

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



Final Report For

Western Newfoundland Model Forest Corporation

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EXECUTIVE SUMMARY

Field research was carried out in the Western Newfoundland Model Forest (WNMF) during 1993 and 1994. The study was concentrated in the old growth forests around Little Grand Lake, though surveys were conducted throughout the WNMF. The objectives of this research project were:

- 1) To develop reliable, standardized techniques with which to survey birds of prey in different-aged forests and clearcuts in the WNMF.
- 2) To determine the species diversity and relative abundances of birds of prey in uncut old growth, different-aged second growth and clearcut sites, and through these comparisons to assess the effects of forestry practices on birds of prey in the WNMF.
- 3) To develop a better understanding of the spatial and temporal distributions of birds of prey in the WNMF.
- 5) To study the feeding ecology and trophic relationships of birds of prey in the WNMF.
- 6) To identify nest-sites of birds of prey and to quantitatively describe the habitat characteristics at these sites.
- 7) To train qualified students in research design, field techniques and in behavioural, wildlife and forestry ecology.
- 8) To identify knowledge gaps with respect to Newfoundland birds of prey, and in doing so to develop research objectives for future projects and monitoring programs.

Survey routes were established along forest access roads that passed through different forest habitat types and clearcuts. Field work was carried out from May through August 1993, during February 1994, from June through August 1994, and during March 1995. Training in research design and behavioural ecology, environmental assessment, and data analyses were carried

out at Memorial University of Newfoundland from September through May in 1993 and 1994. Surveys involving broadcasts of vocalizations of birds of prey were begun at 0600 h for diurnal birds of prey and at 2200 h for owls. Broadcasts were made at 800 m intervals along forest roads in different habitats and clearcuts. Birds of prey were detected during responses to vocalization broadcasts, by searching for nest and prey plucking sites, and by observation.

During the course of this research, 200 detections of nine species of birds of prey were recorded in the WNMF. Boreal Owls, Sharp-shinned Hawks and Northern Goshawks were detected only in uncut old growth and in old second growth forests. Great Horned Owls were detected only in old second growth forests. Merlins were the most commonly detected bird of prey and unlike any other species they were found in all forest habitats and clearcuts. Osprey nested neared larger rivers and lakes in young second growth and uncut old growth forests throughout the WNMF. Northern Hawk-owls and American Kestrels nested in snags in clearcuts and also used clearcuts as hunting areas. Rough-legged Hawks were found nesting in barren areas within the boundaries of the WNMF in 1993, a year of poor rodent abundance in Labrador, but not in 1994. Rough-legged Hawks also hunted in clearcuts. Overall, uncut natural old growth forests contained higher numbers and greater species diversity of birds of prey than did other forest habitat types and clearcuts. The densities of birds of prey in the WNMF were low compared to other forest ecosystems in North America.

The habitat features around the nest- and prey plucking sites of Sharp-shinned Hawks and Boreal Owls were measured and compared with random control sites in the same habitat. Implications for forestry management practices are considered, and suggestions for monitoring birds of prey and other avian species are being developed.

A Masters of Science (Biospsychology) Thesis on the relative abundances, diversity and habitat relationships of birds of prey in the WNMF is nearing completion. Two papers on birds of prey in the WNMF (one on prey of Sharp-shinned Hawks and one on nesting of Rough-legged Hawks in Newfoundland) are being submitted for publication in scientific journals (Appendices 2 and 3). All of these and other publications will be submitted to the Western Newfoundland Modle Forest Corporation which will be acknowledged for support in these research endeavors.

Introduction

Study of the diversity and distribution of birds of prey in different-aged forests in western Newfoundland is an important component of understanding wildlife and forestry interactions in this region. Preservation of top level carnivores offer direct and incisive means with which to understand and maintain biodiversity in terrestrial ecosystems (e.g. Soule' and Wilcox 1980; Frankel and Soule' 1981). Raptors are susceptible to both natural and human-induced perturbation (e.g. Call 1978, Newton 1979, Poole 1989) and thus may be valuable indicator species within boreal forest ecosystems.

Throughout much of North America, habitat fragmentation due largely to intensive forest harvesting practices has led to a general decline in the populations of many forest raptors. More vulnerable species may 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 (i.e. American Kestrels and Northern Hawk-Owls) may benefit from forest fragmentation. Furthermore, alteration of the physical and vegetative structure of forest habitats may influence the availability and accessibility (Bechard 1982, Baker and Brooks 1991, Widen 1994) of food resources which may ultimately influence populations of birds of prey. Maintaining stable populations of birds of prey at the community level necessitates determining the critical habitat requirements for an assemblage of raptor 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.

Woodland birds of prey are typically secretive, wide-ranging species that occur in low densities relative to other avian taxa (Fuller and Mosher 1981, Kennedy and Stahlecker 1993). Consequently, specialized techniques for censusing birds of prey are often necessary for investigating the diversity and distribution of raptors in different forest habitats. One extensively used survey method is to broadcast conspecific vocalizations at regular intervals along roadsides. This method has proven effective for increasing detection rates of Northern Goshawks (Kennedy and Stahlecker 1993), Cooper's Hawks (Rosenfield *et al.* 1988), Barred Owls (Fuller and Mosher, 1981) and other species.

Little is known regarding the diversity, distribution and abundance of woodland raptors in western Newfoundland. To date, the ecology of birds of prey in forest habitats have been unstudied in insular Newfoundland. For these reasons, research objectives were aimed at basic aspects of raptor study techniques and ecology:

1. To generate effective, standardized means to census birds of prey in the Western Newfoundland Model Forest (WNMF).
2. To study species diversity and the relative abundances of birds of prey in different aged forests and clearcuts within the WNMF.
3. To gain an understanding of the spatial and temporal distributions of birds of prey in the WNMF.
4. To develop density and population estimates of selected species of birds of prey.
5. To identify nest sites of birds of prey and quantitatively describe the habitat characteristics at these locations.
6. To identify knowledge gaps with respect to Newfoundland birds of prey, and in doing so to

develop research objectives for future studies.

Study Area, Methods and Materials

The study area for this project during the 1993 field season (24 May to 14 August) encompassed the entire WNMF, however most of the research effort was spent in the area of Little Grand Lake within the Pine Marten Study Area (PMSA) which is protected from forest harvesting. Much of this area is old growth balsam fir forest, however there are also many areas that were clearcut during the 1980s, before timber harvesting in the area was suspended. 8 to 14 July was spent in the Cook's Pond/Serpentine River area. Of particular interest in this area were clearcuts that were treated during the autumns of 1992 and 1993 with the herbicide glyphosate. In addition to Little Grand Lake and Cook's Pond, research trips were made to sites near Deer Lake (1, 4, 5 June, 13 July), Pasadena (10, 19 July, 10 August), Victoria Lake (3-5 July), Stephenville (20 July, 2 August), Gallants (7 July) and Corner Brook (19 July). A winter field trip to Little Grand Lake was also made from 15 to 21 February 1994. Research in 1994 (1 June to 15 August) was conducted almost entirely in the area from the Trans Canada Highway (TCH) east to Little Grand Lake/Marten Pond, the secondary road from the TCH west to George's Lake, and at Cook's Pond (see Figure 1). These sites were largely located within old growth (80+ yr), second growth (40-60 yr), and clearcut areas respectively (see Figures 1-3). Silvicultured (pre-commercially thinned) areas were excluded from consideration since the total land area of this habitat type in the Western Newfoundland Model Forest is essentially negligible. Sites were also investigated at Pasadena (27 June, 17, 22 July), Deer Lake (12 July, 3 August) and at Stephenville Crossing (8-11 August). Furthermore, Boreal Owl surveys were

conducted in old growth forests near Little Grand Lake from 15 to 21 March. Individual survey routes established at the above locations passed through homogeneous habitat types, and routes varied in length from 4.8 to 11.2 kilometres. Survey routes were reestablished in 1994 to ensure that distances surveyed in each habitat type were comparable. The distance surveyed in old growth, second growth, and clearcut areas in 1994 were 18, 16, and 16 kilometres, respectively, and an equal number of surveys were conducted in each habitat type.

Vocalization broadcast surveys were conducted following the methods of Mosher *et al.* (1990) with some minor modifications. The focal species for 1993 were the Sharp-shinned Hawk, Northern Goshawk, Merlin, Boreal Owl and Great Horned Owl. Equipment used for playbacks included a realistic vsc-2001 cassette recorder and a set of realistic portable minimus-0.6 speakers (83 db/1m). Broadcast stops were spaced at 800 m intervals measured using a vehicle odometer. In areas inaccessible by truck, an all terrain vehicle was used, and stop sites were assigned using 1:50,000 scale topographic maps and personal judgement. Upon arriving at each stop on a route, the observer would listen and/or look for birds of prey for 1 minute. A series of six 20 second playbacks of a single species' vocalizations, separated by 30 second silent intervals, were then made over a 5 minute period. Three vocalization segments were broadcast toward a randomly selected side of the road followed by three broadcast segments to the opposite side. The observer would then remain at the site for an additional 5 minutes to listen and look for birds of prey. Nocturnal surveys started at about 2200 h and diurnal surveys at about 0600 h and took from about two to four hours to complete depending on survey length and location.

Results from 1993 indicate that Merlins did not respond to conspecific vocalization

playbacks, however incidental sightings were recorded. Playbacks for this species were not broadcast in 1994 when focal species were the Sharp-shinned Hawk, Northern Goshawk, Boreal Owl, Great Horned Owl and Northern Hawk-owl. In contrast to methods followed in 1993, nocturnal surveys involved broadcasting playbacks for both Boreal and Great Horned Owls during the same night. In the three habitat types surveyed, the vocalization playback of each owl species was broadcast at every second 800 m stop along the survey route. This method was also implemented for diurnal surveys. In this instance the playbacks for any individual species were broadcast at every third 800m stop along the survey routes. This method controlled for variations in weather conditions that may otherwise influence the detectability of the different species when surveys are run on successive days. Furthermore, surveys were initiated at alternating ends of the route on successive visits to balance the potential effect of varying broadcast times. When sites of high activity by birds of prey were located (i.e. prey remains or territorial behaviour) efforts were made to locate nests and plucking areas. Several techniques were employed including vocalization playbacks, concealed observations and ground searches.

Habitat data were collected at nests, roosts, prey plucking sites, and at 50 m and 400 m corresponding control areas. Data on stand structure, vegetation, snags, coarse woody debris (CWD), and a general description of the area were collected within an 11.3 m (0.04 hectare) fixed plot (see Mosher *et al.*, 1987). The percentage of ground cover vegetation was estimated for the entire 0.04 hectare plot, and the total number of snags (DBH > 10 cm) within the plot were counted. An index of CWD was measured by counting the number of dead fallen trees or limbs (diameter > 4 cm) along a 22.6 m random transect through the study plot. Tree species, diameter, height and vigour were recorded for nest trees, roosts and prey plucking sites.

control sites were located by taking a random compass bearing and measuring the appropriate distance from the center of the birds of prey site. Additional habitat analyses were carried out at each 800 m stop along the 1994 survey routes. Fifty-eight 11.3 m habitat plots were measured at a distance of 50 m from a randomly selected side of the road. Where survey routes followed lake shorelines, habitat measurements were made at a distance of 50 m from the shoreline. Equipment used for this work included a DBH measuring tape, 50 m measuring tape, and a compass.

The diversity and abundance of woodland birds of prey was investigated within and between four and three major habitat types in 1993 and 1994, respectively, and both years combined. Within each habitat (e.g. old growth, second growth, etc.) the occurrence of the most abundant focal species was compared to the abundances of the remaining species of birds of prey at two levels of analysis. A randomization procedure involved replicating the distribution of the most abundant species in a given habitat (base population) to create a model population of 2500-3000 survey sites. This population was randomly sampled at varying intensities 3000 times to produce a frequency distribution of mean densities of the base population in a given habitat. Comparisons were statistically significant if the observed mean density of the comparison species occurred within the rejection area (lower 5%) of the base population frequency distribution. This test was also repeated to compare the abundances of the focal species between habitat types. The model population for the randomization procedure in this case was the distribution of mean densities of a species in the habitat where it was most abundant. For example, the mean density of Sharp-shinned Hawks was compared between uncut old growth balsam fir forest (base population) and the remaining habitat types.

Results

Broadcast Census Effectiveness

The survey methods used were not extremely successful. Most sightings were incidental, although definite responses were evoked on occasion. In 1993, only three of 94 birds of prey detected responded to conspecific vocalization playbacks. Two of these were by Boreal Owls and the other by a Sharp-shinned Hawk. In 1994, nine of 105 raptors responded to playbacks, these were: Boreal Owls (1 contact), Great Horned Owls (3), Hawk Owls (3) and Sharp-shinned Hawks (2). Increased success may have been attributable to improved audio equipment employed during 1994, increased observer experience and perhaps better weather conditions that influenced audibility. It is notable that for each of the encounters throughout the study, a positive response to the playbacks was made during the initial 5 minutes of the broadcasting period.

Birds of Prey Species Composition

Nine species of raptors were sighted between 24 May and 11 August 1993, and between 1 June to 14 August 1994 (Table 1). The number of sightings for each species was determined by several factors, including relative populations in the study area, detectability, territorial and foraging behaviours and habitat preferences. For example, species that frequented clearcuts were more easily sighted than those that preferred wooded habitats. In addition, vocal species (e.g. Rough-legged Hawks) were much more detectable than secretive, relatively non-vocal species (e.g. Sharp-shinned Hawks).

Table 1 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. These numbers also include birds of prey recorded in areas outside of the survey routes but within the Western Newfoundland Model Forest boundaries (see Figure 1).

SPECIES	NUMBER OF SIGHTINGS (estimated number of individuals)			FOREST HABITAT
	1993	1994	Total	
Sharp-Shinned Hawk <i>Accipiter striatus</i>	13 (6)	15 (8)	28 (14)	Uncut old growth and old second growth forests
Northern Goshawk <i>Accipiter gentilis</i>	0 (0)	4 (1)	4 (1)	Uncut old growth forests
Rough-legged Hawk <i>Buteo lagopus</i>	22 (18)	0 (0)	22 (18)	Barren ground, clearcuts, cliff faces
Boreal Owl <i>Aegolius funereus</i>	8 (5)	1 (1)	9 (6)	Uncut old growth forests
Great Horned Owl <i>Bubo virginianus</i>	2 (2)	8 (4)	10 (6)	Old second growth forest
Northern Hawk-Owl <i>Surnia ulula</i>	10 (5)	14 (7)	24 (12)	Clearcuts
Merlin <i>Falco columbarius</i>	25 (14)	22 (16)	47 (30)	Clearcuts, old and young second growth, uncut old growth forests
American Kestrel <i>Falco sparverius</i>	9 (8)	4 (4)	13 (12)	Clearcuts
Osprey <i>Pandion haliaetus</i>	5 (4)	35 (24)	40 (28)	Young second growth and uncut old growth forests near large water bodies

Habitat Associations and Relative Densities of Birds of Prey

Results from roadside surveys conducted in three different forest habitats near Little Grand Lake indicate that uncut old growth balsam fir forests had relatively higher densities of Sharp-shinned Hawks in 1993 and 1994, Boreal Owls in 1993, Merlins in 1994, and also contained lower densities of Northern Goshawks in 1994 and Ospreys in both years. Furthermore, Northern Goshawks and Boreal Owls were found exclusively in uncut old growth, while Sharp-shinned Hawks were found mainly in this forest habitat (Table 2).

Three species of woodland raptors were identified in second growth forests near Victoria Lake and Gallants: Sharp-shinned Hawk, Great Horned Owl and Merlin. In addition to the focal species of birds of prey, second growth forest in various successional stages were utilized approximately 20 nesting pairs of Osprey in the Stephenville Crossing area.

Clearcuts provided nesting and foraging habitat for both Northern Hawk-owls and American Kestrels as well as hunting sites for Merlins and Rough-legged Hawks. Pre-commercially thinned areas were utilized by the fewest number of species in comparison to other habitat types. Only Merlins and Rough-legged Hawks were observed hunting in this habitat, and no species were recorded using thinned areas for nesting.

Old growth balsam fir forests are utilized by more species in comparison to second growth forests, clearcuts and precommercially thinned areas. Comparisons were made between the total number of birds of prey (species combined) recorded along survey routes passing through old growth balsam fir forest, second growth forest and clearcuts. Within each breeding season the total number of birds of prey did not differ among habitats, however for both the

Table 2 Densities of raptors detected along survey routes in different forest types in the WNMF (1993-1994).

Habitat Type 1993	km Surveyed	Area (km ²)	Sightings/km								
			SSH	GH	RLH	M	K	O	BO	GHO	NHO
Uncut Old Growth (80+ yr)	15	18	0.27	0	0	0.07	0	0.13	0.33	0	0
Second Growth (40-60 yr)	9	10.8	0.11	0	0	0.11	0	0	0	0.11	0
Thinned (10-20 yr)	18	29	0	0	0.17	0.06	0	0	0	0	0
Clearcut (0-10 yr)	16	25.6	0	0	0.13	0.19	0	0	0	0	0.19
1994											
Uncut Old Growth (80+ yr)	18	21.6	0.22	0.06	0	0.17	0	0.11	0.06	0	0
Second Growth (40-60 yr)	16	30	0	0	0	0.25	0	0	0	0.13	0
Clearcut (0-10 yr)	16	25.6	0	0	0	0.19	0.13	0	0	0	0.19
1993-1994 (combined)											
Uncut Old Growth (80+ yr)	18	21.6	0.22	0.05	0	0.22	0	0.22	0.28	0	0
Second Growth (40-60 yr)	25	30	0.04	0	0	0.20	0	0	0	0.12	0
Clearcut (0-10 yr)	16	25.6	0	0	0.13	0.25	0.13	0	0	0	0.31

1993 and 1994 seasons combined, old growth balsam fir forests had a significantly higher density of total birds of prey than second growth forests (randomization test, $p < 0.005$) but not clearcuts. Clearcuts also contained higher numbers of birds of prey than second growth forests (randomization test, $p < 0.05$).

A comparison of the numbers of the focal species among the different habitat types showed that in 1993, significantly more Sharp-shinned Hawks and Boreal Owls were recorded in old growth balsam fir forests in comparison to pre-commercially thinned areas and clearcuts (randomization test, $p < 0.05$), but not second growth forests. In 1994, the number of birds of prey of each species did not differ significantly between habitat types.

Comparisons of the numbers of individual species within each of the habitat types were also made for 1993, 1994, and both years combined. In 1993, the numbers of Sharp-shinned Hawks and Boreal Owls in old growth forests were similar, however were significantly greater than Northern Goshawks, Merlins, and Great Horned Owls (randomization test, $p < 0.01$). Within second growth forests and pre-commercially thinned areas sample sizes were not sufficient to permit statistical comparisons. In clearcuts, however, the number of Merlins was significantly greater than those of all other focal species (randomization test, $p < 0.05$). In 1994, interspecific comparisons of the numbers of birds of prey did not differ significantly within habitat types. Over both breeding seasons combined, Boreal Owl and Sharp-shinned Hawk numbers were significantly greater than those of Great Horned Owls and Northern Hawk-owls in old growth forests (randomization test, $p < 0.05$). Within clearcuts, both Merlins and Northern Hawk-owls were significantly more abundant than any other species (randomization test, $p < 0.05$).

An analysis was performed to investigate changes in the numbers of avian predators (i.e. Sharp-shinned Hawks and Merlins) and small rodent predators (i.e. Rough-legged Hawks and Northern Hawk-owls) between the 1993 and 1994 breeding seasons. The abundance of raptors primarily dependent on passerines was identical between years, however, the number of rodent specialists (particularly Rough-legged Hawks) decreased drastically from 1993 to 1994 (randomization test, $p < 0.001$; Whitaker *et al.* in prep. - see appendix 3).

Discussion

Woodland birds of prey generally occur in low density, are rapid-moving, wide ranging and therefore difficult to census (Fuller and Mosher 1981). Positive responses to vocalization playbacks by four species of birds of prey (three of which were owls) were evoked on occasion. The same technique as outlined by Mosher *et al.* (1990) could probably be much more effective with some minor modifications to our methodology. For instance, surveys should have commenced earlier in April and May when breeding pairs are establishing territories and are more likely to respond to recorded vocalizations. This may have proved particularly effective for Boreal and Great Horned Owls, both of which begin searching for potential mates in late winter and early spring. However, Forsman *et al.* (1977) found that Spotted Owls responded readily to calls through the entire spring-summer period. Research in forests in the eastern United States have successfully used this survey method in the past. For Cooper's Hawks, Red shouldered Hawks and Barred Owls the contact rates obtained by broadcasting taped vocalizations of conspecifics along roads were significantly greater than contact rates obtained by only looking and listening from the roadside (Mosher *et al.* 1990). In this study, only

Northern Hawk-owls were detected more often by broadcasting vocalizations than by listening and looking only.

Surveys for birds of prey conducted during the 1993 and 1994 breeding seasons indicated that although the densities of birds of prey were generally low, different aged forests and clearcuts were utilized by a broad assemblage of species and that uncut balsam fir forests contained the most birds of prey and the most species. Forests in advanced stages of natural succession in western Newfoundland are typified by extensive snag retention and stands of various ages, thus a potentially wider range of species can inhabit this habitat type. For example, Boreal Owls are dependent upon the presence of tree cavities for nesting (Hayward *et al.* 1993) were restricted to uncut balsam fir forests. Furthermore, Sharp-shinned Hawks prefer a dense canopy cover for nesting (Platt 1974, Call 1978) and a relatively open understory for hunting and were found mainly in old growth forests.

Second growth forests are typically younger even-aged forests with less structural diversity than natural forests. Species with narrower habitat flexibility (i.e. Boreal Owls and Northern Goshawks) are unlikely to select such forests for breeding thus this may explain the decrease in species diversity in comparison to old growth forests. Surveys in second growth forests indicated the presence of only three species of birds of prey, two of which are considered generalistic predators with wider ecological tolerances - Great Horned Owls (Bosakowski *et al.* 1989) and Merlins.

Clearcuts provided suitable breeding habitat for both Northern Hawk-owls and American Kestrels. Large snags were 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, an aerial predator which prefers open ground although typically at more northerly barren or tundra habitats.

Depending on the particular species, breeding density is likely limited by either suitable nest sites, food resources, or some combination of both of these factors (Newton 1979). Two breeding pairs of Sharp-shinned Hawks were identified in old growth forests in 1993 and 1994, and also in older second growth forests in 1994. This is consistent with breeding habitat described by Reynolds *et al.* (1982) and Platt (1979) where nest sites were identified in dense, (0-60 year old even-aged conifer stands. However, Beebe (1974 in Johnsgard 1988) states that perhaps up to 80% of the total North American population of Sharp-shinned Hawks breeds in boreal forests where it favours young forests with a variety of spruce thickets, meadows, or lightly treed areas of aspens or pines. As primarily ambush predators, Sharp-shinned Hawks breeding in Newfoundland would probably select older growth forest where the understory is relatively open thus allowing rapid pursuit of avian prey. Forests in earlier successional stages are generally much more dense and would not allow effective aerial pursuit of prey beneath the canopy layer.

Only one Northern Goshawk was recorded along survey routes in two years of study (Little Grand Lake 1994). The near absence of this species in the habitat types surveyed in 1993 and 1994 may be attributable to the strict habitat requirements of this woodland species. Northern Goshawks prefer forests in advanced successional stages. In the conifer forests of northeastern California, the Northern Goshawk was selected as a management species on the Inyo National Forest because it was designated as a sensitive species and was considered an ecological indicator for mature and old growth forests in the east - side of Sierra Nevada

(McCarthy *et al.* 1989). Clearcuts and second growth forests therefore do not likely provide nesting habitat for this species. The old growth forests at Little Grand Lake may provide suitable stands for nesting, however as suggested for Great Horned Owls, major prey species such as Snowshoe Hare, Ruffed Grouse and waterfowl are not abundant in this area. This may explain the lack of Northern Goshawk sightings during the study. Johnsard (1988) cites grouse, Snowshoe Hare and Red Squirrels as important foods of Northern Goshawks in boreal forests east of the Rocky Mountains. Of these, only Red Squirrels were common around Little Grand Lake.

Boreal Owls were recorded at low densities in old growth forests in 1993 and 1994, and were not recorded during winter surveys in 1995. This low population density may reflect poor rodent years in 1993 and 1994 and may more generally result from the low small mammal prey base typical of insular Newfoundland. Small mammals, particularly voles, are primary prey of Boreal Owls throughout their geographic range (Hayward *et al.* 1993), and seems likely that numbers of voles limit the breeding density of Boreal Owls. The reduction of encounters with meadow voles from 1993 (8 contacts) to 1994 (1 contact) seems to support the suggestion that a crash in small mammal populations may have occurred between years. Furthermore, productivity of Northern Hawk-owls decreased drastically in 1994 compared to 1993. Three Hawk-owl pairs observed in 1994 produced a mean of one fledgling, whereas in 1993, a single pair fledged five young. In northern regions with pronounced vole cycles, Boreal Owls function as microtine specialists and exhibit extreme fluctuations in breeding parameters (Korpimaki 1986). Avian predators may therefore be important indicators of relative populations of small mammals. Korpimaki (1994) found that in western Finland, the breeding densities of Boreal

Owls in two study areas were significantly correlated with trap indices of voles in the prevailing spring and in the preceding autumn, and that this relationship was also positively related for Ural Owls and Hawk - owls. At the landscape level, Boreal Owls are also restricted by the extent of nesting habitat available. In boreal forests in the northern United States, nest sites were restricted to mature and old forest stands with complex physical structure (Hayward *et al.* 1993). As strict cavity nesters, Boreal Owls require forests in advanced successional stages where snag recruitment and the development of cavities provide suitable breeding habitat. Due to forest harvesting operations, as well as natural processes (i.e. fire, insect infestation), mature and old growth forests in Newfoundland are extremely limited thus suitable Boreal Owl breeding habitat is likely restricted.

Surveys for Great Horned Owls indicate that this species inhabits second growth balsam fir forests in western Newfoundland but in low densities compared to mainland populations. In 1994, only one pair was recorded along 16 km of survey routes in second growth mixed fir forest. Food resources also likely limit the breeding density of Great Horned Owls. Snowshoe Hare often form a major component of the diets of Great Horned Owls and Northern Hawk - owls (Johnsgard 1988). It is strongly suggested that periodic fluctuations or invasions of Horned Owls have occurred in northern forests and that these fluctuations or invasions are directly correlated with the varying abundance of hares and grouse (Rusch *et al.* 1972, Bosakowski *et al.* 1989). At present , Snowshoe Hare numbers in western Newfoundland are low (P. St. Croix, pers. comm., 1994), and this may therefore be a major factor influencing populations of Great Horned Owls in the study area. As generalistic nesters (Johnsgard 1988), suitable nest sites for Great Horned Owls are probably not limiting in western Newfoundland.

Northern Hawk-owls were relatively common in clearcut areas in both 1993 and 1994 (see Table 1). The typical breeding habitat of this species consists of open to moderately dense coniferous or mixed coniferous-deciduous forests bordering marshes or other open areas such as those cleared by lumbering (Johnsgard 1988). Our findings are consistent with this contention; all Hawk-owls and two of their nests were found in clearcuts. This habitat, in addition to providing nesting sites, is also used by Hawk-owls for foraging areas. Hawk-owls were observed chasing and capturing small mammals from perch sites within clearcuts. Results from 1993 pellet analysis indicate that meadow voles are important prey. Based on studies at nest-sites in Norway, Finland, and Russia, voles made up at least 93% of the identified prey animals in all cases (Johnsgard 1988). Land management practices should ensure that adequate snags and stumps remain in such areas so that this species can effectively use this habitat for both nesting and hunting.

Merlins were the most common woodland raptor species recorded in western Newfoundland in both 1993 and 1994 (see Tables 1 and 2). This is probably attributable to its ability to inhabit several different habitat types. Nests were found in a mixed second growth forest, a low black spruce-heath area, and territorial behaviour suggesting proximity to a nest-site occurred adjacent to a clearcut and also within an old growth forest stand. In North America the habitats of Merlins vary regionally, with the northernmost populations breeding in coniferous forests that are often near open areas such as forest edges, bogs or lakes with nests often near water, such as on lake shores or on island in lakes (Johnsgard 1988). Merlins may also be more abundant since they are a strongly bird-adapted predator (Johnsgard 1988) and do not rely on fluctuating or cyclic prey such as voles or hares as do Boreal or Great Horned Owls.

The significant decline of microtine-dependent birds of prey (Boreal Owls, Northern Hawk-Owls and Rough-legged Hawks) from 1993 to 1994 suggests that small mammal populations may have crashed in this region between years. Korpimäki (1994) found that in Fennoscandia, juvenile and female Boreal Owls disperse when voles crash, but most old males stay on their territories throughout the year. Northern Hawk-owls are considered to lead an essentially nomadic life, breeding in areas with temporarily high microtine abundance (Nybo and Sonerud 1990). The abundance of avian predators (i.e. Sharp-shinned Hawks and Merlins) remained identical between years suggesting that food resources were more stable for these species. The 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 not concentrate solely on predators or their nesting habitat.

Management Implications

In recent decades birds of prey have received more attention with respect to land use decisions. Historically, however, 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), namely, restriction 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).

Timber management activities have generally resulted in the shifting of mature or old-growth forested areas to younger successional stages (McCarthy *et al.* 1989), therefore species such as Boreal Owls, Sharp-shinned Hawks and Northern Goshawks which rely on older forests for part or all of their life history will be adversely affected. An approach to mitigate the impact of forestry practices on birds of prey may be to create buffer zones around nest-sites and roosting areas. Such an approach may be effective for larger species with obvious nests, however the present research has shown that the nest-sites of woodland birds of prey are extremely difficult to locate. Further increasing the knowledge of nesting areas in western Newfoundland would be very labour intensive and costly. The optimal management strategy from a conservation perspective is to promote preservation of large tracts of land, especially old growth forest, from harvesting operations. This would vastly improve the chances of sustaining viable naturally occurring populations of birds of prey on a long term basis.

Forest harvesting may also have inadvertently increased the amount of habitat available to certain species and consequently resulted in an expansion of their range or an increase in their population. American Kestrels were sighted on numerous occasions and two nests were found in clearcuts. It is probable that the range of this small falcon has expanded into Newfoundland since the 1940s, or at the least that its population has increased (Montevicchi and Tuck 1987). Due to the fact that they were sighted exclusively in clearcuts, it is probable that logging has played a key role in this increase. Rough-legged Hawks were also frequently sighted in cut areas (in 1993), and the four nests found were all within foraging range of clearcuts. It has been

suggested that the high numbers of Rough-legged Hawks seen were present because of an invasion from Labrador, where prey populations may have been low (see appendix 3). Furthermore, populations of small mammals (i.e. *Microtus*) in 1993 seem to have been increased in comparison to recent years (L. Mayo, J. Brazil, pers. comm.). Closed canopy forests would be unsuited to the hunting methods of these large hawks. The number of sightings of Rough-legged Hawks soaring above or perching (their usual method of spotting prey) around clearcuts suggests that they probably captured a considerable portion of their food there. Newfoundland is one of the only regions of their home range where commercial timber harvesting occurs. It is doubtful that the areas surveyed would have been able to support the number of Rough-legged Hawks sighted were they in their natural, forested state.

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Appendix 1

Habitat Parameters for birds of prey Measured at nests, roosts, prey plucking sites and control plots

Table 1 Description of habitat variable abbreviations used in analysis of nest-sites of birds of prey, prey plucking sites, roosts, and randomly selected control sites.

Habitat Variable Abbreviation	Description
Dens	Density of trees (>3 cm DBH)/0.04 ha plot
Dens<15	Density of trees <15 cm DBH
Dens>15	Density of trees >15 cm DBH
DBH	Diameter of tree at breast height
Dead	Dead merchantable and non-merchantable trees
Snags	Standing dead stems DBH>10 cm
Live	Live crown (>3 cm DBH)
CWD	Course woody debris. Includes fallen trees, limbs, and stumps.
Veg cover	Percentage ground cover of shrubs and woody plants
Bf	Balsam fir
Bs	Black spruce
Ws	White spruce
Wp	White pine
Wb	White birch
Yb	Yellow birch

Three areas of high Sharp-shinned Hawk activity were found. Prey plucking sites were located in small clearings (50 x 30 m) within uncut old growth balsam fir stands, where the trees were spaced at about 5 m apart and the canopy started approximately 6 m above the ground. The forest around these sites was often interspersed with small bogs. This seemed well suited to the hunting style of Sharp-shinned Hawks, which are ambush predators. Compared to control sites,

prey plucking sites were characterized by a much lower total density of trees and a higher percentage of dead balsam fir trees likely due to previous Hemlock Looper infestation. The density of snags around the nest sites was similar in comparison to the 50 m control plot, but greater than in the 400 m plot. In each case, after successful hunts, the birds returned to the small clearing, here the prey was eaten. The hawks would perch on fallen trees, stumps and upturned roots where feathers, fur, beaks and entrails were removed from prey. Because juveniles were consistently sighted around these clearings it is believed that nests were within 100-200 m of the prey plucking sites. Furthermore, a study in Colorado (Joy *et al.* 1994) investigating feeding ecology of Sharp-shinned Hawks examined prey remains of which the vast majority were collected around verified nest-sites. It is possible that Sharp-shinned Hawks seek some sort of opening to use as a prey processing area.

Table 2 Habitat characteristics at Sharp-shinned Hawk (SSH) prey plucking sites (n=3) and control sites (50 m and 400 m, n=6) in old growth forests within the WNMF. Mean densities and percentages are recorded for 0.04 hectare plots. Mean frequency counts of CWD are recorded along 22.6 m transects.

Habitat Variable Abbreviation	Post	Ctrl (50 M)	Ctrl (400 m)
Dens	42	100	98
Dens dead Bf<15	6	40	43
Dens dead Bf≥15	11	10	4
Dens live Bf<15	3	9	10
Dens live Bf≥15	16	34	34
Dens live Bs<15	4	1	3
Dens live Bs≥15	1	1	1
Dens live Wb>15	1	4	3
% dead	40	45	41
% live	60	55	59
% Bf dead	72	32	46
% Bf live	28	68	54
% Coniferous	95	93	96
% Deciduous	5	7	4
Dens snag	19	23	9
Dens snags <15 DBH	4	13	5
Dens snags ≥15 DBH	15	10	4
Total freq CWD	18	15	12
Veg Ground Cover	5	5	16

Boreal Owls were detected during nocturnal surveys on five occasions early in the field season (i.e. 25 May - 15 June). The owls were estimated to be within a distance of about 100 to 800 m from the point where vocalizations were broadcast. The habitat was predominantly old growth balsam fir forest with interspersed areas of low spruce and/or bog. Another Boreal Owl was detected in an old growth stand of mixed forest adjacent to Little Grand Lake. This owl was approached on eight occasions and was determined to use one of three trees as a roosting site. One of these trees in fact may have been its nesting site. This was a large white pine snag with

a cavity at approximately 3.5 m from the ground. Most of the bark had been removed, however extensive decay of the wood had not begun. This tree was later climbed to investigate the possibility of a nest-site, however the search was inconclusive. The second tree used as a roosting site was a large black spruce tree (DBH=32) with a dense canopy. The third site was a large white birch tree again with a dense canopy. All three trees were within approximately 100 - 200 m of a small bog. The habitat characteristics were determined for the roost in the black spruce tree and a randomly selected control site. The roosting site had an overall lower density of trees, however it had a greater percentage of live trees. The roosting site was also characterized by a greater number of large (>15 cm DBH) white birch trees (Table 3).

Table 3. Habitat characteristics at a Boreal Owl roosting site and two control sites located in an old growth forest at Little Grand Lake, WNMF. Densities and percentages are recorded for 0.04 hectare plots. Frequency counts of CWD are recorded along 22.6 m transects.

Habitat Variable abbreviation	Boreal Owl		
	Nest	Ctrl (50m)	Ctrl (400m)
Dens	152	191	76
Dens dead Bf<15	34	91	17
Dens dead Bf≥15	4	8	1
Dens live Bf<15	59	46	18
Dens live Bf≥15	19	25	6
% dead	29	53	
% live	71	47	
% Bf dead	86	98	
% Bf live	72	79	
% Coniferous	87	98	
% Deciduous	13	2	
Dens snag	12	17	11
Dens snags <15 DBH	4	8	4
Dens snags ≥15 DBH	8	9	7
Total freq CWD	16	9	4
Veg Ground Cover	10	20	35

Clearcuts were frequently used by raptors. Most of these birds used a sit and wait hunting method, locating prey while perched in trees, which act as good vantage points. Of the 24 sightings of raptors (Merlins, American Kestrels, Northern Hawk-Owls, Rough-legged Hawks, and an Osprey) perched in clearcut areas, 15 were in birch, while the remainder were in spruce or fir. Birch are unsuitable as pulpwood, and so are often left standing in cut areas. Most of the sightings in spruce and fir were in those trees surrounding the cutblocks. Leaving birch and other trees standing within cutblocks seems to facilitate hunting and hence improve the quality of clearcuts as habitat for birds of prey.

The Hawk-Owl nest area and control plot were located in an area that had previously been

naturally burned. Although there were only a few snags in the 11.3 m radius nest and control plots, there were many snags (~10 cm DBH) and alder thickets in the general area. Ground cover vegetation was dense. The nest was on top of a broken snag of DBH = 29 cm and a height of 6 m. The habitat characteristics are summarized in Table 4.

Three Merlin nest sites were found in second growth forests. Sites were characterized by a relatively high density of balsam fir trees with a DBH < 15 cm. Snags and coarse woody debris were not abundant. Measurements were very similar to the 50 m random control plots, however the 400 m control plots had a higher total density of trees, a higher percentage of live trees, and a higher deciduous component (see Table 5).

American Kestrel nest-sites within clearcuts were characterized by a higher density of trees and snags than control plots at both distances, however the frequency of coarse woody debris and the percentage of ground cover was very similar at all sites (Table 6). Alder thickets and snags are numerous outside of the immediate 11.3 m radius plot at the Deer Lake nest site, whereas at Cook's Pond the density of trees and hardwood regeneration away from the nest site is low. The nest cavity at Deer Lake is found in a birch snag of DBH = 38.5 cm. The entrance hole is ~8 cm in diameter and is located 40 cm from the top of the tree.

Habitat characteristics were measured at four Osprey nest-sites within 2 km of Stephenville Crossing. The forest in this area was predominantly 30-60 yr second growth balsam fir with an approximately 25 % deciduous component. All nest-sites measured were within 1 - 2 km from a large water body. Nest sites differed from 50 m control plots by having a greater total mean density of trees and a higher number of balsam fir > 15 cm DBH. There was no apparent difference between these sites regarding any other habitat variables (see Table 7). Nest trees at the four sites were > 15 cm DBH (range 18 - 43 cm DBH) and were typically isolated from surrounding trees or extended above the average canopy layer. Species of the nest trees included black spruce (n=2), yellow birch (n=1), and a wooden platform spanning two telephone poles. The mean height of nest trees was 11 m.

Table 4 Habitat characteristics at Northern Hawk-owl nests (n=2) and control sites (n=4) located in clearcuts near Little Grand Lake and Deer Lake. Mean densities and percentages are recorded for 0.04 hectare plots. Mean frequency counts of CWD are recorded along 22.6 m transects.

Habitat Variable abbreviation	Hawk-Owl		
	Nest	Ctrl (50m)	Ctrl (400M)
Dens	8	11	7
% dead	75	27	70
% live	25	72	30
% Coniferous	67	40	75
% Deciduous	34	60	25
Dens snags	6	5	6
Total freq CWD	15	26	16
Veg Ground Cover	83	65	75

Table 5 Habitat characteristics at Merlin nest-sites (n=3) and control sites in second growth forests near Gallants and River of Ponds. Mean densities and percentages are recorded for 0.04 hectare plots. Mean frequency counts of CWD are recorded along 22.6 m transects.

Habitat Variable Abbreviation	Nest	Ctrl (50 m)	Ctrl (400 m)
Dens	74	52	95
Dens bf >15	11	0	11
Dens bf <15	49	46	33
% dead	50	53	4
% live	50	47	96
% Coniferous	79	67	59
% Deciduous	21	33	41
Dens snags	3	2	1
Dens snags <15 DBH	2	0	0
Dens snags ≥15 DBH	1	2	1
Total freq CWD	23	16	9
Veg Ground Cover	29	36	23

Table 6 Habitat characteristics at American Kestrel nests (n=2) and control site (n=4) located in clearcuts near Cook's Pond and Deer Lake. Mean densities and percentages are recorded for 0.04 hectare plots. Mean frequency counts of CWD are recorded along 22.6 m transects.

Habitat variable abbreviation	Nest	Ctrl (50 m)	Ctrl (400m)
Dens	14	3	12
% dead	86	100	92
% live	14	0	8
% Coniferous	68	80	33
% Deciduous	32	20	67
Dens Snags	6	2	2
Dens snags <15 DBH	2	2	0
Dens snags ≥15 DBH	4	0	2
Total freq CWD	24	10	19
Veg Ground Cover	73	75	75

Table 7 Habitat characteristics at Osprey nests (n=4) and 50 m control sites in second growth forests near Stephenville Crossing. Mean densities and percentages are recorded for 0.04 hectare plots. Mean frequency counts of CWD are recorded along 22.6 m transects.

Habitat Variable Abbreviation	Nest	Control (50 m)
Dens	223	133
Dens bf>15 DBH	60	3
Dens bf<15 DBH	101	78
% dead	2	7
% live	98	93
% coniferous	77	68
% deciduous	23	32
Dens snags	13	7
Dens snags >15 DBH	4	5
Dens snags <15 DBH	9	2
Total freq CWD	35	28
Veg ground cover	70	75

Appendix 2

Prey Remains Collected at Sharp-shinned Hawk Nest-Sites in Western Newfoundland

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Studies of prey remains near Sharp-shinned Hawk nests in old growth balsam fir forests in western Newfoundland indicated that birds, mostly warblers and thrushes, were their primary prey. The hawks appeared to take more thrushes late in the nesting season, and we speculate about this. Bird feeders provide a winter food supply that probably facilitates overwintering by Sharp-shinned Hawks in Newfoundland.

Keywords: Bird feeders, diet, predation, prey, raptor, Sharp-shinned Hawk

Sharp-shinned Hawks (*Accipiter striatus*) are small, secretive ambush predators that typically nest in dense coniferous or mixed forests and prey mainly on small (10-30 g) birds (Platt 1974, Reynolds *et al.*, 1982, Reynolds and Meslow, 1984). To date, Sharp-shinned Hawks have been unstudied in Newfoundland, and knowledge of their feeding ecology is lacking. Here we identify prey remains collected at nest-sites to identify the species and sizes of prey selected by breeding Sharp-shinned Hawks at different times during the nesting season.

Study Area and Methods

The study area located in the Little Grand Lake area (48° 35' N, 57° 50' W) in western Newfoundland (Figure 1) is dominated by an old growth (uncut) balsam fir forest (80+ yr) and a mosaic of bogs and small clearcuts created by timber harvesting. Forest gaps (100-200 m²), resulting from periodic hemlock looper (*Lamdina fiscellaria fiscellaria*) outbreaks, occur in

isolated patches throughout treed areas. From 24 May to 15 August 1993, and from 1 June to 10 August 1994, surveys for woodland raptors were conducted along forest access roads that passed through areas of uncut balsam fir forest, second growth forest, pre-commercially thinned areas, and clearcuts. Conspecific vocalization playbacks were broadcast at 800 m intervals along survey routes in an attempt to locate breeding pairs of both diurnal and nocturnal birds of prey. Ground searches for raptor nest-sites were conducted during both seasons by two researchers walking transects perpendicular to roadsides and evidence of potential raptor breeding (i.e. territorial behaviour, nest structures, prey plucking sites) was noted. Prey remains collected at two Sharp-shinned Hawk prey plucking sites were collected periodically throughout the field seasons and later compared to reference collections at Memorial University of Newfoundland and at the Newfoundland and Labrador Wildlife Division in St. John's. An estimate of the number of prey individuals was derived by counting the number of primary feathers, rectrices, other feathers, beaks, feet, bone and other fragments in each sample collection. Minimum numbers of prey individuals were recorded on the basis of prey remains, e.g. one to 20 primaries and one to 10 rectrices were counted as a single prey.

Results and Discussion

Two Sharp-shinned Hawk plucking sites were located on 18 June and 15 July 1993: both occurred at the edge of a forest gap within a healthy balsam fir stand. Primary feathers and rectrices were the most commonly found prey remains. The fur of small mammals and the chitinous exoskeleton of a beetle were also present, representing only a small proportion of the

total number of prey items (Table 1). Storer (1966) also noted that Sharp-shinned Hawks depend almost entirely on birds as prey, and Joy *et al.* (1994) documented that small mammals comprised only 9% of 513 identifiable prey items at study sites in Colorado.

In the sample from 18 June 1993, six of 12 prey individuals were warblers (*Dendroica* spp.), and one was a thrush (*Catharus* spp). Among prey remains collected at the same site on 17 and 21 July, three of the five prey individuals were thrushes, and there was no evidence of warbler remains. Similarly, at the second site, prey samples collected on 15 and 20 July included three thrushes and two warblers out of a total of eight prey individuals identified (Table 1). These few data suggest a possible switch in diet as the breeding season progressed. The higher occurrence of juvenile thrushes in the later samples (most notable at site 1) may have been attributable to the timing of and to the greater vulnerability of newly fledged birds. Joy *et al.* (1994) also reported that the proportion of nestling and fledgling birds in the diets of Sharp-shinned Hawks increased and remained high through the hawks' fledgling period. Furthermore, thrushes may have been "selected" because their body mass is two to three times greater than that of warblers. The increased proportion of the thrushes in the diet may have also occurred as the considerably larger female Sharp-shinned Hawk, which is capable of taking larger prey, left the nest to hunt after the eggs hatched (Johnsgard, 1990).

The only mammalian remains found were those of the Meadow Vole (*Microtus pennsylvanicus*). It is notable, however, that during a 24 hr period of wet weather, two of three kills at one site were Meadow Voles. This event may reflect decreased foraging activity by songbirds as a means to reduce heat loss during the inclement weather, or perhaps greater exposure of voles during this period.

On 4 August 1994, a Sharp-shinned Hawk plucking site was found within approximately 200 m of a 1993 site. Despite an apparently new plucking site, this was assumed to be the same nesting pair that inhabited the site in 1993. Thrushes, warblers and woodpeckers were again the most common prey remains recovered at the site. No nestling or fledgling Sharp-shinned Hawks were seen at this site during about 30 h of concealed observation at the plucking site, whereas in 1993, fledglings were seen on several occasions during considerably less time in the vicinity. If this pair failed to produce chicks in 1994, then this may explain the smaller number of prey items collected at the plucking post in 1994 compared to 1993.

Records of Sharp-shinned Hawk sightings and prey interactions have been compiled in a data base at Memorial University of Newfoundland (1938-1995; W.A. Montevecchi unpublished data). Seventeen of 20 records with information about predator-prey interactions report Sharp-shinned Hawks pursuing and/or capturing avian prey near bird feeders during fall and winter. Prey species recorded during these observations include Evening Grosbeak (*Hesperophona verpertina*), White-winged Crossbill (*Loxia leucoptera*), Dark-eyed Junco (*Junco hyemalis*), House Sparrow (*Passer domesticus*), European Starling (*Sturnus vulgaris*) and Pine Siskin (*Carduelis pinus*). Bird species pursued by Sharp-shinned Hawks include the above species as well as American Robins (*Turdus migratorius*), Northern Flickers (*Colaptes auratus*), Blue Jays (*Cyanocitta cristata*) and Fox Sparrows (*Passerella iliaca*). Other studies document that Sharp-shinned Hawks prey on a wide variety of species. Storer (1966) lists 81 genera from a sample of 833 prey items taken by Sharp-shinned Hawks of which *Dendroica*, *Melospiza* and *Turdus* are the most frequent. In Colorado, Joy *et al.* (1994) concluded that Sharp-shinned Hawks foraged opportunistically and consumed prey in approximate proportion to their relative abundance and

that Yellow-rumped Warblers (*Dendroica coronata*) were the most common prey; other common prey species were American Robins, White-crowned Sparrows (*Zonotrichia leucophrys*) and Dark-eyed Juncos. Our data are consistent with this contention. Three warbler species (Yellow-rumped Warbler, Black-throated Green Warbler [*Dendroicavirens*], Northern Waterthrush [*Serius novaboracensis*]) and two thrush species (Swainson's Thrush [*Catharus ustulatus*], American Robin) comprise five of the 10 most commonly occurring passerine species in western Newfoundland (H. Hogan unpubl. data). Hairy Woodpeckers (*Picoides villosus*) and Downy Woodpeckers (*P. pubescens*) which were not among most common breeders may have been present in the Sharp-shinned Hawks' diets because of their conspicuous foraging behaviour.

Bird feeders appear to provide adequate food supply to permit Sharp-shinned Hawks to overwinter in Newfoundland. Interestingly, most of the avian species captured during winter are small (e.g. juncos) whereas most of those being chased but not captured are larger (e.g. Blue Jays), suggesting that smaller passerines may be more susceptible to Sharp-shinned Hawk predation at least during winter. Many immature Sharp-shinned Hawks are sighted in winter, and it may be that many of the pursuits of larger species were by immature hawks that had not yet determined the optimal size range of prey that they can effectively capture. Mueller and Berger (1970) studied the size of prey attacked by migrating Sharp-shinned Hawks in northeastern U.S by exposing the hawks to lure birds ranging in size from small (sparrows) to large (pigeons). They concluded that immature Sharp-shinned Hawks of both sexes initiated significantly more attacks on the larger prey than did adults and suggested that the young animals were learning hunting skills and prey selectivity and that age and experience modifies hunting behaviour and prey selection.

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TABLE 1.

Species and estimated number of individual prey taken by Sharp-shinned Hawks at prey plucking sites near Little Grand Lake in western Newfoundland in 1993 and 1994.

Prey Species	Estimated # of individuals		
	1993	1994	Total
Thrush (<i>Catharus</i> spp.)	7	3	10
Warblers spp. (<i>Dendroica</i> spp.)	8	2	10
Mourning Warbler (<i>Opornis philadelphia</i>)	1	0	1
Yellow-rumped Warbler (<i>Dendroica coronata</i>)	1	0	1
American Redstart (<i>Setophaga ruticilla</i>)	1	0	1
Downy Woodpecker (<i>Picoides pubescens</i>)	3	2	5
Sparrows (<i>Melospiza</i> spp.)	3	1	4
White-throated Sparrow (<i>Zonotrichia albicollis</i>)	2	0	2
Brown Creeper (<i>Certhia americana</i>)	1	0	1
Meadow Vole (<i>Microtus pennsylvanicus</i>)	2	1	3
Beetle (<i>Coleoptera</i> spp.)	1	1	2
Total	30	10	40

Appendix 3

Do Rough-legged Hawks (*Buteo lagopus*) From the Labrador Peninsula move to Insular Newfoundland to Breed During Years of Low Prey Abundance?

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We provide information from several sources which suggests that breeding Rough-legged Hawks (*Buteo lagopus*) from the Labrador Peninsula, during years of low prey abundance in this region, nest on insular Newfoundland. Forest clearcuts represented a significant portion of the foraging areas used by nesting pairs observed during the summer of 1993. Forest harvesting may have thus produced an increase in breeding habitat on the island. With the possible exception of Alaska, Newfoundland may be the only portion of the species' North American breeding range where significant clearcutting occurs.

Key words: Rough-legged Hawk, *Buteo lagopus*, clearcut

Rough-legged Hawks (*Buteo lagopus*) are a holarctic species that normally breed in open tundra. In these areas, cyclic populations of their primary prey, small rodents, peak and crash over four to five year cycles. Previous studies of Rough-legged Hawks indicate that local breeding populations drop sharply during years of low prey abundance

(e.g. Newton 1979, Virkkala 1992), but that regional populations remain relatively constant. They provide few observations regarding the fate of the missing individuals. It has been shown that in other species of subarctic raptors having similar diets, such as the Northern Hawk-owl (*Surnia ulula*) and Short-eared Owl (*Asio flameus*), populations relocate to areas of higher prey abundance during poor years (Virkkala 1992). Here we provide circumstantial evidence from several sources that indicates that populations which normally breed on the Labrador Peninsula move south into insular Newfoundland in years of low prey abundance, where they then breed successfully.

During the summer of 1993, we initiated a study of woodland raptors in the Western Newfoundland Model Forest (WNMF). The study area, located inland to the south of the Northern Peninsula, is dominated by Balsam Fir (*Abies balsamea*) forests, however extensive areas of open ground (e.g. clearcuts, bog and rock-barren tundra) exist. We were surprised to find that Rough-legged Hawks, which we had expected to be rare in the study area, were the most frequently sighted species. While Rough-legged Hawks have been observed breeding in Newfoundland in the past, nine out of eleven available nest records are from coastal areas where maritime barrens form the primary ground cover (Montevecchi, unpublished data). In addition to four solitary individuals, seven pairs were sighted, and four nests were located on cliff faces. The average distance between nests was 2 km. At least two young were present in each of the four nests during the last two weeks prior to fledging (July 25 - August 8). Two of these families were seen during the post fledging period, each with two young. Johnsgard (1990) indicated Rough-legged Hawk incubation and fledging periods of 31 and 31-40

days respectively. Based on this information we estimate that egg laying occurred between 13 and 25 May. Seven prey items were identified, all of which were Meadow Voles (*Microtus pennsylvanicus*).

Helicopter surveys of breeding raptors on the Labrador Peninsula are conducted annually by the Newfoundland Wildlife Division and the Natural History Society of Newfoundland and Labrador. During these surveys many breeding pairs of Rough-legged Hawk are usually identified. Surveys conducted during the 1993 season failed to identify any breeding pairs, and only a few lone individuals were sighted (Brazil, NLWD, pers. comm.).

Birdwatchers reported that during the May of 1993 unusually high numbers of Rough-legged Hawks were observed in L'anse aux Meadows, Newfoundland, just across the Strait of Belle Isle from Labrador (MacTavish, Jacques Whitford/St. John's, pers. comm.). The Strait is the shortest possible ocean crossing from mainland North America to insular Newfoundland. Birdwatchers reported abnormally high numbers of Rough-legged Hawk sightings and nests throughout the island during the summer (Mactavish 1993). As one might have predicted, numbers were highest on the Northern Peninsula, along which transient birds would first travel when searching for nesting territories on the island. Also reported during the summer of 1993 was the first nesting record for this species in Gros Morne National Park (Montevecchi, unpublished data), located on the west coast of the Northern Peninsula.

A second season of field study of raptors was carried out in the WNMF during the spring and summer of 1994. Throughout this period only one Rough-legged Hawk was

sighted. Similar survey methods were used along the same survey routes at a similar sampling intensity. None of the nests used during 1993 were occupied. Local populations of Meadow Vole and Deer Mouse (*Peromyscus maniculatus*) were extremely low during the summer, as was indicated by several small mammal studies being carried out in the WNMF. Joe Brazil (NLWD) reported that he located breeding pairs during helicopter surveys conducted in Labrador during 1994. Information from the bird watching community indicated that unusually high numbers of Rough-legged Hawks were also seen on the Island during the summer of 1988 (Mactavish, per. comm.). Although sightings were not as frequent as during 1988, once again the highest numbers were seen on the Northern Peninsula, many of these in clearcuts. This information fits with our suggestion that numbers of this species seen in Newfoundland are related to prey populations in Labrador, as small mammal populations peak and crash on four to five year cycles.

We believe that the inverse correlation between numbers of Rough-legged Hawks observed during surveys in Labrador and on insular Newfoundland over the past two seasons may reflect the existence of a single, mobile population. We speculate that during spring Rough-legged Hawks return from wintering grounds in southern Canada and the United States to their usual breeding grounds in Labrador. During years when populations of prey species are adequate, they nest. If, however, local prey populations have crashed, the hawks migrate out of the region, crossing the Strait of Belle Isle, and, if prey is sufficient, establish breeding territories in Newfoundland. The establishment of territories on the mainland would be difficult at this time, as favourable habitat in other regions would likely already be occupied by breeding pairs of conspecifics. The low

species diversity of small mammals on insular Newfoundland, as well as their relatively low biomass may keep the indigenous (coastal) breeding population on the island small, thus reducing competition for immigrant Rough-legged Hawks.

High Numbers of Rough-legged Hawks on the island of Newfoundland, especially pairs breeding inland, may prove to be a reliable indicator of low prey availability on the Labrador Peninsula.

Forest management in Newfoundland has lead to the formation of large patches of open ground in what are normally woodlands, as clearcutting is the standard harvesting practice in the Province. We regularly observed Rough-legged Hawks hunting in, and returning with prey from, these areas. Forest management may thus have lead to an increase in the area or quality of breeding habitat available to this and other open ground raptor species on insular Newfoundland.

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Figure 1 The Little Grand Lake study area indicating raptor survey routes 1-4. Areas of high raptor activity are depicted by bold typed letters.

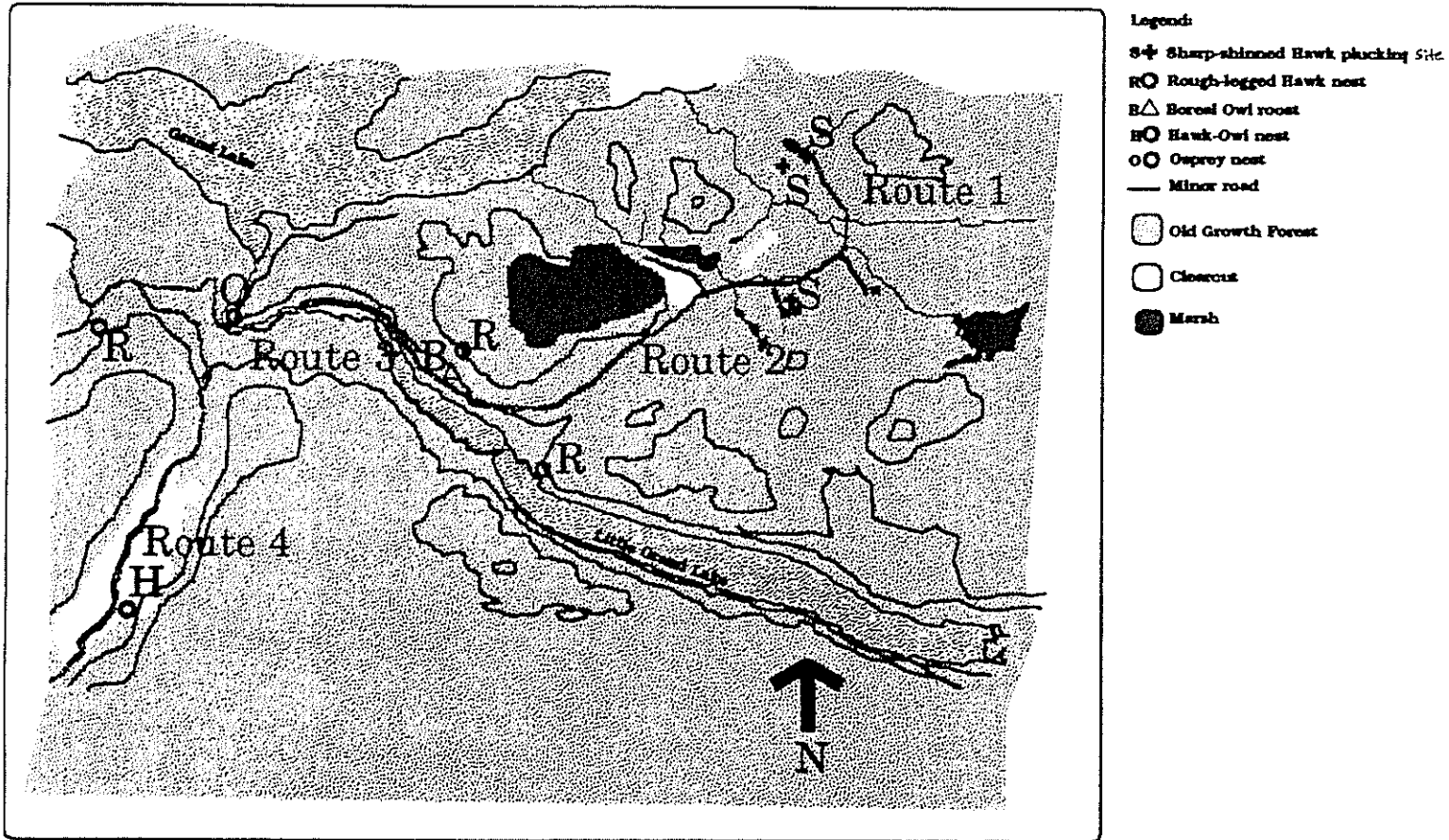
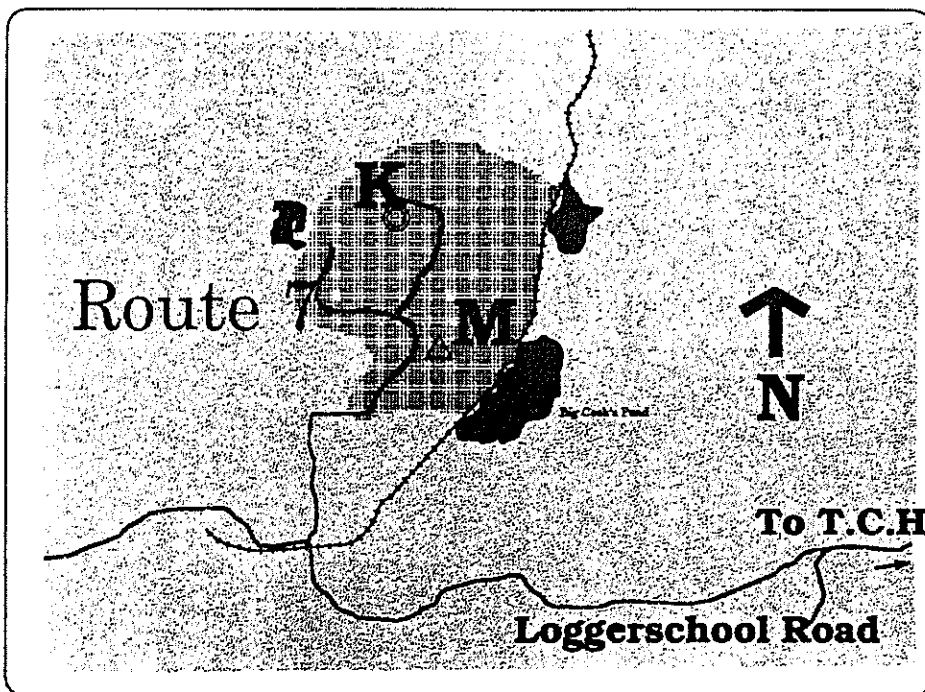


Figure 2. Raptor broadcast survey route in a clearcut at Cook's Pond, 1994.



Legend:

K ○ Kestrel Nest

M △ Merlin Roost

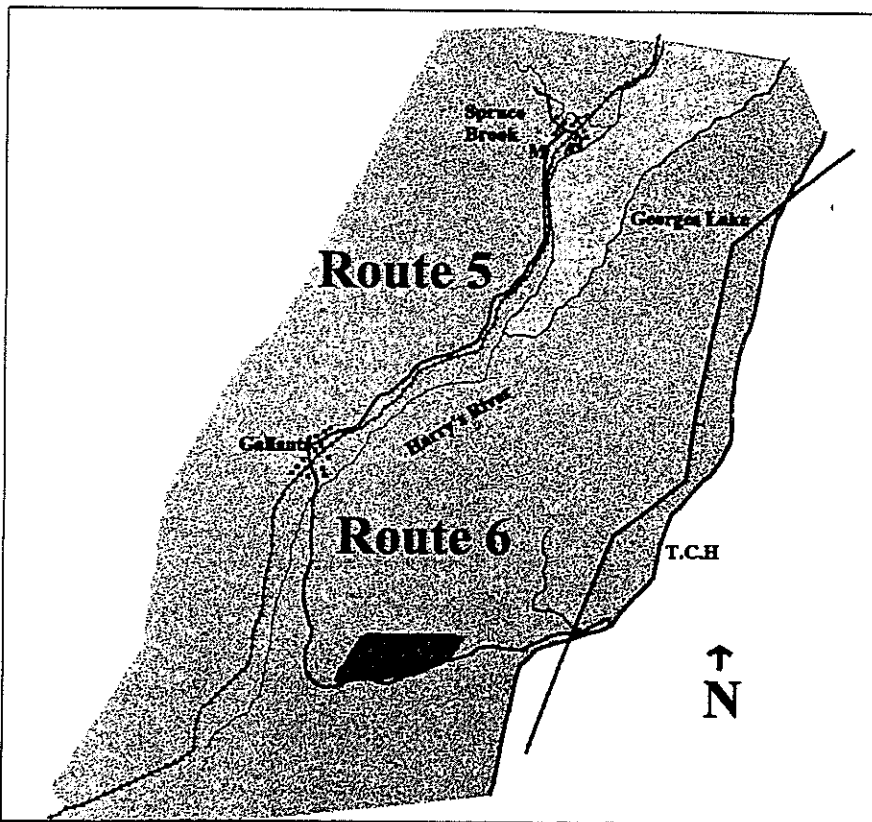
— Railway Bed

— Minor Road

● Clearcut

○ Second Growth FOR.

Figure 3. Raptor broadcast survey routes in second growth forests at Gallants and Spruce Brook, 1994



Legend:

- M** Merlin Nest
- Railway Bed
- Powerline
- Secondary road
- Houses/Cabins
- ▨ Second Growth For.