University of Alberta

Northern Goshawk (*Accipiter gentilis*)
Habitat Characterization in central Alberta
by
Warren Wesley Schaffer 

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Masters of Science

in

Wildlife Ecology and Management

Department of Renewable Resources

Edmonton, Alberta

Spring 1998

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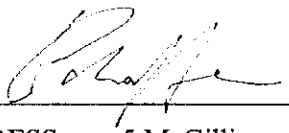
(SIGNED) 

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To my family
Jason, Adam, Mom and Pap

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1.0 Introduction

1.1 STUDY BACKGROUND

In recent years, increased attention has been focused on conservation of biological diversity during forest harvesting operations (Probst and Crow 1991, Spies *et al.* 1991, Ledig 1993, Thompson *et al.* 1993, Thompson and Welsh 1993, Kimmins 1995). Large birds of prey typically occupy a top position in the food-web of a locality (Graham *et al.* 1994, Burnham and Cade 1995). These birds are good candidates for studies aimed at increased understanding of ecological processes (Burnham and Cade 1995). Management techniques that provide habitat for large birds of prey typically protect their ecological community (Franklin 1993, Graham *et al.* 1994, Reynolds 1995).

The Northern Goshawk (*Accipiter gentilis*) is the largest North American member of the genus *Accipiter* (Johnsgard 1990). Reverse sexual size dimorphism is exhibited by Northern Goshawks (adult male mean mass 0.9 kg, adult male wing length: 30 - 33 cm; adult female mass 1.1 kg, adult female wing length: 33 -37 cm) (Dunning 1984; Figure 1.1). The Northern Goshawk breeding range extends from northwestern Alaska, through to Labrador and Newfoundland, south to California, across the continental U.S. to Maryland into Mexico (Jones 1979). Northern Goshawks are partially migratory, with increased numbers of migrants in years of low prey abundance (Mueller *et al.* 1977). The winter range extends from western and central Alaska and British Columbia and southern Newfoundland to southern California, Mexico, Tennessee and the Virginias (Jones 1979).

Northern Goshawks (*Accipiter gentilis*) have been noted for their site fidelity (McGowan 1975, Reynolds and Wight 1978, Speiser and Bosakowski 1991), and their value as an indicator species for old seral stage forests (Bull and Hohmann 1994, Kirk 1995). Northern Goshawk breeding can be disturbed by human-related activities (i.e. logging, vehicular traffic) in the immediate vicinity of the nest that reduce the attentiveness of adult females (Grier and Fyfe 1988, Richardson and Miller 1997), or by changes to the nesting (Reynolds *et al.* 1982, Moore and Henny 1983, Kennedy 1988, McCarthy *et al.* 1989, Reynolds 1989, Crocker-Bedford 1990, Bosakowski and Speiser 1994) or foraging (Kirk 1995, Beier and Drennan 1997) habitats that make these habitats unsuitable for supporting their populations. In certain parts of their range, there has been an increased interest in Northern Goshawk ecology in order to formulate management prescriptions to directly conserve Northern Goshawk populations and their

Figure 1.1 - Adult male (left) and adult female Northern Goshawks (photo courtesy of E. Pletz).

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Northern Goshawk nest areas occupied during 1993-1996. Vegetation was sampled to characterize the habitat used by Northern Goshawks at the scale of nest tree and nest stand, and vegetation at nest areas (0.55 ha around the nest) were compared to the surrounding forest stand to examine selection of nest areas within deciduous-dominated mixedwood forest stands.

2.2 STUDY AREA

This study was conducted in two regions in central Alberta (119°-111°W, 55°-53°N). The study was concentrated on the Foothills Model Forest around the town of Hinton (53°25'N, 117°35'W; the western study area), and around the city of Edmonton (54°N, 114°W; the eastern study area). Sampling was performed in five ecoregions: the Montane Ecoregion, the Sub-alpine Ecoregion, Upper Boreal Cordilleran Ecoregion, Lower Boreal Cordilleran Ecoregion, and the Boreal Mixedwood Ecoregion distributed west to east across the study area (Corns and Annas 1986, Beckingham and Archibald 1996). Elevations range from 1500 m above sea level (Upper Boreal Cordilleran) to less than 800 m above sea level (Boreal Mixedwood Ecoregion) (Corns and Annas 1986, Beckingham and Archibald 1996).

In the western study area, forest cover is dominated by lodgepole pine (*Pinus contorta*), with lesser amounts of trembling aspen (*Populus tremuloides*), white spruce (*Picea glauca*), balsam poplar (*Populus balsamifera*), black spruce (*Picea mariana*) and sub-alpine fir (*Abies lasiocarpa*) (Corns and Annas 1986, Beckingham and Archibald 1996). Access is provided by paved highways (highways 16, 40, 47, and 93), a system of primary and secondary forest access roads, and seismic cutlines. Forested areas are relatively contiguous, and the primary form of disturbance is logging.

In the eastern study area, forest cover is dominated by trembling aspen, balsam poplar, jack pine (*Pinus banksiana*), white birch (*Betula papyrifera*), white spruce, and balsam fir (*Abies balsamea*) (Corns and Annas 1986). Access is provided by a network of paved and unpaved highways, township roads and range roads. Forested areas range in size, but are often small and surrounded by a matrix of agricultural fields.

Stick nest records on the Foothills Model Forest Wildlife Observation Card Database, and stick nest locations that had been documented by other wildlife project personnel were investigated in order to locate Northern Goshawk territories. Stick nests found on Northern Goshawk territories were investigated for the presence of Northern Goshawk feathers from nestlings, and nest decoration to indicate previous occupation. Radio-telemetry locations on Northern Goshawks radiotagged during the first field season were used to find nests during the second field season.

The area sampled during silent searches and broadcast surveys was quantified using measurements and forest cover type determinations from aerial photographs (1:15 000) with verification from field notes made during surveys and ground truthing. The area sampled was grouped according to the following cover types: lodgepole pine (>80% lodgepole pine overstory vegetation), white spruce (>80% white spruce overstory vegetation), black spruce (>80% black spruce overstory vegetation), coniferous-dominated mixedwood (overstory vegetation >50% lodgepole pine, white spruce, and black spruce, with a minimum 20% component of deciduous overstory vegetation), deciduous (*Populus*) (>80% deciduous overstory vegetation), and deciduous-dominated (*Populus*-dominated) mixedwood (overstory vegetation >50% trembling aspen and balsam poplar, with a minimum 20% component of coniferous overstory vegetation). The area sampled during aerial searches was not quantified, due to concerns over the effectiveness of the aerial survey technique (see section 2.4.1).

In other parts of central Alberta, including the eastern study area around the city of Edmonton, additional Northern Goshawk nests were found by raptor banders, fish and wildlife research personnel, and local land owners (E. Pletz, T. Roper, E.T. Jones, J. Moore, R. Cromie, A. de Groot, C. Spytz, D. Mushtuk, C. McCallum, B. Olsen, H. Wollis personal communications). These nests were sighted from roadways, were found during searches in woodlots prior to leaf flush, or were found opportunistically during the course of other forest-related work. In some cases, individuals contributing data to this study restricted their search efforts to areas that contained large deciduous (*Populus*) trees with cavities which are potential nest sites for Northern Saw-whet Owls (*Aegolius acadicus*), Boreal Owls (*Aegolius funereus*), and Barred Owls (*Strix varia*). Other individuals searched for nests in areas where there were a variety of sizes and species of trees. Searches were also conducted in the vicinity of previously active Northern Goshawk nests, and in areas where Northern Goshawk adults aggressively attacked

height classes (>5 m in height; snags), and standing dead trees (5 m≥height≥1.42 m; stubs). Saplings (<5 cm DBH, and >1.42 m in height) and seedlings (<5 cm DBH, and ≤1.42 m in height) were identified to species, and counted. The top (to 5 cm diameter) and base diameter, and length of each piece of downed woody debris was measured. Within each plot, five overstory trees (dominant or codominant) that were judged to be representative of the overstory vegetation were selected, and their height was measured using a clinometer. At a position five metres from the plot centre, in each of the cardinal directions, a canopy closure measurement was made using a spherical densiometer. This canopy closure measurement was taken such that shrubs were excluded from the measurement, but saplings were included. In the next level of the hierarchy, a 0.004 ha plot (circular plot 3.56 m in radius) was located at the centre of each 0.04 ha plot. Within this second plot, an ocular estimate of shrub coverage (%) was recorded. In the final level of the hierarchy, four 1 m^2 plots were located at 5 metres from the plot centre, in each of the cardinal directions. Within these plots, an ocular estimate of herb coverage (%) was recorded.

For each Northern Goshawk nest area, a corresponding contrast vegetation sampling area (0.20 ha) was located in a random direction, at a random distance (90 to 1090 m from the Northern Goshawk nest tree). Within the contrast sampling plots, vegetation was sampled according to the same protocol as in the Northern Goshawk nest areas. Contrast sampling areas were restricted to those areas that exhibited the same forest composition as those at the nest area (deciduous-dominated mixedwood), and they also exhibited the following characteristics (by subjective estimate):

- areas containing trees with an average height >8 m,
- areas containing trees with an average diameter >15 cm,
- areas exhibiting overstory canopy closure >30%.

These minimum requirements were chosen to exclude randomly chosen areas that were deemed unsuitable for Northern Goshawk nesting according to the findings of Schaffer *et al.* (1996), following the guidance in Speiser and Bosakowski (1987).

Additional Northern Goshawk nests were visited to collect basic vegetation measurements: the height of the nest tree, the nest height, the nest tree DBH, the total number of branches supporting the nest structure (excluding the tree bole), and a general description of the nest placement. For nests that did not receive any vegetation sampling, the records of nest observers

Nest site aspects were tested for differences from a uniform distribution using Rayleigh's test (Batschelet 1981, Zar 1984, Kennedy 1988). Nest sites exhibiting flat slope conditions (slope <3°; n=5) were excluded from this analysis. Vegetation at Northern Goshawk nest areas were compared with those at the contrast areas using a Wilcoxon paired-samples test for eight different variables: average height of overstory (m), average diameter (cm), total canopy cover (%), volume of downed woody debris (m^3/ha), live basal area (m^2/ha), total basal area (m^2/ha), total herb coverage (%), and total shrub coverage (%; Zar 1984). The α-value for these Wilcoxon paired-samples tests was set at 0.05 and was then corrected to $\alpha/8$ (0.05/8)=0.00625 in order to account for the multiple univariate comparisons made with the vegetation dataset (Miller 1981, Thomas and Taylor 1990, Wiggers and Kritz 1991). A multivariate analysis was not used because of the limited sample size (Morrison 1984). Chi-square analysis was used to examine for differences in the relative proportion of live and dead trees in individual diameter classes at nest areas and contrast sites (Zar 1984). In order to have adequate counts of trees in each diameter class for analysis, the count data for live trees in the two largest diameter classes was combined to create one diameter class of trees (>35 cm DBH). Similarly, the count data for dead trees in the three largest diameter classes were combined to create one diameter class of trees (>25 cm DBH).

2.4 RESULTS

2.4.1 Nest Location Efforts

No stick nests were observed during the aerial survey flight; two Red-tailed Hawks were the only raptors observed during the flight. The area was primarily deciduous (*Populus*) forest. When the aerial survey method was tested in an area known to contain stick nests, no stick nests could be found. The habitats overflown in the aerial surveys have not been quantified and presented with the results from the other methods owing to concerns over the effectiveness of this survey technique.

In the first field season of the study, silent searches for Northern Goshawk nesting territories occurred between March 13, 1995 and May 24, 1995 (Table 2.1 and Appendix 2). A total of 252.4 ha of forest area was searched in 34 search hours. During these surveys, 2 stick nests were located (2 nests in the deciduous-dominated mixedwood cover type; 0.059 stick nests/hour), and 14 individuals of 7 different raptor species were observed. In the second field season of the

supporting branches = 4.00 ± 0.24 SE; mean nest height as a percent of nest tree height = 68.35% ± 1.78 SE; Figure 2.2). A total of thirty-one different territories were identified; ten of these territories contained nests that were occupied by Northern Goshawks in consecutive years (territories reoccupied for 2 to 4 years; Appendix 4). All territories which were reused had repeated use of deciduous (trembling aspen, balsam poplar) trees. On the Foothills Model Forest, where nest location efforts were conducted in a range of forest cover types, no Northern Goshawk nests were found in coniferous or coniferous-dominated stands (Table 2.1). Five of the seven Northern Goshawk nests on the Foothills Model Forest were located in an unbiased fashion (as a result of radio-telemetry readings, and observations by forest workers). Twelve of the thirty-eight Northern Goshawk nests in other parts of central Alberta, including the eastern study area were located in an unbiased fashion (as a result of search effort in stands with a variety of sizes and species of trees).

2.4.3 Statistical Analysis

Vegetation was intensively sampled around Northern Goshawk nests located on the Foothills Model Forest (n=6; nests active 1994-1996) and in central Alberta (n=11; nests active 1993-1996), and at contrast areas (N=17). Comparison of the Northern Goshawk nest trees with trees from within the nest area (Table 2.2) revealed that Northern Goshawk nest trees were taller than the surrounding canopy (Wilcoxon paired-samples test, P=0.0086), and had a larger diameter than those trees found in the surrounding area (Wilcoxon paired-samples test, P=0.0004). The overstory vegetation in Northern Goshawk nest areas was dominated by deciduous trees (trembling aspen, balsam poplar, white birch; mean relative dominance of deciduous trees=0.78 ± 0.05 SE), with coniferous trees also occupying the overstory (white spruce, lodgepole pine, black spruce; mean relative dominance of coniferous trees=0.22 ± 0.05 SE). The average DBH of overstory trees on all Northern Goshawk nest areas was 19.68 centimetres ± 0.77 SE (range 15.1 - 25.5 centimetres). Nest areas typically had multiple canopy layers of overstory vegetation (mean=1.92 ± 0.08 SE). Nest areas had a high degree of canopy closure at the nest area (mean=77.4% ± 1.68 SE), with limited understory development (Figures 2.3 and 2.4). Canopy gaps created by fallen trees (18 of 25 nests), human-made trails (6 of 25 nests), and proximity to streams with low grass cover (1 of 25 nests) created a flight corridor adjacent to the nest trees. Nest sites were typically in a mid- to lower-slope position (16 of 17 nests), and four of these nests were located at the toe of a slope. Northern Goshawk nest sites faced all directions except west (247.5° - 292.5°) and southwest (202.5° - 247.5°) (Figure 2.5). The distribution of nest

Reynolds *et al.* 1982, Moore and Henny 1983, Speiser and Bosakowski 1987, Hayward and Escano 1989, Reynolds 1989, Squires and Ruggiero 1996), and is not restricted to deciduous nest trees (Shuster 1980, Reynolds *et al.* 1982, Moore and Henny 1983, Hayward and Escano 1989, Reynolds 1989, Squires and Ruggiero 1996). The cause of primary branch forking at the base of the crown of trembling aspen trees is unknown (Stan Lux, Canadian Forest Service, personal communication). Squires and Ruggiero (1996) noted that the high degree of self-pruning in trembling aspen and lodgepole pine trees makes them good candidates for nest placement. A nest at the base of the canopy may be a benefit to Northern Goshawk reproductive success because the nest is more accessible to approaching adult Northern Goshawks for nest defense or feeding activities (Hennessy 1978, Reynolds *et al.* 1982, Hayward and Escano 1989, Moore and Henny 1983, Hall 1984, Speiser and Bosakowski 1987). This nest position also affords the Northern Goshawk the best view of the forest area surrounding the nest tree (Hall 1984, Janes 1985).

In this study, Northern Goshawks used large trees (as indicated by height and diameter) for nest placement in deciduous-dominated mixedwood forest stands. This finding is consistent with habitat selection investigations in southcentral Wyoming, where Northern Goshawks were found nesting in the largest trees in the nest-tree area (0.04 ha) and nest stand (Squires and Ruggiero 1996). In New Mexico, Northern Goshawk nest trees were characterized as being the taller ones on the nest site (Kennedy 1988). Likewise, in Oregon, Northern Goshawks were noted for their use of large trees (Reynolds *et al.* 1982). Large trees offer a secure podium for nest construction, and a well-developed canopy immediately over the nest provides insolation moderating temperature change around the nest (Moore and Henny 1983, Reynolds 1983, Kennedy 1988, Crocker-Bedford and Chaney 1988). Large trees are more likely to have dead branches below the crown (Reynolds *et al.* 1982). These branches may be important as perch sites for nest defense and foraging; they may also provide nesting material, or to act as plucking posts (Schnell 1958, Reynolds *et al.* 1982, Kennedy 1988). In a study of Northern Goshawk populations in Utah, Hennessy (1978) found that fledging rate increased with the average tree diameter for the nest stand and with the size of the nest tree.

The stands used by nesting Northern Goshawks in this study exhibit a variety of attributes (i.e. multiple canopy layers, canopy gaps, large standing and fallen dead trees, multiple ages of trees) that characterize the mature seral stage of deciduous-dominated mixedwood vegetation in this part of North America (Perala 1990, Mehl 1992, Moir 1992). Other studies conducted in North

nest location has been suggested to aid in orientation of the foraging Northern Goshawks to the nest (Speiser and Bosakowski 1987).

The choice of mid- to lower-slope positions has been noted in other Northern Goshawk nesting studies (McGowan 1975, Reynolds *et al.* 1982, Speiser and Bosakowski 1987, Hayward and Escano 1989, Squires and Ruggiero 1996), and this preference may be owing to the proximity to sources of water (Reynolds *et al.* 1982). The distance from Northern Goshawk nest sites to water was not measured in this study.

2.5.2 Nest Habitat Selection

Northern Goshawks in central Alberta did not exhibit a preference for nest site aspect. It has been suggested that this characteristic of nest site influences levels of protection, levels of soil moisture in nesting microenvironment, and overall stand structure (Reynolds *et al.* 1982, Crocker-Bedford and Chaney 1988, Crocker-Bedford 1994). In studies which concluded that Northern Goshawks exhibit a preference for nest site aspect, north facing sites are generally preferred in the more southern parts of the Northern Goshawk range (Colorado - Shuster 1980, Oregon - Reynolds *et al.* 1982, California - Hall 1984, Arizona - Crocker-Bedford and Chaney 1988, Idaho - Hayward and Escano 1989, Arizona - Ingraldi and MacVean 1994). This may be owing to the fact that northern aspects receive less solar radiation, and thus have greater soil moisture which results in greater leaf areas (Reynolds *et al.* 1982). Additional leaf area could contribute to the protection of Northern Goshawk nest sites and could result in cooler temperatures during the breeding season, and could result in reduced understory vegetation (Reynolds *et al.* 1982, Hall 1984). The preference for nest site aspect has been noted to change to southern aspects in the more northern parts of the Northern Goshawk range (Alaska - McGowan 1975), although the use of southern aspects may have been related to the distribution of white birch and trembling aspen trees in that part of the Northern Goshawk range.

We inferred habitat selection among Northern Goshawks within stands used for nesting by comparing nest sites with random contrast sites. The lack of difference between the nest areas and contrast areas with regard to distribution of live and dead stem diameters and the eight vegetation characteristics tested suggests that Northern Goshawks do not select particular microhabitats in the deciduous-dominated mixedwood stands in central Alberta. There are differences between the design of this study and investigations of habitat selection from other parts of the range of the Northern Goshawk, and this hampers direct comparisons of the study

Table 2.1 - Area searched (ha) and stick nests (# in brackets) on the Foothills Model Forest 1995 - 1996 by forest cover type.

Survey Technique	Lodgepole Pine	White Spruce	Black Spruce	Coniferous-dominated Mixedwood	Trembling Aspen	Deciduous-dominated Mixedwood
Silent Searches 1995	38.0(0)	5.0(0)		78.3(0)		129.1(2)
Broadcast Surveys 1995	136.8(0)	28.3(0)		129.5(0)	127.1(0)	193.1(0)
Silent Searches 1996	671.5(0)	170.8(0)	163.0(0)	73.1(3)	458.6(3)	884.2(10)
Broadcast Surveys 1996				14.1(0)	35.4(0)	21.2(0)
TOTAL	846.3	204.1	163.0	295.0	621.1	1227.6
% of TOTAL	25.2	6.1	4.9	8.8	18.5	36.6

Table 2.2 - Comparison of Northern Goshawk nest trees to nest stands in central Alberta.

Habitat Variables	Nest Sites (n=17)		Nest Stands (n=17)		Wilcoxon Matched-Pairs Test Statistic	*P*-value
	Mean	S.E.	Mean	S.E.		
Tree Height (m)	22.65	0.60	20.98*	0.52	-2.6273	0.0086
Tree DBH (cm)	30.35	1.34	19.68**	0.77	-3.5740	0.0004

* - average of 25 trees/nest area.

** - average of all stems >5 cm DBH in the nest area.

Table 2.3 - Comparison of Northern Goshawk nest sites and contrast sites in central Alberta.

Nest Site Variable	Nest Site (n=17)		Contrast Sites (n=17)		*P*-value- Wilcoxon Matched Pairs Test
	Mean	S.E.	Mean	S.E.	
Average Height of Overstory (m)	21.0	0.52	21.2	0.49	0.5699
Average DBH (cm)	19.7	0.77	19.7	0.75	0.8684
Total Canopy Closure (%)	77.4	1.68	72.9	1.79	0.0312
Volume of Downed Woody Debris (m^3)	4.9	0.62	5.3	0.75	0.4925
Live Basal Area (m^2/ha)	5.6	0.26	5.3	0.42	0.4631
Total Herb Coverage (%)	36.0	2.47	34.7	2.18	0.9058
Total Shrub Coverage (%)	45.4	4.06	44.8	3.49	0.9058
Total Basal Area (m^2/ha)	6.4	0.26	6.3	0.39	0.6874

Table 2.4 - Frequency of live and dead stems by DBH class (cm) at Northern Goshawk nest areas and contrast areas.

Sampling Area	All Trees	Live Trees by DBH class (cm)					All Live Trees	Dead Trees by DBH Class (cm)			All Dead Trees
		<5.0	5.0-14.9	15.0-24.9	25.0-34.9	>35.0		5.0-14.9	15.0-24.9	>25.0	
Nest Area	1980	285	314	164	34	797	1041	162	68	12	243
Contrast Area	1784	275	303	146	42	763	1041	181	78	18	277

Table 2.5 - Average canopy closure for Northern Goshawk nest stands (%).

Location	Canopy Closure (%)	Sample Size	Method of Measurement	Source
Alberta, central	77.4	17	Spherical densiometer	this study
Arizona	76.0	36	Spherical densiometer	Crocker-Bedford and Chaney (1988)
California, N.W.	94.0	10	Spherical densiometer	Hall (1984)
Montana - Idaho	80.0	17	Spherical densiometer	Hayward and Escano (1989)
New Mexico	65.7	42	Spherical densiometer	Siders and Kennedy (unpubl. data)
New York - New Jersey	90.0	16	Ocular sighting tube	Bosakowski *et al.* (1992)
Oregon, E.	59.8	7	Ocular estimate	Reynolds *et al.* (1982)
Wyoming	66.7	39	Line-intercept sampling	Squires and Ruggiero (1996)

Figure 2.3 - Northern Goshawk nest area in a deciduous-dominated stand (photo by W. Schaffer).

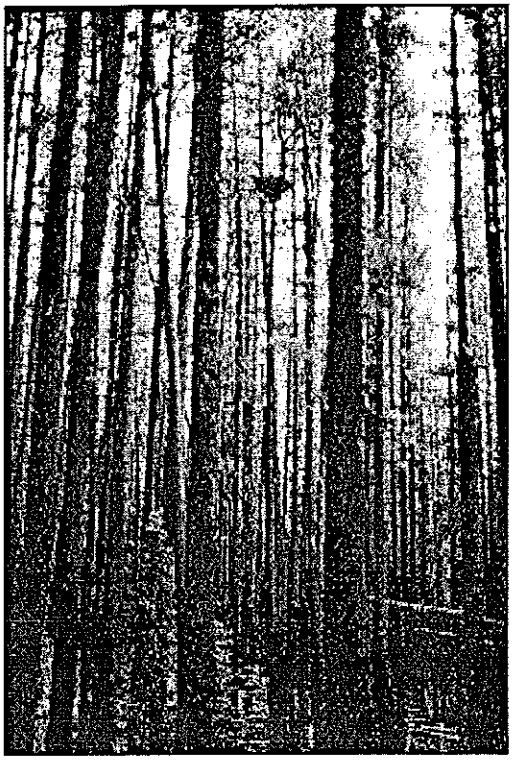

Figure 2.4 - Northern Goshawk nest area in a coniferous-dominated stand (photo by W. Schaffer).

2.7 LITERATURE CITED

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biased and the analysis of prey use data from studies employing indirect methods should reflect this bias (Marti 1987, Simmons *et al.* 1991, Bielefeldt *et al.* 1992).

The diet and habitat use of Northern Goshawks has been investigated in various locales (see reviews by Jones 1979, Reynolds *et al.* 1992, and Squires and Reynolds 1997). Reynolds and Meslow (1984) combined information on prey use with descriptions of the life history of prey species to examine partitioning of microhabitat resources, and differences in foraging strategies within the genus *Accipiter*. Few studies have examined Northern Goshawk foraging habitat, and foraging habitat-use preferences are poorly understood in North America (Bright-Smith and Mannan 1994, Squires and Reynolds 1997).

I investigated prey use by Northern Goshawks during the breeding season (nests active 1993-1996) in deciduous-dominated (*Populus*-dominated) mixedwood forest stands distributed across central Alberta. Data were collected from nests in west-central Alberta (around the town of Hinton), and in east-central Alberta (around the city of Edmonton). The data from the direct sampling technique (nest observation - employed in the western study area) was used to characterize Northern Goshawk diet. Data from an annual survey of trappers in the province of Alberta was used to provide information on the status of Snowshoe Hare populations during the study years. In a development of the approach taken by Reynolds and Meslow (1984), I used information on the microhabitat associations of Northern Goshawk prey species, combined with knowledge of Northern Goshawk hunting tactics in order to draw inferences on the characteristics of Northern Goshawk foraging environments. Owing to the differences in the distribution of prey species across the province (Flack 1976, Erskine 1977), the prey use data gathered by indirect sampling techniques was divided according to study area. Northern Goshawk diet as determined by indirect sampling was compared in the western and eastern study areas by testing for differences in the relative contribution of key prey species.

3.2 STUDY AREA

A detailed study area description is found in section 2.2.

a weight that was one-half the adult weight (Reynolds *et al.* 1994). Prey items that were identified only to genus were assigned the average body mass for individuals of that genus that were recorded as prey in this study. Unidentified prey items were assigned the average body mass of prey from that taxa as recorded by this study (Joy *et al.* 1994).

3.3.2 Prey Population Status - Questionnaire of Registered Trappers

Information on the status of Snowshoe Hare populations was compiled from the data gathered by a questionnaire circulated annually (1988-1995) to registered trappers in the province of Alberta (A.E.P. 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995). The questionnaire was designed to gather subjective information on the status of furbearers and game animals based on observations made during trapping. A status index for each survey year was computed by subtracting the percentage of respondents that indicated that Snowshoe Hares were scarce from the percentage of respondents that indicated that Snowshoe Hares were abundant (A.E.P. 1994). The number of respondents in the Eastern Slopes survey area (which contains the western study area) varied from a minimum of 202 respondents (1995) to a maximum of 300 respondents (1988). The total number of respondents in the province of Alberta varied from a minimum of 795 respondents (1995) to a maximum of 1455 respondents (1989).

3.3.3 Diet Characterization and Prey Description - Direct Sampling Technique

Prey use data gathered by direct sampling techniques (nest observation - employed on the western study area) was used to characterize Northern Goshawk diet. Prey were categorized based on the size classes of body mass in Storer (1966). These categories were designed for *Accipiter* diet studies, and they arrange prey species of similar form in categories differing by a constant increase in linear measurements (Storer 1966). Prey species were described based on their foraging position in four height zones (ground-shrub, shrub-canopy, canopy, aerial) following the design presented in Reynolds and Meslow (1984) based on published accounts of life histories (Banfield 1974, Kaufman 1996). It was assumed that the prey occupied this position in the forest when detected by the Northern Goshawk. Prey species that could not be assigned to one zone were classified as a generalist (Reynolds and Meslow 1984). Information on the foraging position of Northern Goshawk prey from the direct sampling techniques was combined with information on the foraging behaviour of Northern Goshawks to construct a description of the Northern Goshawk foraging environment in the western study area.

(by biomass). During daylight hours, Northern Goshawk prey were typically found in the ground-shrub layer of vegetation (67.84% of prey; Table 3.2).

3.4.2 Status of Snowshoe Hares - Results from Survey of Trappers

Questionnaire results from the Eastern Slopes survey area and the province of Alberta show similar trends for changes in the status index for Snowshoe Hares. The status index exhibits a gradual increase through the years 1988-1990, and a sharp decrease in the years 1991-1993, with a slight increase in the years 1994-1995 (Figure 3.2).

3.4.3 Diet Comparison - Indirect Sampling Techniques

In the western study area, a total of 49 prey items were identified from 66 pellets and 34 prey remain collections (Table 3.3). Snowshoe Hare (41.49%), Ruffed Grouse (21.43%), Red Squirrel (13.43%), Spruce Grouse (*Falcipennis canadensis*; 5.87%), and Blue Grouse (*Dendragapus obscurus*; 4.29%) comprised the majority of Northern Goshawk diet (by biomass; Appendix 5). In the eastern study area, a total of 49 prey items were identified from 74 pellets and 16 prey remain collections (Table 3.4). Snowshoe Hare (28.47%), Mallard (*Anas platyrhynchos*; 18.69%), Ruffed Grouse (18.30%), Richardson's Ground Squirrel (*Spermophilus richardsonii*; 10.98%), and Red Squirrel (4.30%) comprised the majority of Northern Goshawk diet (by biomass; Appendix 6). There was no difference in the relative proportion of Snowshoe Hare, Ruffed Grouse, and Red Squirrel in Northern Goshawk diet in the two study areas (Pearson Chi-square = 2.0968, $0.75<P<0.50$).

The indirect sampling found that certain prey formed a portion of Northern Goshawk diet in only one study area:

- prey unique to Northern Goshawk diet in the western study area were Pika (*Ochotona princeps*), Blue Grouse, Spruce Grouse, Pileated Woodpecker, Northern Flicker (*Colaptes auratus*), Three-toed Woodpecker (*Picoides tridactylus*), Gray Jay (*Perisoreus canadensis*), Black-throated Green Warbler (*Dendroica virens*);
- prey unique to Northern Goshawk diet in the eastern study area were Richardson's Ground Squirrel, Green-winged teal (*Anas crecca*), Blue-winged Teal (*Anas discors*), Mallard, Northern Shoveler (*Anas clypeata*), Sharp-shinned Hawk, Yellow-bellied Sapsucker (*Sphyrapicus varius*), Blue Jay (*Cyanocitta cristata*), Black-billed Magpie (*Pica pica*).

eastern study areas are consistent with other studies (Schnell 1958, Root and DeSimone 1978, Reynolds and Meslow 1984, Palmer 1988, Bosakowski and Smith 1992b, Boal and Mannan 1994, Reynolds *et al.* 1994). The diet breadth could arise due to the sexual size dimorphism exhibited by Northern Goshawks (Storer 1966, Snyder and Wiley 1976), changes in Northern Goshawk prey choice to partially deal with cyclical or low density of prey populations (Schoener 1969, Newton 1976, Hamerstrom 1979, Linden and Wikman 1983, Boal and Mannan 1994) or may be a reflection of the changes in prey availability over the course of the breeding season due to timing of hibernation, fledging, inactivity, and migration in prey species (Schnell 1958, Snyder and Wiley 1976, Steenhof and Kochert 1988, Reynolds *et al.* 1992, Jacobsen and Sonerud 1993, Younk and Bechard 1994, Tornberg 1997). Northern Goshawk predation can depress certain prey populations (Eng and Gullion 1962), but the use of a wide variety of prey species has the effect of spreading out the impact of predation (Snyder and Wiley 1976).

There was no difference in the relative contribution of key prey species (Snowshoe Hare, Red Squirrel and Ruffed Grouse) between the two study areas. Heavy use of these species in central Alberta could represent selection of prey species that are present year-round (Storer 1966, Widen 1984). Information from the questionnaire completed by trappers in the province of Alberta indicates that Snowshoe Hares reached a peak abundance in 1990, and were moderately abundant during the study years. These findings are agreement with observations on the status of Snowshoe Hares in the Yukon (Mowat *et al.* 1996), and Wisconsin (Erdman *et al.* 1998), and are consistent with the 10-year cycle observed to operate in these populations (Keith 1963). Scientific investigations have found a high degree of synchrony between the cycle of Snowshoe Hares and Ruffed Grouse (Keith *et al.* 1977, Mueller *et al.* 1977). There may be a shift in the diet of Northern Goshawks towards alternative prey during years of lower abundance of Snowshoe Hares and Ruffed Grouse (Doyle and Smith 1994).

3.5.4 Northern Goshawk Hunting

The predominant hunting technique used by Northern Goshawks involves scanning for prey and initiating attack from frequently changed perches (the short-sit-and-wait-short-flight technique) (Kenward 1982, Widen 1984, Fischer 1986). Surprise attack is sudden and swift, although reckless pursuit of the quarry may occur (Duncan and Kirk 1994, Squires and Reynolds 1997). Other hunting is undertaken on the wing with prey already in flight (Kenward 1982, Widen 1985), by flushing prey (Widen 1984, Johnsgard 1990), or by pursuing prey on foot (Schnell 1958, Brown and Amadon 1968, Jones 1979, Bergstrom 1985). Northern Goshawk hunting

interspersion of habitat age classes could provide areas where prey populations will thrive (younger age classes of forest), adjacent to areas where prey are available to the Northern Goshawks (older age classes of forest).

Table 3.3 - Diet of Northern Goshawks on the western study area as detected by the indirect sampling techniques.

Prey Species	Frequency of Prey Species				Diet Composition
	Pellets	Prey Remains	Other Sightings	Total	Percent of Total Biomass
MAMMALS	14	7	5	26	61.5
Snowshoe Hare *(Lepus americanus)*		5	2	7	41.49
Snowshoe Hare (immature) *(Lepus americanus)*		2		2	5.93
Pika *(Ochotona princeps)*	1			1	0.57
Red Squirrel *(Tamiasciurus hudsonicus)*	12		3	15	13.43
Unidentified Microtine	1			1	
BIRDS	11	10	2	23	56.25
Blue Grouse *(Dendragapus obscurus)*		1		1	4.29
Spruce Grouse *(Falcipennis canadensis)*	3			3	5.87
Ruffed Grouse *(Bonasa umbellus)*		8	1	9	21.43
Pileated Woodpecker *(Dryocopus pileatus)*			1	1	1.19
Northern Flicker *(Colaptes auratus)*	1			1	0.46
American Robin *(Turdus migratorius)*		1		1	0.32
Hermit Thrush (Catharus guttatus)	1			1	0.13
Black-throated Green Warbler (Dendroica virens)	1			1	0.04
Unidentifed Passerine	1			1	0.19
Unidentified bird	4			4	4.53
TOTAL PREY	25	17	7	49	100.00

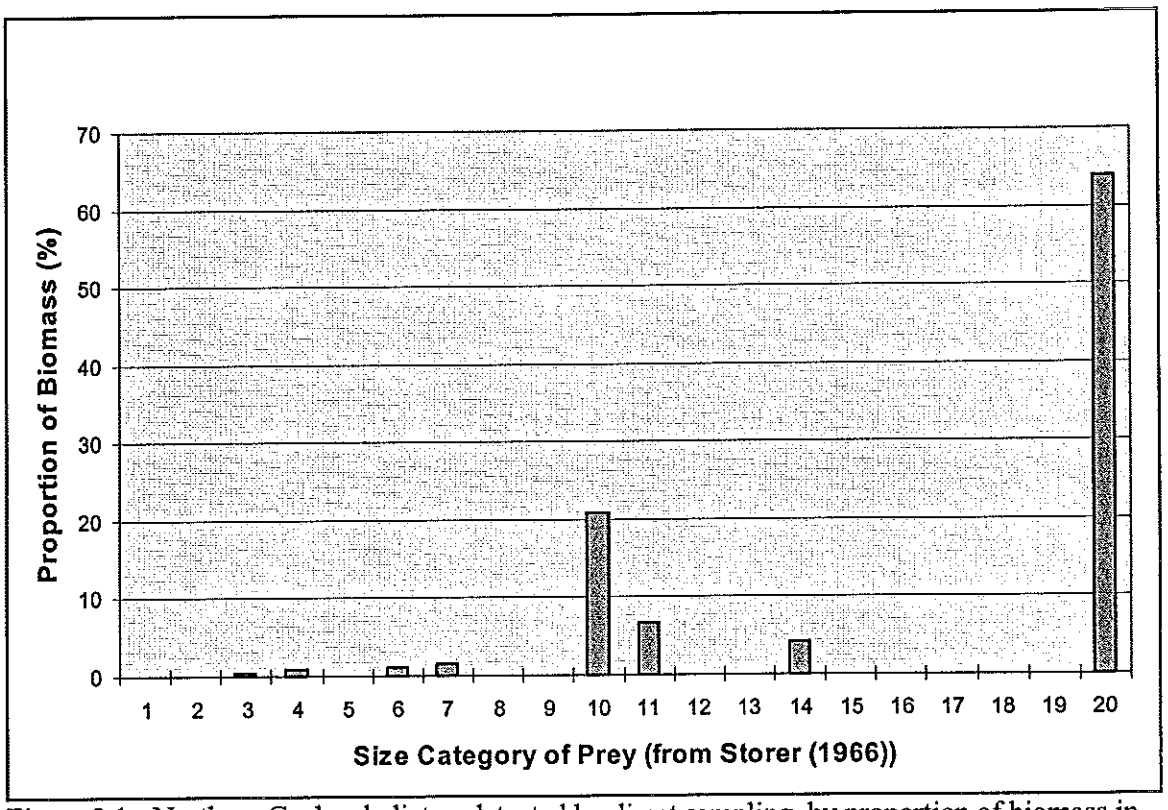

Figure 3.1 - Northern Goshawk diet as detected by direct sampling, by proportion of biomass in size classes presented in Storer (1966).

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4.0 Northern Goshawk (*Accipiter gentilis*) Habitat Management in central Alberta

4.1 INTRODUCTION

This study is the first to examine the habitat requirements of Northern Goshawks in the Parkland and Boreal Forest Ecoregions of Alberta. At present, forest harvesting for logging, seismic exploration and agricultural development represents the major cause of anthropogenic disturbance for forest-dwelling animals in central Alberta (Clark 1988, Farr 1992, Thompson and Welsh 1993, Lieffers and Beck 1994). Investigations have identified that Northern Goshawks are vulnerable to habitat fragmentation in the vicinity of nest sites (Woodbridge 1988, Patla 1990, Woodbridge and Detrich 1994, Erdman *et al.* 1998), and are sensitive to disturbance during the nesting season (Fyfe and Olendorff 1976, McCarthy *et al.* 1989).

The habitat conservation methods suggested herein are conservative, and this reflects the current lack of information on the size and composition of home ranges for adult and immature Northern Goshawks in central Alberta, and on the response of Northern Goshawks to habitat fragmentation in the Parkland and Boreal Forest Ecoregions. The habitat conservation methods should be adopted as an interim minimum acceptable standard for wildlife management in the province of Alberta (see sections 4.2 and 4.4). Effective Northern Goshawk habitat management will require participation and cooperation by forest industry, and representatives from the federal and provincial governments, and could utilize local field-naturalists as a volunteer workforce. It is recognized that at present, the majority of forest management planning in central Alberta is based on remotely sensed information (i.e. forest inventory, hydrology information) that does not attempt to intensively sample forest conditions.

Interim management strategies for Northern Goshawk populations in central Alberta should be directed towards:

- conserving habitat for Northern Goshawks at the microsite level (active nest sites);
- conserving habitat for Northern Goshawks at the landscape level (future nest sites, and foraging areas around nest sites);
- educating resource management personnel and forestry workers on the value, function, and appearance of Northern Goshawks and other woodland raptors; and
- conducting further research.

the breeding season for adults and newly fledged young (Crocker-Bedford and Chaney 1988, Reynolds *et al.* 1992).

In order to provide habitat for future Northern Goshawk nest areas, and to ensure the provision of foraging habitat in association with nest areas, certain stands of deciduous-dominated mixedwood should be managed to attain mature and old forest attributes (Reynolds *et al.* 1982, Nyberg *et al.* 1987, Reynolds 1989, Squires and Ruggiero 1996). Characteristics that are associated with mature deciduous-dominated forest include: closed canopy, multiple canopy layers, canopy gaps, large standing and fallen dead trees, and multiple ages of trees (Mehl 1992, Moir 1992). Efforts in this regard include lengthening the timber harvest rotation for certain stands to allow them to develop structural characteristics required by wildlife species dependent on mature and older seral stages of forest (Hansen *et al.* 1991, Crocker-Bedford 1994, Squires and Ruggiero 1996). At present, the rotation length for deciduous-dominated mixedwood management in Alberta is 60 years (Henderson 1988). Logging is typically undertaken on a two-pass clear-cut system with cut-blocks ranging from 20-40 ha in size (Nietfeld and Stelfox 1992, Stelfox 1995). Mature trembling aspen dominated stands average 95 years of age in the Rocky Mountain region of the United States (Shepperd and Engelby 1983). At 100 years of age trembling aspen stands start to break up, and there is an increased component of conifer regeneration (Mueggler 1985, Telfer 1992). A timber harvest rotation of at least 110 years will allow the development mature trembling aspen forest, and formation of structural attributes (i.e. large trees, closed canopies, open understories) that are important for Northern Goshawk nesting and foraging areas. Until information on Northern Goshawk post-fledging movements, and home range size of becomes available (see section 4.4), the minimum area to be conserved for future Northern Goshawk nesting areas should be 170 hectares. Forest harvesting blocks should be arranged to ensure minimal isolation of Northern Goshawk nest areas from adjacent areas of mature and old seral stage forest (Kennedy 1988).

4.3 RAPTOR EDUCATION

An education program should be established to increase awareness of the appearance, importance and management concerns surrounding Northern Goshawk populations amongst wildlife managers, forestry workers, forest managers and the general public (Postovit and Postivit 1987, Hammond and Bradley 1992, Thompson and Welsh 1993). This approach has worked effectively within the forestry sector in Canada on issues such as provision for snag trees

and by describing the habitat conditions in Northern Goshawk nest areas. Variables to be included in this analysis should be:

- those that were found to influence *Accipiter* nest placement in other parts of North America: distance to water, distance to nearest roadway, distance to nearest opening, and type of opening (Falk and Stauffer 1989, Bosakowski *et al.* 1992, Bosakowski and Speiser 1994);
- those characteristics of macrohabitat that have been identified as having the strongest influence on *Accipiter* nesting habitat selection: interspersion of cover types, area of the habitat patch (Reynolds *et al.* 1982, Bosakowski *et al.* 1992, Schaffer *et al.* 1996); and
-those descriptors of macrohabitat patches that are used in published studies of habitat fragmentation: perimeter to area ratio, and index of patch isolation (Forman and Godron 1986, Turner 1989, Harrison and Fahrig 1995).

Additional information can be obtained by evaluating the composition of the nesting habitat at certain distances from the Northern Goshawk nest (Ripple *et al.* 1991, Hunter *et al.* 1995, Kimmel 1995).

4.4.3 Nest Monitoring

A monitoring program should be established to evaluate the effects of forestry operations on Northern Goshawk nest occupation and productivity (Robinson 1989). A nest monitoring program developed for Cooper's Hawk and Red-shouldered Hawk (*Buteo lineatus*) populations in Ontario (Szuba 1990) could be used as a guide for the nest monitoring protocols. Monitoring should be conducted as part of a long term study and will involve the direct manipulation of the habitat conditions around raptor nest sites by forest harvesting, with nest location work and productivity monitoring (Szuba 1990). The area of no-harvest buffer zones around Northern Goshawk nests could be modified to reflect the findings on minimum habitat conditions from nest site monitoring. Raptor banders could make yearly visits to nest sites to band Northern Goshawks, and to provide data on nest productivity. The use of colour bands by raptor banders could aid in the investigation of nest site fidelity (Detrich and Woodbridge 1994, Reynolds *et al.* 1994).

Table 4.1 - Recommended management area for provision for Northern Goshawk nest sites.

Location	Area (ha.)	Radius (m)	Source
United States	50.0 - 80.0	400.0 - 500.0	Jones 1979
Oregon	8.0	160.0	Reynolds *et al.* 1982
western United States	8.0	160.0	Reynolds 1983
New Mexico	20.0	250.0	Kennedy 1988
Arizona	>8.0	>160.0	Crocker-Bedford and Chaney 1988
New Hampshire	50.0	400.0	Lanier and Foss 1989
California	50.0	400.0	McCarthy *et al.* 1989
southwestern United States	12.0	200.0	Reynolds *et al.* 1992
New Mexico	10.0	180.0	Kennedy *et al.* 1994

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Appendix 1 (continued)
Vegetation variables recorded during Northern Goshawk nest area vegetation surveys.

1) Site Position - Macro
- 1 - Apex
- 2 - Upper Slope
- 3 - Middle Slope
- 4 - Lower Slope
- 5 - Valley Floor
- 6 - Plain
- 7 - Plateau

2) Site Position - Meso
- 1 - Crest
- 2 - Upper Slope
- 3 - Middle Slope
- 4 - Lower Slope
- 5 - Toe
- 6 - Depression
- 7 - Level

3) Surface Shape
- 1 - Straight
- 2 - Concave
- 3 - Convex

4) Soil Drainage
- 1 - Rapid
- 2 - Moderate
- 3 - Poor

5) Flood Hazard
- 1 - No hazard
- 2 - Rare
- 3 - May be expected
- 4 - Frequent

6) Slope (in degrees)
7) Aspect (in degrees)
8) Tree Height for 5 dominant overstory trees
9) Number of canopy layers
10) Dominant species in canopy
11) Dominant species in subcanopy
12) Dominant sapling species
13) Shrub coverage (%) in height classes:
>2.5 m, 1-2.5 m, <1 m
14) Herb coverage (%)
15) Grass/Sedge coverage (%)
16) Litter coverage (%)
17) Mineral coverage (%)
18) Moss coverage (%)
19) Lichens/Fungi coverage (%)
20) Downed Wood coverage (%)
21) Total Canopy Closure (%)
22) Number of Seedlings
23) Tree Description
a) Tree Species
b) Tree Type
- T - Tree
- S - Stub
- N - Snag

c) Distance of tree to plot centre (m)
d) Diameter at breast height of tree (cm)
e) Lean (in degrees)
f) Condition of trees
- 0 - Healthy
- 1 - Leaf/Needle Loss
- 2 - Dieback

g) Condition of Snags/Stubs
- 1 - Fresh/Recently Dead
- 2 - Hard/Dead a short time
- 3 - Hard/Dead a few years
- 4 - Hard/Many years dead
- 5 - Soft
- 6 - Decomposed

g) Damage
- 0 - None
- 1 - Insects
- 2 - Falling/breakage
- 3 - Animal
- 4 - Other

h) Animal Cavities
- 0 - None
- 1 - Present

24) Dead and Downed Wood
a) log length (m)
b) log base (cm)
c) log tip (cm)
d) log condition
1- Fresh
- 2 - Hard
- 3 - Soft
- 4 - Rotten or Punky
- 5 - Becoming part of the ground.

Appendix 2 (continued)
Search effort for Northern Goshawk territories on the Foothills Model Forest - 1996.

Method	Date	Area (ha.)	Observations
Silent Search	Feb 8/96	538.0	1 stick nest
Silent Search	Feb 20/96	314.0	2 stick nests
			1 Merlin (*Falco columbarius*)
Silent Search	Mar 5/96	314.0	2 stick nests
Silent Search	Mar 8/96	314.0	1 stick nest
			1 Northern Goshawk (*Accipiter gentilis*)
Silent Search	Mar 13/96	29.0	none
Silent Search	Mar 19/96	4.8	none
Silent Search	Mar 21/96	270.0	1 stick nest
			1 Red-tailed Hawk (*Buteo jamaicensis*)
Silent Search	Mar 23/96	60.3	1 Northern Goshawk (*Accipiter gentilis*)
Silent Search	Apr 5/96	4.8	none
Silent Search	Apr 6/96	18.0	none
Silent Search	Apr 11/96	13.0	1 Northern Hawk Owl (*Surnia ulula*)
Silent Search	Apr 15/96	19.3	none
Silent Search	Apr 16/96	40.0	none
Silent Search	Apr 16/96	33.3	none
Silent Search	Apr 19/96	2.0	1 Northern Goshawk (*Accipiter gentilis*)
Silent Search	Apr 21/96	18.0	none
Silent Search	Apr 26/96	5.4	none
Silent Search	Apr 26/96	39.7	none
Silent Search	May 3/96	40.9	none
Silent Search	May 8/96	9.6	1 Merlin (*Falco columbarius*)
Silent Search	May 15/96	42.3	1 Red-tailed Hawk (*Buteo jamaicensis*)
			1 Golden Eagle (*Aquila chrysaetos*)
			1 Northern Goshawk (*Accipiter gentilis*)
			1 Unidentified raptor
Silent Search	May 16/96	2.0	2 stick nests
Silent Search	May 16/96	11.2	1 stick nest
Silent Search	May 17/96	15.8	none
Silent Search	May 21/96	27.5	1 Sharp-shinned Hawk (*Accipiter striatus*)
Silent Search	Jun 3/96	105.0	1 Northern Goshawk (*Accipiter gentilis*)
Silent Search	Jun 5/96	72.0	none
Silent Search	Jun 6/96	6.4	1 Red-tailed Hawk (*Buteo jamaicensis*)
			2 stick nests
Silent Search	Jun 8/96	22.5	1 Northern Goshawk (*Accipiter gentilis*)
			1 stick nest
Silent Search	Jun 10/96	8.0	1 Red-tailed Hawk (*Buteo jamaicensis*)
Silent Search	Jun 11/96	10.1	1 stick nest
Silent Search	Aug 25/96	10.0	2 stick nests
TOTAL		**2421.0**	
Broadcast Surveys	Jun 14/96	70.7	none
TOTAL		**70.7**	

Appendix 4 - Northern Goshawk nest tree characteristics (nests active 1952-1997).

Nest	Tree Species	Year Occupied	Nest tree DBH (cm)	Nest tree ht. (m)	Nest ht. (m)	% Nest Height	Nest Placement	# of Supporting branches	# of Canopy Layers	Flight Corridor (Present/Absent)
A1	*Populus tremuloides*	1994, 1996, 1997	32.5	24.9	15.3	61.4	Primary branch fork at crown base	5	2	Present
A2	*Populus tremuloides*	1995	25.3	21.0	15.3	72.9	Primary branch fork at crown base	5	2	Present
B1	*Populus tremuloides*	1995	24.4	19.5	12.0	61.5	Primary branch fork at crown base	6	2	Present
C1	*Populus tremuloides*	1995	39.4	24.0	15.9	66.3	Primary branch fork in tree crown	5	3	Present
D1	*Populus balsamifera*	1996	35.6	25.8	14.7	57.0	Primary branch fork at crown base	3	2	Present
E1	*Populus tremuloides*	1996	37.3	28.0	14.6	52.0	Primary branch fork at crown base	6	2	Present
F1	*Populus tremuloides*	1995	25.2	25.8	16.2	62.8	Primary branch fork at crown base	4	1	Present
F2	*Populus tremuloides*	1996	25.9	20.7	14.1	68.1	Primary branch fork at crown base	5	1	Present
F3	*Populus tremuloides*	1994	26.2	19.8	17.4	87.9	Primary branch fork at crown base	5	2	Present
F4	*Populus tremuloides*	1997	27.1	19.5	14.7	75.4	Primary branch fork at crown base	3	2	Present
G1	*Populus tremuloides*	1993	38.9	21.0	10.8	51.4	Primary branch fork in tree crown	5	2	Present
H1	*Populus tremuloides*	1994, 1995	33.0	24.9	16.5	66.3	Primary branch fork at crown base	5	2	Present
I1	*Populus tremuloides*	1996	30.8	21.0	15.0	71.4	Primary branch fork at crown base	5	2	Present
I2	*Populus tremuloides*	1995	34.6	21.0	12.9	61.4	Primary branch fork at crown base	6	2	Present
I3	*Populus tremuloides*	1997	23.0	18.3	13.8	75.4	Primary branch fork in tree crown	3	2	Present
J1	*Populus tremuloides*	1994	21.2	21.0	15.0	71.4	Primary branch fork at crown base	3	2	Present
J2	*Populus tremuloides*	1991,1993	25.1	18.0	13.0	72.2	Primary branch fork at crown base	6	2	Present
K1	*Populus balsamifera*	1996	28.0	21.0	13.8	65.7	Primary branch fork at crown base	4	2	Present
K2	*Populus tremuloides*	1993	26.9	22.2	13.5	60.8	Primary branch fork at crown base	4	1	Present
K3	*Populus tremuloides*	1995								

Appendix 5 - Weights of Northern Goshawk prey in the western study area.

Prey Species	Individual Biomass (g)[a]
MAMMALS	
Snowshoe Hare *(Lepus americanus)*	1435.00
Snowshoe Hare (immature) *(Lepus americanus)*	717.50
Red Squirrel *(Tamiasciurus hudsonicus)*	216.82
Bushy-tailed Woodrat *(Neotoma cinerea)*	335.10
Meadow Vole *(Microtus pennsylvanicus)*	31.00
Pika *(Ochotona princeps)*	138.05
Unidentified microtine	31.00
BIRDS	
Blue Grouse *(Dendragapus obscurus)*	1039.50
Spruce Grouse *(Falcipennis canadensis)*	474.00
Ruffed Grouse *(Bonasa umbellus)*	576.50
Pileated Woodpecker *(Dryocopus pileatus)*	287.00
Northern Flicker *(Colaptes auratus)*	111.00
Three-toed Woodpecker *(Picoides tridactylus)*	65.65
Gray Jay *(Perisoreus canadensis)*	71.10
American Robin *(Turdus migratorius)*	77.30
Hermit Thrush *(Catharus guttatus)*	31.00
Black-throated Green Warbler *(Dendroica virens)*	8.80
Unidentified passerine	47.05
Unidentified bird	274.19

[a] - based on information found in Steenhof 1983, Dunning 1984, Smith 1993, and M. Wheatley, University of Alberta, unpublished data.

Appendix 7 - Additional Northern Goshawk prey use information from central Alberta, compiled from Pileated Woodpecker study, sightings and records of raptor banders.

Prey Species	Frequency in Diet
MAMMALS	**17**
Snowshoe Hare (*Lepus americanus*)	8
Richardson's Ground Squirrel (*Spermophilus richardsonii*)	5
Red Squirrel (*Tamiasciurus hudsonicus*)	2
Muskrat (*Ondratra zibethica*)	1
Unidentified microtine	1
BIRDS	**27**
Sharp-shinned Hawk (*Accipiter striatus*)	1
Gray Partridge (*Perdix perdix*)	2
Ruffed Grouse (*Bonasa umbellus*)	7
Great Gray Owl (*Strix nebulosa*) (immature)	2
Northern Saw-whet Owl (*Aegolius acadicus*)	1
Pileated Woodpecker (*Dryocopus pileatus*)	8
American Crow (*Corvus brachyrhynchos*)	1
Varied Thrush (*Ixoreus naevius*)	1
European starling (*Sturnus vulgaris*)	1
Domestic chicken (*Gallus gallus*)	2
Domestic turkey (*Meleagris gallopavo*) (immature)	1
Total PREY	**44**