RELATIVE ABUNDANCES OF BIRDS OF PREY IN DIFFERENT FOREST HABITATS IN THE WESTERN NEWFOUNDLAND MODEL FOREST

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Relative Abundances of Birds of Prey in Different Forest Habitats in the Western Newfoundland Model Forest

By

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Abstract

Balsam fir forests in western Newfoundland are intensively managed for pulpwood production resulting in a fragmented landscape of different-aged forests and clearcuts. Prior to this research, the ecology of woodland birds of prey had been unstudied on insular Newfoundland, and knowledge regarding consequences of forestry practices on aspects of their biology was lacking. As top-level carnivores, raptors are susceptible to both natural and human induced perturbation and may effectively be used as indicator species of environmental health in boreal forest ecosystems.

During the breeding seasons of 1993 and 1994, the diversity and relative abundances of birds of prey were investigated in the Western Newfoundland Model Forest (WNMF). The primary research objectives were to: 1) develop reliable, standardized techniques with which to census birds of prey in different-aged forests and clearcuts in the WNMF, 2) determine the species diversity and relative abundances of birds of prey in uncut old growth, second growth forest, clearcuts and pre-commercially thinned areas, 3) develop density estimates of selected species of birds of prey, 4) identify nest-sites of birds of prey and quantify habitat characteristics at these sites, 5) identify knowledge gaps with respect to Newfoundland birds of prey, and in doing so to develop research objectives and management strategies for future studies.

Surveys using conspecific vocalization playbacks were conducted along forest access roads and lake shorelines that transected different forest habitats. Ground searches were made for raptor activity sites (i.e. nests, roosts, prey-plucking-sites), and habitat measurements at these sites and unused control sites were obtained. The vocalization playback method used was reasonably effective for locating owls but less effective for other woodland raptors.

Nine species of birds of prey were recorded in the area: Merlin, American Kestrel, Osprey Rough-legged Hawk, Sharp-shinned Hawk, Northern Goshawk, Boreal Owl, Great Horned Owl, and Northern Hawk-Owl. Uncut old growth forests contained more species than second growth forests and clearcuts, however abundances in all forest types were low. Boreal Owls and Northern Goshawks were found exclusively in uncut old growth, and Sharp-shinned Hawks mainly in this habitat type. Three species of birds of prey were recorded in second growth

forests in the study area, one of which, the Great Horned Owl, was found only in this habitat type. Clearcut areas were utilized by four species of raptors and Northern Hawk-Owls and American Kestrels used clearcuts extensively. Merlins were the most commonly detected bird of prey and unlike any other species were found in all forest habitats.

Predator-prey relationships influence the occurrences of birds of prey in different habitats. A comparison of avian-dependent birds of prey (i.e. Sharp-shinned Hawks, Merlins) and small mammal specialists (i.e. Boreal Owls, Northern Hawk-Owls, Rough-legged Hawks) indicated that between 1993 and 1994, the numbers of avian predators remained identical whereas the numbers of rodent predators declined significantly. This population decrease is likely a result of the simultaneous decline in small mammals in this region and reflects the importance of food resources in influencing population dynamics of birds of prey in different habitats.

Density comparisons made between western Newfoundland and a range of locations throughout boreal forest systems in North America and Scandinavia indicate that raptor populations are extremely variable. Although lacking rigorous empirical analysis, such comparisons provide an index of raptor populations at different spatial and temporal scales. In western Newfoundland, the low diversity and numbers of small mammals likely limits the densities of birds of prey dependent on this food resource, (Boreal Owl, Northern Hawk-Owl, Rough-legged Hawk). Great Horned Owls and Northern Goshawks may also have been food limited as their major prey species (Snowshoe Hare, Ruffed Grouse) were uncommon in this region. These predator-prey relationships may be responsible for the low densities of birds of prey found in the boreal forests of western Newfoundland.

Habitat selection theory postulates that species are preferentially associated with particular habitats in which they can optimally survive and reproduce. For birds of prey, the mechanisms that elicit selection of habitats are not well understood yet this information is needed in order to effectively manage forests to maintain the natural biodiversity and abundance of birds of prey. Sample sizes of raptor activity sites were small, however trends of habitat selection were apparent and consistent with research conducted elsewhere.

In recent years, the management of non-game wildlife has become an important issue in

light of approaches to preserving forest ecosystems that go beyond the primary objective of fibre and timber production. In North America, birds of prey are protected under governmental legislation, and conservation measures for them have been implemented in forest management strategies. In Newfoundland, however, a previous lack of knowledge regarding the distributions and abundances of woodland raptors has resulted in minimal attention with respect to forestry planning. Based on census results of this present study, I suggest that large tracts of remaining uncut old growth forests be preserved from timber harvesting and that the existence of this habitat type be ensured at a landscape level in future years. Furthermore, research and systematic monitoring of woodland raptor populations should continue in an attempt to better understand impacts of forest harvesting operations.

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Chapter 1

1.1 Introduction

Study of the diversity and abundances of birds of prey in different-aged forests in western Newfoundland is an important component of understanding wildlife-forestry interactions. Preservation of top level carnivores offers a direct means with which to understand and maintain biodiversity in terrestrial ecosystems (e.g. Soule´ and Wilcox 1980; Frankel and Soule´ 1981). If forest habitats and associated communities of these wide-ranging top-level carnivores can be ensured, then the protection of many other wildlife species at lower trophic levels will also be promoted. Raptors are susceptible to both natural and human-induced perturbation (e.g. Newton 1979, Poole 1989, Carey and Peeler 1995) and can be used as indicator species of boreal forest ecosystem integrity (see Landres *et al.* 1988). As an example, the Northern Goshawk (*Accipiter gentilis*) was selected as a management indicator species in northeastern California, because it was designated as a sensitive species and an ecological indicator for mature and old-growth forests (McCarthy *et al.* 1989). Birds of prey are also often featured in conservation strategies because of their position in food webs and of their public attractiveness (Noss 1990). In addition to their value as ecological indicator species, birds of prey are also considered aesthetically important, and this perception is reflected in the change of public attitudes toward this group of species. Governmental legislation now protects all species of raptors, whereas in past decades, birds of prey were considered harmful predators and pests and were often directly persecuted by humans (Johnsgard 1988).

Extensive research describing raptor distributions and habitat associations has been conducted in North America and Europe (Titus and Mosher 1981, Armstrong and Euler 1982, Reynolds *et al.* 1982, Hayward *et al.* 1993, Solonen 1994). Though patterns of habitat use have emerged, results are often site-specific and vary greatly across the geographic ranges of some species. The boreal forest of insular Newfoundland constitutes the extreme eastern limit of the range of many North American woodland raptors, and is ecologically unique in that episodic insect events function as the primary mechanism for forest succession under natural conditions (Thompson 1994). The requirement for research on forest birds of prey in this region is further accentuated since the western Newfoundland landscape has been drastically altered by forest harvesting since 1924

(Horwood 1986). This has resulted in extensive fragmentation and a shift in the age-class distribution of forests in this region. Knowledge of deleterious effects of these activities on bird and other wildlife populations has not been documented. For these reasons, research objectives of this study were aimed at basic aspects of raptor survey techniques and ecology, and were:

1. To develop reliable, standardized techniques with which to survey birds of prey in different-aged forests and clearcuts in the Western Newfoundland Model Forest (WNMF).
2. To determine the species diversity and relative abundances of birds of prey in uncut old growth, second growth forest, clearcuts and pre-commercially thinned areas.
3. To develop density estimates of selected species of birds of prey.
4. To identify nest sites of birds of prey and quantify habitat characteristics at these sites.
5. To identify knowledge gaps with respect to Newfoundland birds of prey, and in doing so to develop research objectives and management strategies for future studies.

1.2 Study Area

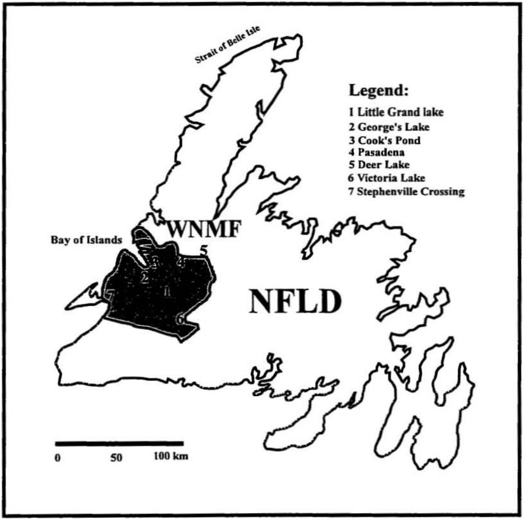
The WNMF study area falls within the Corner Brook subregion (Damman 1983) and is characterized by hilly terrain with altitudes of up to 600 m. Forests are primarily *Dryopteris* - balsam fir (*Abies balsamea*) mixed occasionally with white spruce (*Picea glauca*), black spruce (*P. mariana*) and white birch (*Betula papyrifera*; Nfld. For. Serv. 1992). The humid climate minimizes fires from this region (Damman 1983), and under natural conditions infestations of hemlock looper (*Lambdina fiscellaria*) or spruce budworm (*Choristoneura fumiferana*) are responsible for forest renewal (Bazukis and Hansen 1965). Defoliated patches of forest in conjunction with clearings from timber removal has resulted in a very fragmented landscape in this region.

In the following study I have classified "uncut old-growth" forests as 80-100 year old uncut stands. Small forest openings (100 x 100 m), resulting from insect defoliation, and an abundance of snags and coarse woody debris are typical. Tree heights in this forest type often reach up to 20-24 m (Nfld. For. Serv. 1992). Second growth stands in western Newfoundland are regenerated stands following timber harvesting earlier in the century. Compared with uncut older forests, these stands are 40-60 years old and are characterized by smaller tree diameters, more stems/ha, higher shrub diversity and less woody debris (Thompson and Curran 1995). Clearcut sites resulting from forest harvesting have had most of the wood volume removed, though some deciduous and otherwise unmerchantable trees remain on these sites. Herbaceous ground vegetation consisting of raspberry (*Rubus* spp.) and alder (*Alnus* spp.) is dense; however, clearcuts near Cook's Pond are devoid of most ground vegetation because of prior treatment with the herbicide glyphosphate. Clearcut sites ranged from 5-15 years old. Pre-commercially thinned areas were found throughout the study area and ranged from 10-30 years old. These were regenerating sites that had been artificially thinned to promote more efficient tree growth and were almost exclusively composed of balsam fir. My study sites represented an area of approximately 400 km^2 within the WNMF.

The main study area during the 1993 field season (24 May to 14 August) was located near Little Grand Lake within the Environmental Assessment Area where cutting has been suspended. Much of this area is uncut balsam fir forest, though 5.3 km^2 was harvested prior to protection of this area. July 8 - 14 was spent in the Cook's Pond area. Research trips were also made to sites near Deer Lake (1, 4, 5 June, 13 July), Victoria Lake (3-5 July), and Stephenville Crossing (20 July, 2 August).

Research in 1994 was conducted near Little Grand Lake almost entirely in the area from the Trans Canada Highway (TCH) east to Little Grand Lake, the secondary road from the TCH west to George's Lake, and at Cook's Pond (15 - 21 March, 1 June to 15 August). These sites were largely located within uncut old growth (80+ yr), second growth (40-60 yr), and clearcut areas respectively. Sites were also surveyed at Pasadena (27 June, 17, 22 July), Deer Lake (12 July, 3 August) and at Stephenville Crossing (8-11 August; see Figure 1.1).

Figure 1.1 The Western Newfoundland Model Forest Study area (shaded region). Study sites are indicated by numbers 1-7.



Chapter 2

A survey of woodland birds of prey in the Western Newfoundland Model Forest

2.1 Introduction

Forests in western Newfoundland are intensively managed for pulpwood production, and clearcutting is the primary harvesting method. Consequently, the landscape is composed largely of various aged clearcuts, regenerated second growth forest, and remnant stands of uncut old growth balsam fir forest. Habitat loss from timber harvesting is recognized as a serious threat to populations of some woodland raptors (Armstrong and Euler 1982, McCarthy *et al.* 1989, Carey *et al.* 1990, Crocker-Bedford 1990). Consequently, management guidelines have been imposed in some regions in an effort to offset the potential adverse affects that forest harvesting may have on birds of prey as well as other wildlife species (Nelson and Titus 1987). On insular Newfoundland, however, management guidelines for woodland raptors are lacking, and prior to this research, the consequences of forest removal on raptor ecology had not been considered. Timber harvesting is scheduled to continue in this region, so it is important to investigate the species composition and relative abundances of birds of prey in different habitats to assess how forestry practices will influence raptor diversity, abundance and habitat associations. Systematic surveys were conducted in different-aged balsam fir forests in an effort to achieve these objectives.

Breeding densities of birds of prey are generally assumed to be limited by either the number and distribution of suitable nesting sites, an adequate food source or some combination of these two factors (Newton 1979). Furthermore, these factors likely vary within and between species and across different temporal and spatial scales. Monitoring the densities of wildlife populations (number of individuals or pairs/area) is of interest to ecologists and managers when assessing the potential impacts of land-use practices on the environment. Habitat quality can be assessed partially by determining the number of individuals that inhabit an area, although the validity of using breeding density as the only or most important indicator of habitat quality has been questioned (Van Horne

1983). Raptor surveys have been conducted throughout much of North America (Rusch *et al.* 1972, Schmutz 1984, Andersen and Rongstad 1989); however, density estimates are difficult to obtain for woodland species during the breeding season because they are typically wide-ranging, secretive and often nest in inaccessible areas, particularly in northern boreal forests (Fuller and Mosher 1987). Estimates of raptor densities are presented and I speculate on the main factor(s) which may limit raptor densities in this region. In addition, I compared estimated breeding densities of woodland birds of prey in western Newfoundland with densities recorded in other North American and European boreal forest ecosystems. This will provide some insight into raptor populations in the study area.

2.1.1 Raptor censusing methods

Compared with birds at lower trophic levels, most forest-dwelling birds of prey nest at relatively low densities, are wide ranging, secretive and are therefore difficult to census (Fuller and Mosher 1981, Millsap and Lefranc 1988, Kennedy and Stahlecker 1993, Solonen 1994). In recent decades, however, the increased interest of biologists and land-use planners in recording the numbers and distributions of raptors has led to the necessity of developing efficient and accurate censusing techniques. As a group, raptors occupy a wide range of habitats, differ behaviourally and therefore differ in their detectability to observers. Consequently, modifications to traditional methods of counting raptors as well as new census techniques have evolved that are suitable for specific birds of prey, habitat types and the study objectives of researchers.

Perhaps the most commonly used method for censusing birds of prey has been the road count (e.g. Andersen and Rongstad 1989, Donazar *et al.* 1993, Smallwood 1995). This method involves driving an automobile along roadways at a constant speed and recording the species and numbers of raptors encountered. Despite inherent biases such as differences in observer capability and seasonal and climatic variables that may affect detection rates of raptors (Morrell *et al.* 1991), this technique has been widely employed since the 1930s (Leopold 1942) because of its suitability for censusing extensive areas and targeting multiple species. Data collected from road counts have been used to provide an index into the relative abundances and populations of birds of prey in a specific area (Fuller and Mosher 1981).

Nest searches have also been historically used to count birds of prey and develop breeding and population estimates (Fuller and Mosher 1981). Depending on the resources available and the study objectives of the investigator, nest searches may be conducted on foot, by ground vehicle or aircraft. This technique has been particularly effective for censusing larger birds of prey such as Bald Eagles (*Haliaeetus leucocephalus*) and Osprey (*Pandion haliaetus*; Wetmore and Gillespie 1976, Call 1978). These species typically have prominent stick nests that often extend above the tree canopy and are often conspicuous. Nest searches for smaller woodland raptors are generally more difficult, particularly in the dense coniferous dominated regions of the boreal forest where nests are highly concealed (Devaul 1988).

Another method that has traditionally been used for censusing birds of prey, as well as other avian species (Marion *et al.* 1981), has been to listen for vocalizations of territorial adults and to record their estimated locations. Within the past two decades, researchers have also begun broadcasting recorded vocalizations at varying intervals along survey transects. The objective of this technique is to improve detection rates of breeding raptors in forested habitats that are typically difficult to census (Bondrup-Nielsen 1978, Devaul 1988, Mosher *et al.* 1990, Solonen 1994). To date, this method has proven effective for increasing the detection rates of several species of hawks and owls, including Spotted Owls (*Strix occidentalis*; Forsman *et al.* 1977), Ferruginous Pygmy-owls (*Glaucidium gnoma*; Proudfoot and Beasom 1996), Barred Owls (*Strix varia*; Mosher *et al.* 1990), Cooper's Hawks (*Accipiter cooperi*), Red-shouldered Hawks (*Buteo lineatus*; Rosenfield *et al.* 1988, Mosher *et al.* 1990) and Northern Goshawks (Kennedy and Stahlecker 1993).

In the present study, I used systematic point counts in conjunction with vocalization playbacks (Mosher *et al.* 1990) and nest searches to intensively census woodland birds of prey in four forest habitats; uncut old growth balsam fir forests, second growth forests, pre-commercially thinned areas and clearcuts.

2.2 Methods

2.2.1 Survey protocol

Seven transects passing through uncut old growth forest (total transect distance = 15 km), second growth forest (9 km), pre-commercially thinned areas (18 km) and clearcuts (16 km) were established along forest roads in 1993 and were surveyed three times for each target species during the breeding season (Table 2.1). Transects varied in length (depending on roads in different-aged forests) from 4.8 to 11.2 km and comprised a number of broadcast stations at 800 m intervals measured using a vehicle odometer. In areas inaccessible by truck, an all-terrain vehicle or boat was used and broadcast stations were assigned using 1:50,000 scale topographic maps (see Appendix 1 for locations of survey routes). Surveys for woodland birds of prey were conducted along the transects by broadcasting conspecific territorial vocalizations at each of the stations (Mosher *et al.* 1990). These vocalizations were intended to elicit aggressive responses from territorial adults that may occur in the area, thus improving detection rates of birds. In 1993, the target species were the Sharp-shinned Hawk (*Accipiter striatus*), Northern Goshawk, Merlin (*Falco columbarius*), Boreal Owl (*Aegolius funereus*) and Great Horned Owl (*Bubo Virginianus*). Equipment used for playbacks included a battery powered Realistic vsc-2001 cassette recorder and 2 Realistic portable Minimus-0.6 speakers (83 db/1m). Recordings were obtained from the Cornell Laboratory of Ornithology and from the Peterson Field Guide Series (Myer and Peterson 1990), though only one recording was used for any one species. Surveys were not conducted during periods of inclement weather, i.e. heavy fog, prolonged rain or winds greater than Beaufort 3 (13-19 km/h; Mosher *et al.* 1990).

Upon arriving at each broadcast station, the observer would listen and look for birds of prey for 1 min. A series of six 20 sec playbacks of a single species' vocalizations, separated by 30 sec silent intervals, were then made over a 5 min period. Three vocalization segments were broadcast toward an arbitrarily selected side of the road (determined by coin toss) followed by three broadcast segments to the other side. The observer would then remain at the site for an additional 5 min to listen and look for birds of prey. Only one target species was surveyed on any morning or night. Playbacks for the remaining target species were broadcast on successive mornings and nights. Each route was surveyed three times during the breeding season.

Nocturnal surveys were done each night from 10:30 p.m to 2:00 a.m, and morning surveys from 6:00-10:00 a.m. The survey period was 24 May to 14 August in 1993, 15-21 March, and 1 June to 15 August, 1994.

In 1994, survey routes were re-established to ensure that distances surveyed in each habitat type were comparable. The distances surveyed in uncut old growth, second growth and clearcut areas were 18, 16 and 16 km respectively (Table 2.1), and an equal number of surveys (n=3) were again conducted along each route. Pre-commercially thinned areas were not surveyed in 1994 since the total area of this habitat type in the WNMF is essentially negligible and therefore of less interest. Playbacks for Merlins were not broadcast in 1994 because results from 1993 indicated that they did not respond to broadcast vocalizations. Vocalizations of Sharp-shinned Hawk, Northern Goshawk, Boreal Owl, Great Horned Owl and Northern Hawk-Owl (*Surnia ulula*) commenced on 1 June, 1994. In contrast to the methods used in 1993, individual surveys involved playbacks for multiple species. That is, nocturnal surveys involved broadcasting playbacks for each owl species at every second 800 m interval along the survey route. Potential behavioural suppression of smaller species as a result of broadcasting the calls of larger raptors was unknown but was expected to be minimal. Lack of response due to habituation to the playbacks was also considered minimal since only 3 visits were made to each point count during the season.

Playbacks for individual diurnal species were broadcast at every third 800 m interval along survey routes. This method controlled for variations in weather conditions that might otherwise influence detectability of the different species when individual species broadcasts were run on successive days. Further, surveys were initiated at alternating ends of survey routes on successive visits to balance the potential effect of varying broadcast times.

In March, 1995, 26 km of uncut old-growth forest was surveyed for Boreal and Great Horned Owls using conspecific vocalizations. Broadcast stations were 800 m apart and access was by snowmobile.

The area surveyed in each habitat type was calculated by multiplying the km surveyed by the estimated distance on each side of the road for which broadcasts were audible. Mosher et al. (1990) found that broadcasts were audible to humans at 750 m away from the source in a hardwood stand in Maryland. In this study, the distance that broadcasts were still audible to researchers was estimated to be 600 m for forest habitats and 800 m for clearcuts and pre-commercially thinned areas.

In addition to the point count method using vocalization broadcasts, areas adjacent to the transects were systematically searched by foot throughout the study period in an attempt to locate sites of raptor activity (i.e. nests, roosts and *Accipiter* prey-plucking-sites). This involved taking a compass bearing perpendicular to the transect and walking an estimated distance of 500 to 800 m on each side of the road. Any signs indicative of raptor activity (i.e. nest structures, territorial behaviour, prey remains) were noted. Birds sighted while driving between broadcast stations were also recorded.

2.2.2 Statistical analyses

A two-sample t-test (Sokal and Rohlf 1981) was used to compare the mean abundance of woodland birds of prey (species and years combined) among the four forest habitats. Species were combined because of the exceedingly small sample sizes of individual species. By lumping species together, valid statistical comparisons of species assemblages between forest habitats could be performed. If distributions of the residuals for normality (n-score probability plots) indicated that the residuals were not normally distributed, then a non-parametric randomization technique (Manly 1991) was employed. The randomization test is a re-sampling procedure which creates its own frequency distribution based on the original data, thus eliminating any assumptions of normality (Adams and Anthony 1996). The test statistic used for the among habitat comparisons was the number of raptors/broadcast station averaged over all visits to that station. In the initial step of the randomization test, the difference between the observed mean values of raptors/broadcast station between the two habitats being compared was calculated. A frequency distribution of 3000 possible outcomes of differences between the mean values was then randomly generated with replacement from the original data. The habitats are significantly different with respect to the number of raptors/broadcast station if the observed difference of mean values between the two habitats lies outside the 95 % confidence interval set around the distribution of

3000 possible mean outcomes.

2.2.3 Comparative densities

The breeding densities of birds of prey were compared between western Newfoundland and a range of locations in boreal forest systems (coniferous dominated) throughout their distributions. In the present study, birds were considered to be breeding if: 1) active nests were located, or 2) territorial behaviour was recorded at the same location over multiple visits. Density estimates found in the literature were presented in varying scales and were standardized (pairs/100 km^2) to permit more meaningful comparisons. However, I emphasize that due to discrepancies in survey methods and habitat types between studies, such comparisons between distant populations must be considered with caution. Abundance data in boreal forests ecosystems were not found for Ospreys, American Kestrels and Rough-legged Hawks thus density comparisons were not made for these species.

2.3 Results

2.3.1 Effectiveness of conspecific broadcasts

Seven transects totalling 58 and 50 km (habitats combined) were surveyed for woodland birds of prey in 1993 and 1994, respectively (see Table 2.1). Although responses of raptors to the broadcast vocalizations were elicited on occasion, most sightings occurred while driving between broadcast stations or before the calls were broadcast. In 1993, only three of 94 birds detected (3.2 %) were in response to broadcast vocalizations. Two of these were Boreal Owls and the other a Sharp-shinned Hawk. In 1994, eight of the 105 raptors detected (7.6 %) were in response to broadcast vocalizations, these included Sharp-shinned Hawks (2), Boreal Owl (1 contact), Great-Horned Owls (2), and Northern Hawk-Owls (3). For both years combined, the proportion of individuals that responded to broadcast vocalizations versus the total number of detections for each of these species were: Sharp-shinned Hawk (60%), Boreal Owl (60%), Great Horned Owl (66%), and Northern Hawk-owl (60%). No raptors were detected during winter 1994 along 30 km of unuct balsam fir forest. It is notable that for each encounter, positive responses to broadcasts were made during the 5 min broadcasting period.

2.3.2 Species composition of birds of prey

Nine species of raptors were recorded within the study area between 24 May and 11 August 1993, and between 1 June and 14 August 1994: Merlin, American Kestrel (*Falco sparverius*), Osprey, Rough-legged Hawk (*Buteo lagopus*), Sharp-shinned Hawk, Northern Goshawk, Boreal Owl, Great Horned Owl, and Northern Hawk-Owl (see Table 2.2).

2.3.3 Habitat associations and relative abundances of birds of prey

Uncut balsam fir forests near Little Grand Lake were utilized by Sharp-shinned Hawks, Merlins, Boreal Owls and Ospreys in 1993 and 1994, and a Northern Goshawk in 1994. The number of adult raptors (not pairs) and the number of detections/km for each species by habitat and year are given in Table 2.3. Although numbers are low, an index of their relative abundances is attained. In 1993, Sharp-shinned Hawks and Boreal Owls were the most abundant species (detections/km for these species were 0.27 and 0.33, respectively). Merlins and Ospreys were less abundant along survey routes through this habitat and were recorded at 0.07 and 0.13 detections/km, respectively. In 1994, the numbers of Sharp-shinned Hawks, Merlins and Ospreys were similar to those in 1993; however, only one Boreal Owl was detected in comparison with five the previous year. In addition, the only goshawk recorded during this study occurred in uncut forest in 1994.

Three species of woodland raptors were identified along survey routes transecting second growth forests near Victoria Lake and George's Lake: Sharp-shinned Hawk, Merlin and Great Horned Owl. In 1993, 9 km of this habitat was surveyed resulting in only one sighting of each of these species. In 1994, vocalizations broadcast along 16 km of second growth forest near George's Lake resulted in four Merlins and two Great Horned Owls being detected (Table 2.3). In addition to the focal raptor species, second growth forests in various successional stages were utilized by an estimated 20 nesting pairs of Osprey in the Stephenville Crossing area (P. St. Croix, pers. comm.).

Clearcuts provided nesting and foraging habitat for both Northern Hawk-Owls and American Kestrels as well as foraging sites for Merlins and Rough-legged Hawks. In 1993, detections/km ranged from 0.13 for Rough-legged Hawks (two individuals) to 0.19 detections/km for Merlins and Northern Hawk-Owls (three individuals each). In 1994, Rough-legged Hawks were not sighted in clearcuts; however, two American Kestrels were recorded (0.13 detections/km). Merlin numbers were identical to those found in 1993 (Table 2.3).

In 1993, surveys conducted along 18 km of a pre-commercially thinned area indicated that only Rough-legged Hawks (0.17/km) and Merlins (0.06/km) were associated with this habitat (Table 2.3). No owls were detected along 26 km of uncut old-growth forest in March, 1995.

Old-growth balsam fir forests were utilized by more species compared with second growth forests, clearcuts and pre-commercially thinned areas. Statistical comparisons were made between the total number of birds of prey/broadcast station (species and years combined) recorded along survey routes passing through old-growth balsam fir forest, second growth and clearcuts. A two-sample t-test (Sokal and Rohlf 1981) was first used for each pairwise comparison (e.g. old-growth vs. second growth), however examination of the residuals and normal scores of the original data indicated that the residuals were non-normally distributed, thus warranting the use of non-parametric methods. Subsequent analysis using a randomization procedure (Manly 1991) indicated that habitats did not differ significantly with respect to the mean number of raptors (species and years combined)/broadcast station recorded along the survey routes.

An analysis was also performed to investigate changes in the numbers of avian predators (i.e. Sharp-shinned Hawks, Merlins) and small rodent predators (i.e. Rough-legged Hawks, Boreal Owls, Northern Hawk-Owls) between the 1993 and 1994 breeding seasons. The abundance of raptors primarily dependent on passerines was similar between years (Table 2.3), however, the number of rodent specialists (particularly Rough-legged Hawks) decreased significantly from 1993 to 1994 (randomization test, $P < 0.001$).

2.3.4 Breeding Chronology

Specific information on the breeing biology of woodland birds of prey on insular Newfoundlland is lacking. However, estimates of egg-laying dates can be derived by back-dating from the periods when nestlings or fleglings are first observed. Sharp-shinned Hawk fledglings were first sighted near a nest site on 20 July, 1993. The birds at this time appeared to be near adult size. Assuming that hatching occurred in the first week of July, egg-laying would have occurred on 1 June since incubation typically lasts 30 days (Johnsgard 1990). Three Rough-legged Hawk nests were monitored for breeding chronology and hatching was noted to occur between 18 - 25 June, 1993. The incubation time for this species is 28 days (Johnsgard 1990) so egg-laying was estimated for 17-24 May. Two nestling Hawk-Owls were observed on a nest on 20 June, 1994 and hatching was estimated to have occurred around 10 June. Egg-laying was estimated on 13 May. Three Merlin nestlings were first observed on 25 July, 1994, and hatching was estimated to have occurred on 20 July. Merlins incubate for approximately 30 days (Johnsgard 1990) so egg-laying would have occurred in late June.

Table 2.1. Survey transect specifications for the four forest types in the Western Newfoundland Model Forest in 1993-94. Each transect was surveyed three times during each breeding season.

Habitat Type	Number of transects	Total transect Length (km)	Total # of broadcast stations	Area Surveyed (km^2)
1993				
Uncut old growth	2	15	19	18
Second growth	1	9	11	10.8
Pre-commercially thinned	2	18	22	28.8
Clearcut	2	16	20	25.6
Total	**7**	**58**	**72**	**83.2**
1994				
Uncut old growth	3	18	22	21.6
Second growth	2	16	20	19.2
Clearcut	2	16	20	25.6
Total	**7**	**50**	**62**	**66.4**

Table 2.2 Sightings of adult birds of prey in the Western Newfoundland Model Forest, 1993-1994. Numbers of sightings include multiple sightings of individuals, but do not include nestlings or fledglings. These numbers also include birds of prey recorded in areas outside of the survey routes but in the WNMF region (see Figure 1.1).

Species	Number of Sightings (estimated # of individuals)			Forest Habitat
	1993	1994	Total	
Merlin *Falco columbarius*	25 (14)	22 (16)	47 (30)	Clearcuts, old and young second growth, uncut old growth
American Kestrel *Falco sparverius*	9 (8)	4 (4)	13(12)	Clearcuts
Osprey *Pandion haliaetus*	5 (4)	35 (24)	40 (28)	Young second growth and uncut old growth near large water bodies.
Rough-legged Hawk *Buteo lagopus*	22(18)	0 (0)	22 (18)	Barren ground, clearcuts, cliff faces
Sharp-shinned Hawk *Accipiter striatus*	13 (6)	15 (8)	28 (14)	Uncut old growth and old second growth balsam fir
Northern Goshawk *Accipiter gentilis*	0 (0)	4 (1)	4 (1)	Uncut old growth
Boreal Owl *Aegolius funereus*	8 (5)	1 (1)	9 (6)	Uncut old growth
Great Horned Owl *Bubo virginianus*	2 (2)	8 (4)	10 (6)	Old second growth
Northern Hawk-Owl *Surnia ulula*	10 (5)	14 (7)	24 (12)	Clearcuts

Table 2.3 Densities of raptors (raptors/km) detected along survey routes in different balsam fir forest types in the Western Newfoundland Model Forest, 1993-1994. Numbers in parentheses are individual adult raptors (not pairs) and do not include repeat sightings.

Habitat Type	Km	Raptors/km										
1993	**Surveyed**	**M**	**K**	**O**	**RLH**	**SSH**	**GH**	**BO**	**GHO**	**NHO**	**Total**	**# of Sp**
Uncut old growth	15	0.07 (1)	0	0.13 (2)	0	0.27 (4)	0	0.33 (5)	0	0	0.80 (12)	4
Second growth	9	0.11 (1)	0	0	0	0.11 (1)	0	0	0.11 (1)	0	0.33 (3)	3
Clearcut	16	0.19 (3)	0	0	0.13 (2)	0	0	0	0	0.19 (3)	0.51 (8)	3
Thinned	18	0.06 (1)	0	0	0.17 (3)	0	0	0	0	0	0.23 (4)	2
1994												
Uncut old growth	18	0.17 (3)	0	0.11 (2)	0	0.22 (4)	0.06 (1)	0.06 (1)	0	0	0.62 (11)	5
Second growth	16	0.25 (4)	0	0	0	0	0	0	0.13 (2)	0	0.38 (6)	2
Clearcut	16	0.19 (3)	0.13 (2)	0	0	0	0	0	0	0.19 (3)	0.51 (8)	3
1993-94 (combined)												
Uncut old growth	18	0.22 (4)	0	0.22 (4)	0	0.22 (4)	0.06 (1)	0.33 (6)	0	0	1.01 (19)	5
Second growth	25	0.20 (5)	0	0	0	0.04 (1)	0	0	0.12 (3)	0	0.36 (9)	3
Clearcut	16	0.25 (4)	0.13 (2)	0	0.13 (2)	0	0	0	0	0.37 (6)	0.82 (14)	4

Species name abbreviations:

M = Merlin
K = American Kestrel
O = Osprey
RLH = Rough-legged Hawk
SSH = Sharp-shinned Hawk
GH = Northern Goshawk
BO = Boreal Owl
GHO = Great Horned Owl
NHO = Northern Hawk-Owl

2.4 Discussion

Positive responses to vocalization playbacks were elicited by four species of birds of prey in the study (three of which were owls). Broadcasting vocalizations accounted for 66 % of the Great Horned Owl detections and 60 % of Boreal Owl, Northern Hawk Owl and Sharp-shinned Hawks detections. However, the playback method accounted for only 3.2 and 7.6 % of the total detections in 1993 and 1994, respectively. Woodland birds of prey generally occur in low densities, are secretive, wide-ranging and therefore difficult to census (Fuller and Mosher 1981). In light of this, broadcasting taped calls of conspecifics as a means of improving detection rates has become an increasingly prevalent method for locating forest raptors and has been shown to increase detection rates of Spotted Owls (Forsman *et al.* 1977), Red-shouldered Hawks, Cooper's Hawks, Barred Owls (Mosher *et al.* 1990) and Northern Goshawks (Kennedy and Stahlecker 1993). We tested the hypothesis that responses to vocalizations might be higher in late winter or early spring (1 March - 15 April), particularly for Boreal and Great Horned Owls when territories are being established (Morrell *et al.* 1991, Hayward *et al.* 1993). Broadcast surveys for these two owl species were conducted in uncut old-growth forest from 15-21 March, 1995, though no owls were detected along 26 km of this habitat. With respect to the breeding stage, other studies have shown that woodland birds of prey, including Red-shouldered Hawks, Cooper's Hawks and Spotted Owls, responded readily to calls throughout the entire spring-summer period (Forsman *et al.* 1977, Kimmel and Yahner 1990 and Mosher *et al.* 1990). The lack of Boreal Owl detections may have been attributable to decrease densities of small mammals in the study area at this time (W. Adair, pers. comm.). Boreal Owls are assumed to be nomadic in response to prey fluctuations (Lundberg 1979, Hayward and Hayward 1993) and may have relocated in search of more favourable breeding conditions, or alternatively, may have been present yet suspended the onset of the courtship ritual (i.e. remained non-vocal) in response to low prey abundance. Great-Horned Owls were likely absent from this study area due to the scarcity of their primary prey, i.e. Snowshoe Hare (*Lepus americanus*) and Ruffed Grouse (*Bonasa umbellus*; Rusch *et al.* 1972).

Lundberg (1979 in Hayward *et al.* 1993) found that "territorial and breeding pairs of Boreal Owls were more silent than non-territorial individuals," so censuses using playbacks may give biased estimates of owl abundances. Hayward *et al.* (1993) contended that a lack of an understanding of the factors that affect Boreal Owl singing rates makes the vocalization method an inappropriate monitoring tool. Overall, censusing birds of prey in forested habitats remains problematic. Further research should be conductec to develop more reliable censusing techniques for woodland raptors.

Surveys for birds of prey conducted during the 1993 and 1994 breeding seasons indicated tha: uncut old growth forests contained both the most individuals and the most species. Overall, the densities of birds of prey were generally low, and different-aged balsam fir forests and clearcuts were utilized by a broad assemblage of species. Forests in advanced stages of natural succession in western Newfoundland are typified by extensive snag retention (Sturtevant 1996) and stands are of various ages, thus allowing a potentially wider range of species to inhabit this habitat type. For example, Boreal Owls are dependent upon the presence of tree cavities for nesting (Hayward *et al.* 1993) and were restricted to uncut old growth balsam fir forests. Sharp-shinned Hawks prefer a dense canopy cover for nesting (Platt 1976, Call 1978) and a relatively open understory for hunting and were found mainly in old growth forests.

Second growth forests in Newfoundland are typically younger even-aged forests (Thompson and Curran 1995) with less structural diversity than uncut old growth forests. Species with more restricted nesting requirements (i.e. Boreal Owls, Hayward and Hayward 1993) are unlikely to select such forests for breeding, which may help explain the decrease in species numbers in comparison with uncut old growth forests. Surveys in second growth forests indicated the presence of only three species of birds of prey, one of which, the Great-Horned Owl, is considered a habitat generalist with a wide ecological tolerance (Bosakowski *et al.* 1989).

Clearcuts provided breeding habitat for both Northern Hawk-Owls and American Kestrels. Large hardwood snags have been left intact throughout these areas providing both nesting structures and perching sites for foraging. Merlins were also frequently observed hunting in this habitat as were Rough-legged Hawks in 1993. The latter species is an aerial predator which prefers open ground, although typically at more northerly tundra habitats (Poole and Bromley 1988, Whitaker *et al.* 1996).

An apparent link of raptor densities to food supply stresses that forest management should also consider the impact of timber harvesting operations on species at lower trophic levels and should not concentrate solely on predators or their nesting habitat. The significant decline of microtine-dependent birds of prey, i.e. Boreal Owls, Northern Hawk-Owls and Rough-legged Hawks, from 1993 to 1994 suggests that small mammal populations may have declined in this region between years. In Fennoscandia, juvenile and female Boreal Owls disperse when vole populations crash, but most old males stay on their territories throughout the year (Korpimaki 1994), whereas Northern Hawk-Owls lead an essentially nomadic life, breeding in areas with temporarily high microtine abundance (Nybo and Sonerud 1990). The abundance of avian-dependent birds of prey, i.e. Sharp-shinned Hawks and Merlins, remained similar between years suggesting that food resources were more stable for these species. This phenomenon has been previously documented by Newton (1979) who stated that "raptor populations that depend on fairly stable (often varied) food sources show fairly stable densities over many years, whereas populations that depend on fluctuating (often restricted) food sources show fluctuating densities, in accordance with prey cycles."

2.4.1 Comparative Densities

Breeding densities of birds of prey are generally assumed to be limited by either the number and distribution of nesting sites, an adequate food supply or some combination of these two factors (Newton 1979). Two breeding pairs of Sharp-shinned Hawks were found in uncut balsam fir forests in 1993 and 1994, and a pair in older second growth forest in 1994. A density estimate of breeding Sharp-shinned Hawks for these two forest types combined based on survey results is 6 pairs/100 km^2. This approximates the breeding density of 4 pairs/100 km^2 reported by Reynolds *et al.* (1982) in Oregon, but is a much lower density than that recorded in the coniferous forests of interior Alaska by Clarke (1984), where a density of 24 pairs/100 km^2 was found. This four-fold difference in breeding density may be due to a more abundant food supply in comparison with insular Newfoundland. Sharp-shinned hawks prey primarily on songbirds (Storer 1966, Reynolds *et al.* 1982, Reynolds and Meslow 1984) which are generally considered to be more abundant on continental North America (Montevecchi and Tuck 1987). Regional variation in breeding density in relation to songbird abundance has also been noted for the European Sparrowhawk (*Accipiter nisus*; Newton 1979).

One Northern Goshawk (assumed unpaired) was recorded in the study area during 1993-1994. Densities of Northern Goshawks recorded elsewhere in North American coniferous forests are 7.5 pairs/100 km^2 in Colorado (Shuster 1977), 3.4 pairs/100 km^2 in Oregon (Reynolds *et al.* 1982) and 2 pairs/100 km^2 at a site in interior Alaska (McGowan 1975). Northern Goshawks prey heavily on Snowshoe Hare, Ruffed Grouse and Red Squirrels (*Tamiasciurus hudsonicus*) all of which were uncommon in western Newfoundland during this study (pers. observ.), and the abundance of this species is again likely limited by the availability of adequate food resources.

Boreal Owls were recorded in uncut old growth forests at a moderate density in 1993, low density in 1994 and were not recorded during late winter surveys in 1995. Density estimates extrapolated from roadside surveys in uncut old growth were 17 and 5 pairs/100 km^2 for 1993 and 1994, respectively. Other studies report Boreal Owl breeding densities of 3 pairs/100 km^2 during a 5-year study in Minnesota (Lane, unpubl. data), 9.1 pairs/100 km^2 at two study sites in Ontario and Alberta (Bondrup-Nielsen 1978), 12 pairs/100 km^2 recorded in the Rocky Mountains of the United States (Hayward *et al.* 1993) and 22 pairs/100 km^2 at a study location in Finland (Korpimaki 1981). The variation in breeding density recorded in this study may reflect fluctuating rodent numbers between years and may more generally result from the low small mammal prey base typical of insular Newfoundland where only one species of small mammal, the meadow vole (*Microtus pennsylvanicus*) is endemic and occurs in any abundance (Bateman 1986). Small mammals, particularly voles, are the primary prey of Boreal Owls throughout their geographic range (Hayward *et al.* 1993), and, in northern regions with pronounced fluctuations of vole numbers, Boreal Owls are microtine specialists and exhibit extreme fluctuations in breeding parameters (Korpimaki 1986).

Great Horned Owls apparently inhabit second growth balsam fir forests in western Newfoundland in low density compared with mainland populations. The estimated breeding density for western Newfoundland is 2 pairs/100 km^2 whereas studies conducted in Saskatchewan (Houston 1975), Alberta (Rusch *et al.* 1972) and Michigan (Craighead and Craighead 1956), found densities were 12, 5 and 7 pairs/100 km^2, respectively. Food resources likely limits the breeding density of Great Horned Owls. Snowshoe Hare often form a major component of their diets (Rusch *et al.* 1972), and periodic fluctuations or invasions of Great Horned Owls in northern forests occur in relation to the varying abundance of hares and grouse (Rusch *et al.* 1972, Bosakowski *et al.* 1989). During this study, Snowshoe Hare and Ruffed Grouse numbers in western Newfoundland were low (P. St. Croix, pers. comm. 1994).

Northern Hawk-Owls were relatively common in clearcuts in both 1993 and 1994 (see Table 2.3) where breeding densities were estimated at 4 pairs/100 km^2. This is similar to the breeding densities of approximately 3 pairs/100 km^2 (range 0-6) reported in the Yukon by Rohner *et al.* (1995) and 2 pairs/100 km^2 in Norway (Hagen 1956), but is much less than that recorded for Sweden (Cramp 1985) where a mean of 10 pairs/100 km^2 (range 0.2-20) has been documented. Northern Hawk-Owls are an irruptive species that lead a nomadic life, occurring at places with temporarily high microtine densities (Mikkola 1983 in Johnsgard 1988, Nybo and Sonerud 1990). Analysis of regurgitated owl pellets collected during 1993 from a nest site in the study area indicated that Meadow Voles were important prey as all 7 pellets were exclusively comprised of Meadow Vole remains (see appendix 2). Voles made up at least 93 % of the identified prey animals at nest sites in Norway, Finland and Russia (Mikkola 1983). It is likely that small mammal abundance is the main factor limiting the breeding density of Northern Hawk-Owls in western Newfoundland.

Merlins were the most common woodland raptor recorded in western Newfoundland for both years and habitats combined (16 pairs/100 km^2). Comparative breeding densities for this species in other coniferous forest systems are lacking, however. The abundance of Merlins may be more stable than other woodland birds of prey since they are a strongly bird-adapted predator (Sherrod 1978) and do not rely on fluctuating or cyclic prey such as voles or hares as do Boreal Owls, Great Horned Owls and Northern Goshawks. However, it may also be that Merlins are easier to detect by observers since this species is typically more vocal than other woodland raptors (pers. observ.).

2.4.2 Breeding Chronology

Obtaining precise dates on reproductive stages of raptors is problematic. Birds of prey occur in low densities and are difficult to locate and monitor. Furthermore, breeding chronology may vary between seasons, individual pairs, and across geographic areas. Breeding chronology of raptors on insular Newfoundland has not been adequately documented. Some insight may be gained by comparing estimated clutch initiation dates from this study with those documented elsewhere in North America.

The egg-laying period for Sharp-shinned Hawks in western Newfoundland was estimated to be 1 June. In Alaska, Clarke (1984) found that this period ranged from 22 May - 4 June, and in Oregon, from 11 May to 19 June (Reynolds 1978). Rough-legged Hawks in this study were estimated to commence egg-laying from 17-24 May. Similarly, Rough-legged Hawks in Ungava Bay begin laying in the last week of May and first two weeks of June (J. Weaver and D.M. Bird, pers. comm.). Clutch initiation for Northern Hawk-owls was estimated to occur on 13 May. In southwestern Yukon, egg-laying ranged from 19 April to 11 May (Rohner *et al.* 1995), and in Denali National Park, Alaska, Kertell (1986) reported a range from 13-24 April. Merlins in western Newfoundland were estimated to begin egg-laying in late June. This is a much later date than recorded by Laing (1985) in interior Alaska where Merlins were estimated to commence incubation during the third week of May.

Chapter 3

Habitat characteristics of raptor activity sites in western Newfoundland

3.1 Introduction

Habitat selection theory states that species are preferentially associated with a particular habitat in which they can optimally function and reproduce (Cody 1985). For birds of prey, the importance of specific habitat attributes for providing life history requirements has been documented and includes selection of suitable nesting (Titus and Mosher 1981, Reynolds *et al.* 1982, Speiser and Bosakowski 1988, Bosakowski *et al.* 1989), roosting (Barrows 1981, Hayward and Garton 1984) and hunting sites (Bechard 1982, Widen 1994). Nest-site features that influence selection are many and varied, and include stand age (Reynolds *et al.* 1982), tree density and size (Brauning 1983, Morris and Lemon 1983, Selas 1996), topography (Speiser and Bosakowski 1988) and proximity to physiographic features such as water and forest openings (Titus and Mosher 1981). Likewise, roost-site selection has been attributed to factors such as tree density, percent canopy cover and the aspect of slopes where roosts occur (Barrows 1981, Hayward *et al.* 1993). Foraging areas are also subject to patterns of selection and may be influenced by prey availability as well as structural features of habitats. For example, Sonerud (1986) suggested that Boreal Owls in Norway shifted hunting areas early in the spring in relation to snow conditions and the accessibility of prey, and in Sweden, Widen (1994) determined that the presence or absence of suitable perches influenced the use of clearcuts by foraging raptors that use the pause-travel tactic.

Because of the habitat specificity of many raptors, alteration of the physical and vegetative structure of their habitats through forest harvesting, agriculture and human habitation has led to a general decline in the populations of many woodland raptors throughout much of North America (Mosher 1987). More vulnerable species include those that have narrow ecological tolerances, particularly if dependent on older seral stages such as Northern Goshawks (McCarthy *et al.* 1989, Crocker-Bedford 1990), Boreal Owls (Hayward *et al.* 1993) and Spotted Owls (Forsman *et al.* 1977). Conversely, other raptor species that prefer open or edge habitats such as Northern Hawk-Owls and American Kestrels may benefit from forest fragmentation. Alteration of forest structure may also influence the availability and accessibility of food resources which can ultimately influence populations of birds of prey (Bechard 1982, Baker and Brooks 1981, Widen 1994). Attempting to manage for the protection of populations of birds of prey at the community level necessitates determining the habitat requirements for an assemblage of species, and assessing the availability of this habitat at a landscape level. This information may then be implemented into forest management strategies and coordinated with wildlife objectives.

Information on the structural and vegetative characteristics of raptor activity areas has been described elsewhere in North America, particularly in the Northeast and Rocky Mountains of the United States (Titus and Mosher 1981, Reynolds *et al.* 1982, Siders and Kennedy 1996). However, the applicability of this site-specific information in predicting or describing raptor habitat in the insect-driven balsam fir forests of western Newfoundland is unknown. It is therefore necessary to investigate the habitat features of sites utilized by woodland birds of prey in the extreme eastern portion of their range in order to more fully understand the habitat requirements of these species as a whole.

In this chapter, an exploratory approach is used in an attempt to identify the structural features that may influence raptor habitat selection at a micro-habitat scale. I recognize and caution, however, that sample sizes are small and the subsequent analyses are not conclusive. However, this approach is useful for generating new hypotheses that warrant further investigation. Management recommendations for birds of prey in western Newfoundland are also proposed.

3.2 Methods

Habitat data relating to forest stand structure and composition were collected at raptor activity sites (i.e. nests, roosts, prey-plucking-sites) and at corresponding unused sites at distances of 50 and 400 m. Unused sites were investigated for signs of activity several times throughout the breeding season to ensure that raptors did not utilize these sites. Unused sites were selected by haphazardly turning the housing on a compass and walking the appropriate distance in line with the compass direction arrow from the centre of the activity site. Additional habitat data were also collected at each 800 m interval along the 1994 survey routes (n=58). These sites were 50 m from a randomly selected side of the road (determined by coin toss) and will hereafter be referred to as roadside sites. Where survey routes followed lake shorelines, habitat measurements were made at a distance of 50 m from the shoreline. For all sites, stand level attributes including the number, species, diameter at breast height (DBH), and vigour (live, dead) of trees were recorded within an 11.3 m radius (0.04 ha) fixed plot. Other measurements included an visual estimation of the percent of ground vegetation and canopy cover, the number and DBH of snags and a tally of coarse woody debris abundance (CWD, i.e. dead fallen trees and limbs with a diameter of > 4 cm) along a 22.6 m random transect through the centre of the plot.

A principal components analysis (PCA) was employed to determine the most important habitat factors at the nest-sites, roosts and prey-plucking-sites of woodland birds of prey. This multivariate procedure reduces a large number of variables into a smaller subset of related factors which may be useful in identifying significant features of selected habitats (Bosakowski *et al.* 1992). It should be noted, however, that the factor analysis used here is an exploratory technique to identify potential multivariate patterns in the data from which specific hypotheses may be developed. It is not used to confirm or test any pre-existing hypotheses regarding raptor habitat utilization. Habitat variables used in this analysis include: 1) tree density, 2) number of live balsam fir (BF) >15 cm DBH, 3) live BF <15 cm DBH, 4) dead BF > 15 cm DBH, 5) dead BF < 15 cm DBH, 6) % live BF, 7) % dead BF, 8) live black spruce (BS) >15 cm DBH, 9) dead BS < 15 cm DBH, 10) live white birch >15 cm DBH, 11) % dead trees (species combined), 12) % live trees (species combined), 13) total number of snags, 14) snags >15 cm DBH, 15) snags < 15 cm DBH, 16) % coniferous, 17) % deciduous, 18) % canopy cover, 19) % ground vegetation cover, 20) CWD. Significant factors (i.e. eigenvalues > 1) were retained in the analysis. Following the reduction of all habitat variables into factors, each factor was plotted against the habitat variable most strongly correlated with it to ensure that the data distribution was not skewed (Knoechel and Campbell 1988). Scatterplots were then examined to investigate the distribution of raptor activity sites with random 50 m, 400 m, and roadside plots in relation to the factors.

Differences in habitat structure and composition were compared among raptor activity sites and random sites at distances of 50 and 400 m for the variables listed above using the Mann-Whitney U statistic. This nonparametric test was used since the underlying distributions of the habitat data were unknown and normality could not be assumed (Manly 1991). The level of significance for all comparisons was α=0.05. All computations were performed using the SPSS statistical package at Memorial University of Newfoundland. The data collected at two Northern Hawk-Owl and American Kestrel nests were not included since this factor analysis is specific to forested sites and inclusion of the data would produce misleading results. Qualitative descriptions of these species and of Ospreys are presented, however.

3.3 Results

Factor analysis resulted in a reduction from 20 original habitat variables to six factors that describe the structural and vegetative components at nests, roosts and prey-plucking-sites and accounted for approximately 76 % of the variance in the original data. However, only three factors describing 53 % of the variance were used because the others were difficult to interpret in an ecological context (see Table 3.1). Factors are described based on the measured habitat variables most strongly correlated with them and are given a subjective name indicative of this relationship. Factor 1 (stand health) represents a gradient from a vigourous, late successional balsam fir stand to an older degenerating forest stage dominated by large (> 15 cm DBH) senescent balsam fir trees. Factor 2 (snags) describes an increase in the density of snags that have resulted from previous Hemlock Looper infestations. Factor 3 (young tree density) is defined by an increase in tree density, particularly live balsam fir with small (< 15 cm DBH) tree diameters.

The distribution of Sharp-shinned Hawk prey-plucking-sites (n=3) and unused sites (n=6) in relation to factors 1 and 3 is illustrated in Figure 3.1. Factor 1 (stand health) did not discriminate between these sites when considered solely; however, when plotted with factor 3 (young tree density), the used and unused sites were reasonably segregated. Factor 2 (snags) did not provide any further discriminatory power when plotted with either of the other two factors.

Merlin nest-sites (n=3) and unused sites (n=5) are plotted in relation to factors 1 and 2 (see Figure 3.2). Nests and unused sites were separated entirely along factor 1 (stand health), however their distributions overlapped with respect to factor 2. Factor 3 did not contribute any additional discriminatory power.

Figure 3.3 shows a plot of the distribution of raptor nests, roosts, prey-plucking-sites and unused sites (50 m, 400 m, roadside) in second and uncut old growth forest. There was no separation between the Sharp-shinned Hawk plucking-sites and the Boreal Owl roost along factor 1, however, Merlin nest-sites showed a strong positive relationship with stand health and Osprey nests sites were slightly negative along this gradient. Along the x-axis (factor 2), the Boreal Owl roost related to an increasing abundance of snags, whereas Sharp-shinned Hawk plucking-sites and Osprey nests were neutral along this factor. Merlin nest-sites fell out at the lower end of this distribution and were negatively associated with snag abundance. When these sites are plotted in reference to factors 1 and 3 (young tree density), the Boreal Owl roost and Osprey nest-sites show a strong positive relationship with factor 3, whereas Sharp-shinned Hawk plucking-sites and Merlin nest-sites are neutral along this gradient (Figure 3.4).

All comparisons of habitat structure made between activity sites (i.e. nest-sites, roosts, prey-plucking-sites) and the 50 and 400 m unused sites using the Mann-Whitney test were non-significant. This is likely attributable to low sample sizes (range 1-4) of raptor activity sites and unused sites compared in the test.

Two active Northern Hawk-Owl nests were found in the study area. One near Deer Lake was located in an extensive clearcut that had also been damaged by fire. Large snags (>10 cm DBH) were present outside of the immediate 11.3 m plot, and ground vegetation, composed mainly of alders, was dense. The nest was situated at the top of a snag (DBH=29 cm) at a height of 6 m. The second nest-site near Little Grand Lake was also in a large clearcut, though there were few snags in the immediate nesting area. Ground vegetation was also dense at this site exceeding about 80 % of cover. The nest was also on top of a broken snag (DBH=61 cm). Both nests were on relatively level ground (slope < 5 degrees) and within approximately 200 m of a forest access road.

Two American Kestrel nesting cavities were found in clearcuts that were characterized by numerous snags near the nesting tree. Both nests were in white birch (DBH=38.5 and 31 cm) which were larger than the majority of the residual trees in the 11.3 m plots. CWD and ground cover vegetation was high at the first site and low at the second.

Habitat characteristics were measured at four Osprey nest-sites within 2 km of Stephenville Crossing. The forest in this area was predominantly dense, 30-60 yr second growth balsam fir with an approximately 25 % deciduous component. All nest-sites measured were within 1-2 km of a large water body. Nesting trees at three of these sites were > 15 cm DBH (range 18-43 cm DBH) and extended above the canopy layer. The mean height of these trees (two black spruce, one yellow birch) was 11 m (Standard deviation = 4.3 m, n = 3). The fourth nest was on top of a wooden platform spanning two telephone poles.

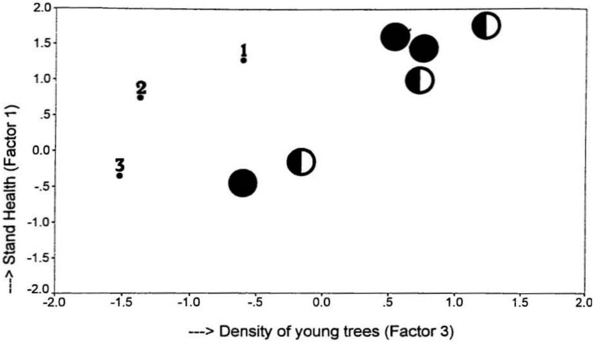
Table 3.1. Factor analysis of structural and vegetative characteristics at raptor nest-sites, roosts, prey-plucking-sites and unused sites in second and uncut old growth forests. Correlations of log and arcsine transformed data are reported with the first three extracted factors. Only significant correlations (>0.6) are shown.

Variable	Factor 1	Factor 2	Factor 3
Density of dead balsam fir > 15 cm DBH	0.69		
Density of live balsam fir < 15 cm DBH	0.81		
Density of trees (species combined)			0.93
Total density of snags		0.94	
Density of live balsam fir < 15 cm DBH			0.84
Percentage of live balsam fir	-0.78		
Percentage of dead trees	0.82		
Percentage of live trees	-0.87		
Density of snags < 15 cm DBH		0.69	
Density of snags > 15 cm DBH		0.83	
Cumulative Explained variance	26.9%	40.7%	53.2%

Figure Legend

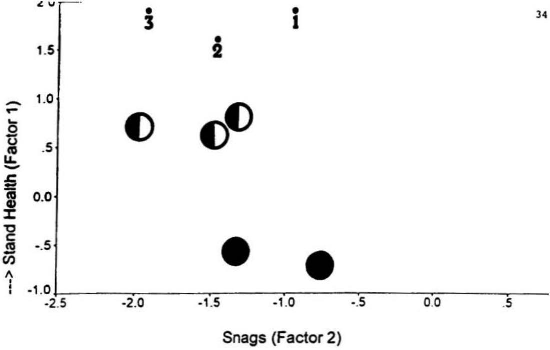
Symbol	Site
1,2,3	Activity site (i.e. nest, roost, prey-plucking-site)
S	Sharp-shinned Hawk prey-plucking-site
M	Merlin nest
B	Boreal Owl roost
O	Osprey nest
◐	Unused site (50 m)
●	Unused site (400 m)
•	Unused site (roadside)

Figure 3.1 Sharp-shinned Hawk prey-plucking-sites and unused sites in uncut old growth balsam fir forest in reference to factors 1 and 3.



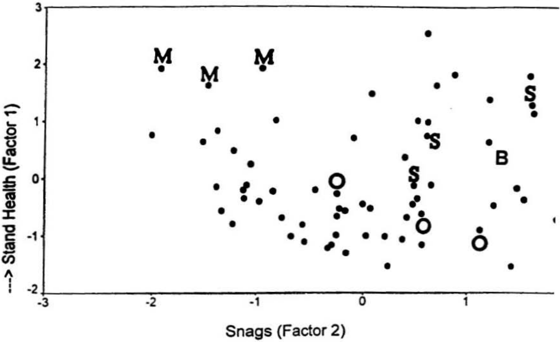
2.0
1.5
1.0
.5
0.0
-.5
-1.0
-1.5
-2.0
---> Stand Health (Factor 1)
1
2
3
-2.0
-1.5
-1.0
-.5
0.0
.5
1.0
1.5
2.0
---> Density of young trees (Factor 3)

Figure 3.2 Merlin nest-sites and unused sites in second growth balsam fir forests in reference to factors 1 and 2.



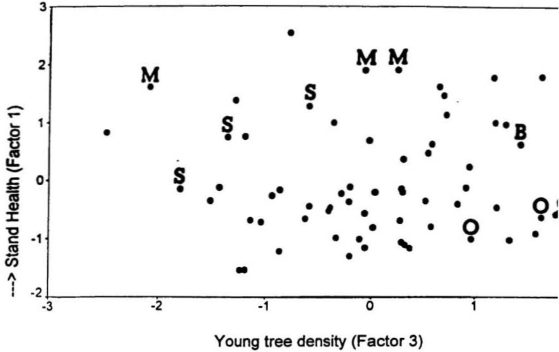
3
2
1
--> Stand Health (Factor 1)
1.5
1.0
.5
0.0
-.5
-1.0
-2.5
-2.0
-1.5
-1.0
-.5
0.0
.5
Snags (Factor 2)

Figure 3.3 The distribution of nests, roosts, prey-plucking-sites and unused sites in second and uncut old growth balsam fir forests in western Newfoundland in reference to factors 1 and 2.



* All unused sites (roadside, 50 m and 400 m) are represented by a small dot.

Figure 3.4 The distribution of nests, roosts, prey-plucking-sites and unused sites in second and uncut old growth balsam fir forests in western Newfoundland in reference to factors 1 and 3.



* All unused sites (roadside, 50 m and 400 m) are represented by a small dot.

3.4 Discussion

Sharp-shinned Hawk prey-plucking-sites in western Newfoundland occur in balsam fir forests in advanced successional stages. Principal components analysis revealed that prey-plucking-sites were characterized by a lower tree density in comparison with unused sites. This is attributable to their occurrence in small (50 x 30 m) forest openings resulting from previous insect defoliation events. The abundance of fallen logs and snags in these openings provide many perching sites for prey handling, and I hypothesize that these small clearings allow improved detection of prey as well as of competing species and predators. These small insect damaged clearings are frequent across the forested landscape in western Newfoundland and may be an important component of Sharp-shinned hawk nesting habitat.

The habitat surrounding Boreal Owls was predominantly composed of uncut old growth balsam fir forest interspersed with areas of low black spruce and/or bog. The habitat associations of these owls appear similar to those described throughout much of their range. In coniferous forests of the northern United States, Hayward *et al.* (1993) determined that nest-sites were restricted to mature and old forests as suitable nesting cavities were abundant in these habitats relative to other forest types, and in Germany, conifer forests with old trees were used for nesting (Konig 1969 in Hayward *et al.* 1993). However, Boreal Owls also nest in nest boxes in regions where few natural cavities occur (Korpimaki 1986).

Roosting sites are critical features of Boreal Owl habitat by providing specific thermal environments, particularly in summer, and concealment from predators (Hayward and Garton 1984). In this study, an adult Boreal Owl frequently roosted in a large black spruce tree (DBH=32 cm) within an old (80+ yrs) balsam fir stand with a dense canopy. The factor analysis indicated a slightly positive relationship between the Boreal Owl roost and an abundance of snags (Figure 3.3) as well as a strong positive association with a high density of young trees (Figure 3.4). These habitat attributes may appear contradictory, however, the relationship of the roosting site with an abundance of snags indicates the occurrence in a predominantly older age class of forest, whereas the high density of young trees would suggest selection of the roost site in a dense, sheltered portion of the stand with high crown closure. Similarly, Hayward *et al.*

(1993) found that summer roosts had greater canopy cover, higher basal area, and denser trees of specific size classes than paired random sites. Roost utilization in dense forest stands has also been documented for Saw-whet Owls (*Aegolius acadicus*), Screech Owls (*Otus asio*; Hayward and Garton 1984) and Spotted Owls (Barrows 1981).

The breeding habitats of Merlins in North America vary regionally ranging from purely coniferous forest in their northern range (Laing 1985), to deciduous woodlands, open prairies (Aphelbaum and Seelbach 1983) and urban environments (Oliphant and Haug 1985); however specific descriptions of nest-sites in eastern boreal forests are lacking. In western Newfoundland, Merlins were the most commonly detected bird of prey, and unlike the other raptor species, were seen in all habitat types. The three nest sites, however, were only found in older (60 yr) second growth forests. From the factor analysis (Figure 3.2), Merlin nest-sites differed from the unused sites in their strong positive association with stand health (factor 1). A forest stand with this relationship can be interpreted as a mature, vigourous balsam fir stand prior to senescence and degeneration. I hypothesize that Merlins, although dependent on abandoned nests of other birds (Trimble 1975, Laing 1985), would likely select such sites that have live tree crowns and dense canopies and hence provide adequate cover from larger raptors that may prey on these smaller falcons. Further investigation of Merlin nest-site utilization is warranted.

Northern Hawk-Owls are rare to low in abundance in eastern Canada (Fyfe 1976 in Kertell 1986), thus detailed information regarding nest-site utilization in this region is lacking. In western Newfoundland, Northern Hawk-Owl nests were found on the top of large (DBH=29 and 61 cm) broken off white birch and balsam fir snags (height = 6 m) within extensive clearcuts. Similarly, four nests found in Denali National Park, Alaska, were located at the tops of large snags (mean DBH=42.7 cm) at a height of 6.33 m (Kertell 1986) and in southwestern Yukon, 7 of 9 nest sites were in hollow tops of truncated spruce snags at 3.4 to 7 m above ground (Rohner *et al.* 1995). This consistency in nest-sites suggests that large remnant snags left standing in open areas, either naturally or by forest harvesting practices, are critical for breeding Hawk-Owls in such habitats.

American Kestrels are a widely distributed species that breed in habitats ranging from forest edges, farmland, deserts and suburbs (Johnsgard 1990). This may be attributable in part to their ability to use a range of natural cavities (i.e. woodpecker excavations, earthen banks) and human-made structures such as nest boxes and building ledges (Bird and Palmer 1988). In western Newfoundland, American Kestrels utilized woodpecker cavities in clearcuts for nesting and the trees used for nesting were among the largest of those remaining in the sampled plots. Kestrel nests in Pennsylvania differed from unused cavities by having higher cavity entrances and larger DBH's (Brauning 1983).

Ospreys were uncommon in the immediate study area, however were very abundant at an estuary within the WNMF at Stephenville Crossing. It is estimated that up to 40 pairs of Osprey nest within a 10 km radius of this community (P. St. Croix pers. comm.). Ospreys typically nest on large trees that extend above the canopy and are generally located near water close to favoured fishing areas (Westall 1990). However, Ospreys also commonly nest on various human-made structures including transmission poles, towers, buoys and lighthouses (Westall 1990). In Labrador, nests were erected on the tops of the taller (15 to 18 m) spruce and balsam fir in the dense forest overlooking water bodies (Wetmore and Gillespie 1976).

3.4.1 Recommendations for the management of birds of prey in western Newfoundland

Birds of prey have received increasing attention with respect to land use decisions in recent decades. Human development has led to a general decline in birds of prey on a global scale. In general, three main factors have been identified as causing declines (or limiting numbers): destruction and degradation of habitat, persecution by humans, and contamination by toxic chemicals (Newton 1979). Forest harvesting is a major environmental factor that contributes to habitat destruction and fragmentation. A study conducted in Maine on migrant landbirds in an extensive industrial forest landscape reported that "the acceleration of clearcutting has resulted in a complicated mosaic of habitats, about which little is known concerning the consequences for wildlife, particularly non-game species" (Hagan and Wiley 1992).

The traditional method of timber harvesting in western Newfoundland is clearcutting. This method may be the most economical and efficient in terms of obtaining large amounts of timber for pulp and paper production, however it creates vast areas of habitat unsuitable for woodland birds of prey. Clearcutting reduces forest vertical structure and, in terms of all bird species, generally reduces species richness and biomass (Nelson and Titus 1987). Alternative harvesting techniques must be implemented to ensure the continued existence of wildlife populations in regions with intensive forest utilization. Since different silvicultural strategies may influence raptor populations in various ways, it is critical to determine which species of birds of prey are to be given priority in forestry management plans. Though none of the woodland birds of prey observed in this study are listed by the Committee for the Status of Endangered Wildlife in Canada (COSEWIC) as being either endangered, threatened or vulnerable (COSEWIC 1996), I propose that the raptor species primarily associated with mature and uncut old-growth balsam fir forest be featured in management programs because the distribution of this habitat in western Newfoundland has been greatly reduced, and further habitat degradation would likely have negative impacts on their populations. These species include Sharp-shinned Hawks, Northern Goshawks and Boreal Owls. Preserving adequate expanses of breeding habitat across the landscape requires knowledge of the home range sizes of these species, however, locating a reliable sample of raptors for a biotelemetry study would be difficult. Conservation of large expanses of older forests would also benefit other wildlife species such as the American marten (*Martes americana atrata*) which has been recently upgraded as endangered on insular Newfoundland (COSEWIC 1996).

Forest harvesting may also have inadvertently increased the amount of habitat available to certain species that prefer open habitats and consequently resulted in an expansion of their range or an increase in their population. For example, Northern Hawk-Owls and American Kestrels utilized clearcuts for both nesting and foraging. The American Kestrels' range has probably expanded into Newfoundland since the 1940s, or at least its numbers has increased (Montevecchi and Tuck 1987). Nesting trees for these two species were remnants from logging operations and included truncated snags used by Northern Hawk-Owls and American Kestrels. Foraging raptors that use the pause-travel-search tactic (i.e. Northern Hawk-Owls) have been documented to use clearcuts with perches significantly more frequently than clearcuts lacking perches (Widen 1994). Large residual trees are evidently valuable to specific birds of prey thus provisions for leaving these trees intact in clearcuts should be implemented in forest planning. Habitats for cavity-dependent species such as Boreal Owls and American Kestrels may also be potentially expanded and/or improved by establishing nest-box programs, especially in younger successional forests where suitable nesting cavities may be lacking. Such a program would be relatively inexpensive and could provide data regarding breeding parameters and long term population dynamics. Furthermore, nest-box programs can provide valuable and much needed public education concerning raptors and wildlife conservation in general.

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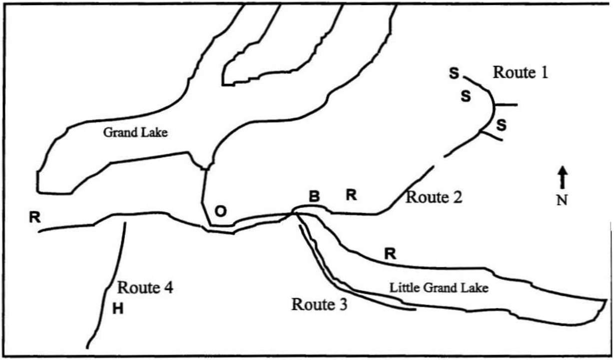
Appendix 1

Illustrations and coordinates of the seven survey routes near Little Grand Lake, George's Lake and Cook's Pond (see Figures 1 to 3).

Survey Route Number		**Latitude**	**Longitude**	**Habitat Type**
1	(start)	48°39' 40" N	57°47' 30" W	Uncut old-growth
	(end)	48°38' 60" N	57°48' 07" W	
2	(start)	48°38' 07" N	57°49' 08" W	Uncut old-growth
	(end)	48°37' 02" N	57°57' 03" W	
3	(start)	48°37' 03" N	57°55' 00" W	Uncut old-growth
	(end)	48°35' 05" N	57°52' 00" W	
4	(start)	48°36' 04" N	57°56' 03" W	Clearcut
	(end)	48°35' 06" N	57°57' 04" W	
5	(start)	48°41' 00" N	58°10' 02" W	Second growth
	(end)	48°42' 00" N	58°14' 00" W	
6	(start)	48°42' 05" N	58°13' 08" W	Second growth
	(end)	48°45' 02" N	58°10' 09" W	
7	(start)	48°52' 00" N	58°05' 08" W	Clearcut
	(end)	48°53' 05" N	58°05' 05" W	

Figure 1. The Little Grand Lake study area illustrating routes 1-3 (uncut old growth) and route 4 (clearcut).



Legend:

S Sharp-shinned Hawk prey-plucking-site

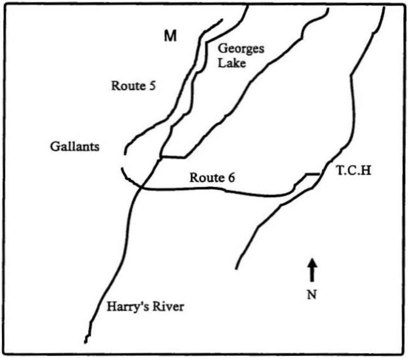
R Rough-legged Hawk nest

B Boreal Owl roost

H Northern Hawk-Owl nest

O Osprey nest

Figure 2. Survey routes 5 and 6 transecting second growth forests near Gallants and George's Lake.

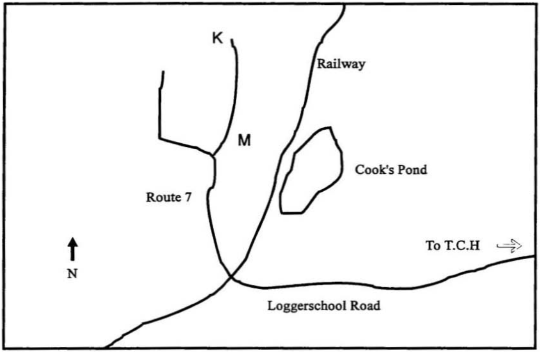


Legend:

M Merlin nest

T.C.H Trans Canada Highway

Figure 3. Survey route number 7 transecting a clearcut near Cook's Pond.



Legend:

K Kestrel nest

M Merlin roost

Appendix 2

Composition of Merlin, Rough-legged Hawk and Northern Hawk-Owl prey remains found near nest-sites in western Newfoundland, 1993-1994.

Table 1. Merlin food remains collected near a nest site, 1993.

Species	Estimated number of individuals
Thrush, *Catharus* spp.	1
Yellow Rumped Warbler *Dendroica coronata*	1
Rusty Blackbird *Euphagus carolinus*	1
Meadow Vole *Microtus pennsylvanicus*	1
Chuckly pear fruit Family Rosaceae	1

Table 2. Rough-legged Hawk food remains collected from 3 pellets at a nest-site near Little Grand Lake, 1993.

Species	Estimated number of individuals
Meadow Vole	5

Table 3. Northern Hawk-Owl food remains collected from 7 pellets at 2 nest-sites in western Newfoundland, 1993-1994.

Species	Estimated number of individuals
Meadow Vole	13