%)	live	100
	Canopy Class (%)	Sapling	100
Site	Aspect (°)		75 ± 88
	Slope (%)		23 ± 12
	Canopy Cover (%)		65 ± 14
	Elevation (m)		198 ± 16
Owl	Height (m)		2.6 ± 0.8
	Distance to Trunk (cm)		10 ± 7
	Concealment (%)		53 ± 60

[a] angular deviation

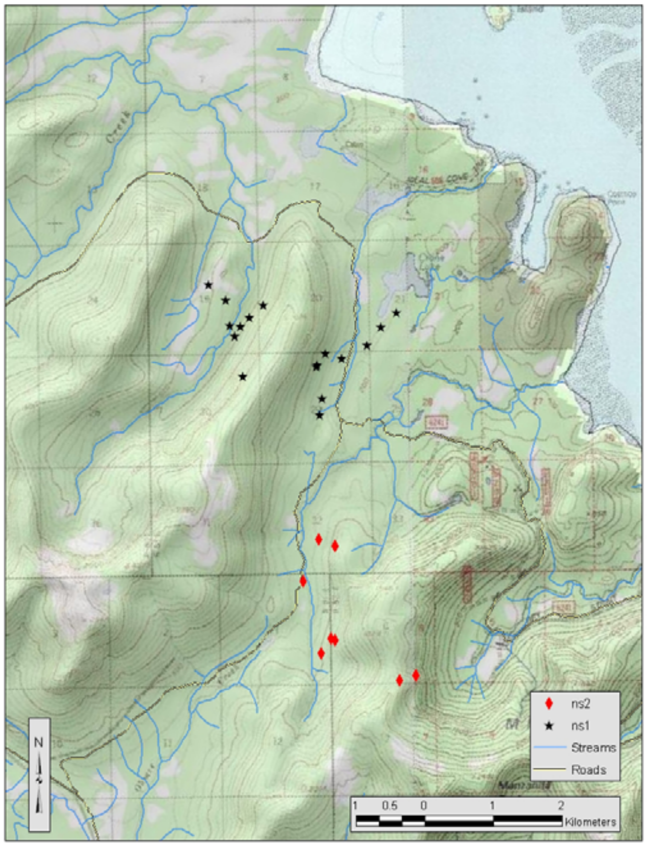

Figure 1. Map of location from 2 radio-marked Northern Saw-Whet Owls on Mitkof Island in central Southeast Alaska, USA, 2005.

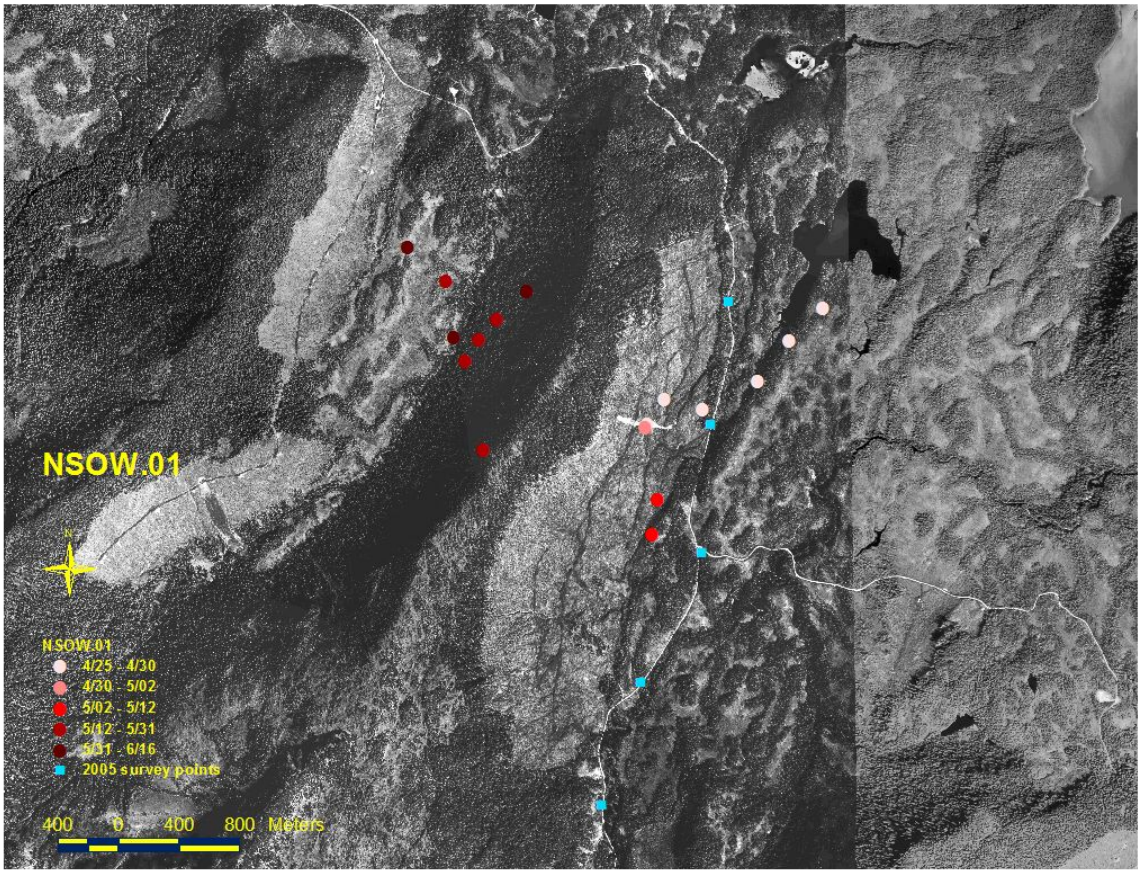

Figure 2. Locations of radio-marked Northern Saw-Whet Owl (#NS1) gathered in 2005 on Mitkof Island in central Southeast Alaska, USA.

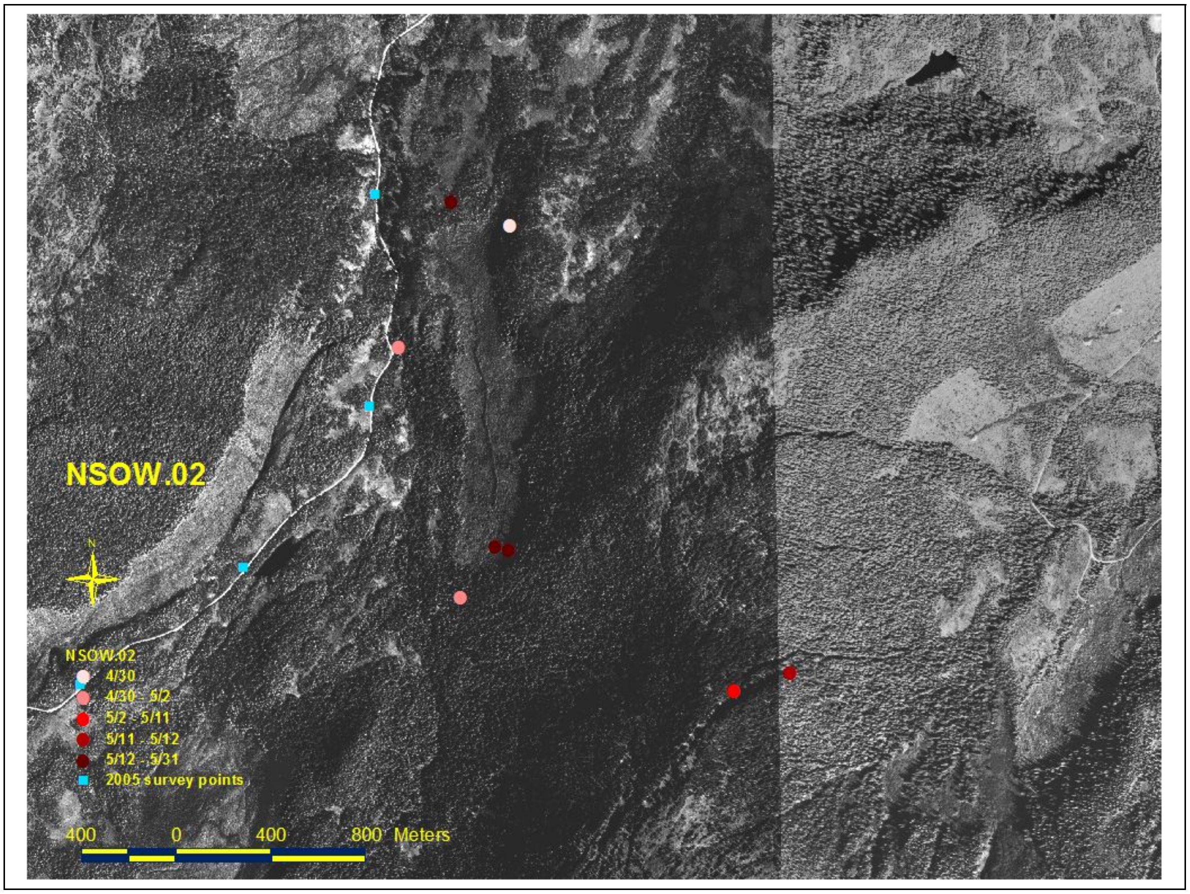

Figure 3. Locations of radio-marked Northern Saw-Whet Owl (#NS2) gathered in 2005 on Mitkof Island in central Southeast Alaska, USA.