Photo by Wayne Lynch

# NORTHERN GOSHAWK HABITAT CHARACTERIZATION IN THE FOOTHILLS MODEL FOREST

Warren Schaffer
Department of Renewable Resources
7-51 General Services Building
University of Alberta
EDMONTON, Alberta
T6G 2H1

Annual Report 1995

ABSTRACT

The following presents first year data from a project designed to determine the elements of habitat critical for northern goshawk (*Accipiter gentilis*) nesting and foraging on the Foothills Model Forest area of Alberta, Canada, and to use this information to refine a Habitat Suitability Index model for the goshawks. The project methodology entailed efforts to locate, capture, and radiomonitor goshawks, to sample their nesting habitat, and their prey use. In the first field season of this study, seventeen stick nests were checked for goshawk occupancy. Eight nests were occupied, two by goshawks and three others by other raptor species. Efforts to locate goshawks sampled 938 hectares of habitat, this resulted in one goshawk location, and the location of thirteen individuals of eight other raptor species. Mist netting resulted in the capture and radiotagging of one goshawk. Drop-lid trapping resulted in the capture and radiotagging of two goshawks, and the capture of five individuals of three other raptor species. Thirty-eight radiotelemetry locations have been taken on the three radiotagged goshawks. Observation at the three goshawk nests (one active 1994, two active 1995), and the location of kill sites resulted in the identification of thirteen prey items. Sampling for prey populations will commence in the winter of 1995-1996. Vegetation sampling was conducted at the three goshawk nests. First year conclusions of this study are as follows: goshawks select large aspen trees for nest placement; goshawk nesting stands exhibit a forest cover of deciduous-dominated mixedwood; goshawks forage in a variety of habitats; goshawk diet is dominated by mammals.

ACKNOWLEDGEMENTS

The author wishes to recognize the financial contribution of the following organizations to this work:

Foothills Model Forest
Canadian Wildlife Service
Canadian Circumpolar Institute
Alberta Sport, Recreation, Parks and Wildlife Foundation
Millennium III Enterprises Incorporated
Alberta Fish and Wildlife Services
Student Temporary Employment Program
Summer Employment/Experience Development Program.

The author wishes to recognize the contribution of the following individuals to the design and execution of this work:

Dr. Geoff Holroyd
Dr. Gordon Court
Lisa Takats
Dr. Dan Farr
Dr. Jim Beck
Rick Bonar
Hardy Pletz
Ray Cromie
Trevor Roper
Dr. Susan Hannon
Dr. Brian Naylor
Dr. Barb Beck
Dr. Wayne Lynch
Mark Piorecky
Ben Olsen
Jim Herbers
Marg Lomow
Paul Jones
Eloise Pulos
Jody Watson
Matt Wheatley
Dean Jewison
Kent McDonald
Marianne Gibbard
Carrie Melanson
Jason Duxbury
Sue Cotterill
Karen Graham
Laurie Hunt
Elsabe Kloppers.

## TABLE OF CONTENTS



## LIST OF TABLES



## LIST OF FIGURES

## INTRODUCTION

The Foothills Model Forest (FMF) was established in 1992 as a cooperative initiative of the Government of Canada, Weldwood of Canada Ltd., the Alberta Environmental Training Center (Hinton, Alberta), Alberta Department of Environmental Protection, and Jasper National Park. Its mission is "to develop and recommend an approach to sustainability and integrated resource management through research and technology developed by means of collaborative partnerships". There are currently 40 research projects underway in the FMF. The objective of the wildlife research projects is to gain a better understanding of the habitat requirements of various wildlife species in the FMF.

Habitat suitability index models have been recognized as valuable modeling tools for management decision-making on forested areas (Bonar 1991, Greig *et al.* 1991, Patch 1987). These tools are the foundation for habitat supply analysis - a process where the quantity and quality of habitat present over a landscape under different management scenarios is evaluated, in order that the most appropriate management activities may be selected (Naylor 1993). Scientific investigations that elucidate the relationships between specific wildlife populations and their habitat are the basis for the development of habitat suitability indices (Duinker 1988, Patch 1987, Stelfox 1991). Investigations must focus on contributing to increased understanding of causal mechanisms (examples: microenvironment of the nest site, distribution and abundance of prey) underlying the patterns observed. The findings of these studies will provide vital information to act as a base for conservation efforts (Keane and Morrison 1994).

The northern goshawk (*Accipiter gentilis*) is the largest North American member of the genus *Accipiter*. Estimates of home range size for North American goshawk populations vary from 210 hectares to 2500 hectares (Reynolds *et al.* 1992). Goshawks are a raptor species and consume a great variety of prey species including ruffed grouse (*Bonasa umbellus*), common crow (*Corvus brachyrhynchos*), American robin (*Turdus migratorius*), red squirrel (*Tamiasciurus hudsonicus*), and snowshoe hare (*Lepus americanus*) (Jones 1981). Studies have concluded that suitable nesting habitat and food availability are critical factors determining goshawk populations in an area (Reynolds *et al.* 1992, Widen 1988, Kennedy 1988). Goshawks typically nest in dense stands of large trees, and they forage in forest with open understory, clearings and open fields (Jones 1981, Crocker-Bedford 1990). Modern forestry practices may cause alterations to habitat that will threaten goshawk populations (Reynolds 1989, Crocker-Bedford 1990, Reynolds *et al.* 1982, Moore and Henny 1983, Kennedy 1988). There have been no habitat suitability indices developed for goshawk in the boreal zone of North America. No studies of habitat selection by goshawks have been undertaken in Alberta.

The purpose of this project is to develop and verify a habitat suitability index model for goshawk populations on the FMF area by using original observation, consultation with scientific literature, and local knowledge. The information gleaned by this study will be incorporated into the Decision Support System which is being developed for the FMF to aid forest industry to better accommodate both timber and wildlife goals in logging operations.

There are several objectives for this study:
(1) to determine the habitat features of goshawk nesting areas, including physiography, vegetation structure, and composition;
(2) to determine the habitat features of goshawk foraging areas, including physiography, vegetation structure, and composition;
(3) to determine the prey used by goshawks, and analyze the relative abundance of goshawk prey species; and;
(4) to use the information gathered in the fulfillment of objectives (1) - (3) to refine a preliminary habitat suitability index model (Schaffer *et al.* 1995) for the goshawk.

## STUDY AREA

The FMF is located in west-central Alberta and is composed of the Forest Management Agreement area of Weldwood of Canada Ltd., several Crown management units, Switzer Provincial Park, and Jasper National Park (Figures 1 and 2). The FMF contains boreal, montane and sub-alpine forest cover composed of lodgepole pine (*Pinus contorta*), trembling aspen (*Populus tremuloides*), white spruce (*Picea glauca*), balsam poplar (*Populus balsamifera*), black spruce (*Picea mariana*), and subalpine fir (*Abies lasiocarpa*). Access is provided by paved highways (highways 16, 40, 47, and 93), a system of primary and secondary forest access roads, and seismic cutlines.


Figure 1 - Map of North America showing the location of the Foothills Model Forest.

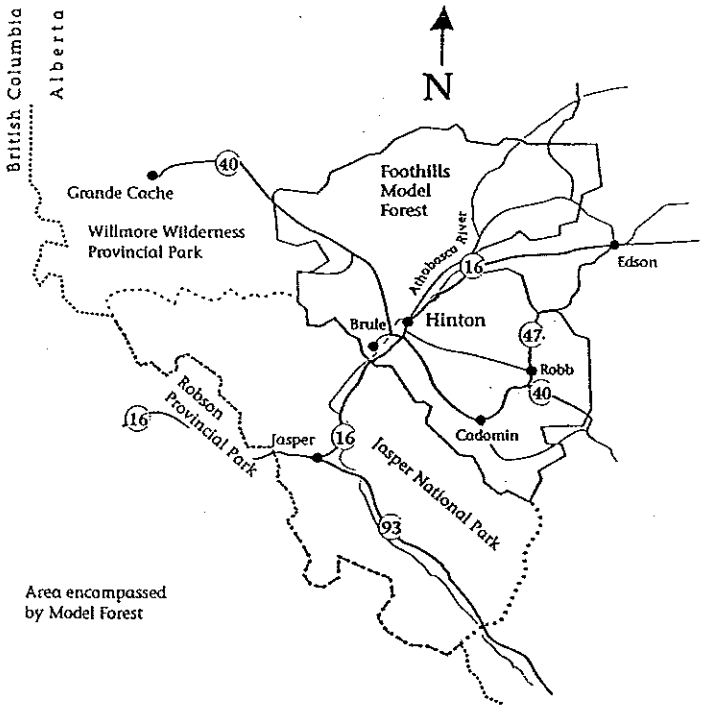


Figure 2 - Map showing major points of interest in the Foothills Model Forest.

## METHODOLOGY

Field personnel conducted silent searches for goshawks and surveys accompanied by broadcasts of goshawk vocalizations, in areas associated with goshawk sightings, and in areas of favourable goshawk nesting habitat. Prior to surveys, personnel were trained in the field methods, and identification of calls and physical characteristics of the goshawk, Cooper's hawk (*Accipiter cooperii*), sharp-shinned hawk (*Accipiter striatus*), red-tailed hawk (*Buteo jamaicensis*), and the goshawk mimics (Joy *et al.* 1994). Areas were surveyed with broadcast stations spaced 300 metres apart on transects that were separated by 260 metres. Stations on adjacent transects were offset by 130 metres (Kennedy and Stahlecker 1993). Stick nests that were documented on the Foothills Model Forest Wildlife Observation Card Database, and that had been documented by other wildlife project personnel were checked for nesting goshawks. Additional stick nests in the region surrounding the documented nests, and in areas associated with goshawk sightings were located and checked for goshawk nesting.

In order to capture goshawks for radio-tagging, both Dho-gaza mist nests, and drop-lid traps were used. At each active goshawk nest tree, a Dho-gaza mist nest was erected and baited with a

great horned owl (*Bubo virginianus*) model accompanied by a broadcast of great horned owl vocalizations. A network of drop-lid traps was set up in a range of forest cover conditions along seismic cutlines adjacent to active nests, and in areas where goshawks had been sighted (Kenward *et al.* 1983, Bloom 1987). The drop-lid traps were checked and maintained with the personnel from the barred owl (*Strix varia*) study that is also being conducted on the FMF. The trap-hours and trapping results presented in this report and the barred owl report will be the same.

Goshawks were fitted with backpack radio transmitters in order to make observations on home range size, foraging habitat use, and nest site reoccupancy by radiotelemetry (Kenward 1985, Kenward 1987). Lessons on effective radiotelemetry techniques in mountainous terrain from other areas of North America were used as a basis for a training program for field assistants (Guetterman *et al.* 1991). The locations of the goshawks were determined by triangulation. There was only one receiver package available for readings during most observation periods. Readings were taken from roadside using teams of two observers in order to minimize the time between successive observations. Radiotelemetry work has continued outside the breeding season to monitor migratory behaviour of the goshawks.

Radiotelemetry data was divided into three groups:
(a) data used to determine foraging locations was composed of readings taken over the course of 25 minutes or less, where the readings were separated by at least ten degrees, and the readings described a triangulation polygon of ten hectares or less;
(b) data used to determine goshawk home range size came from two sources, those readings that met the requirements outlined in (a), and data that was gathered over the course of 25 minutes or less, where the readings were separated by at least ten degrees, but the readings described a triangulation polygon greater than ten hectares;
(c) data that was discarded was composed of readings that were not collected over the course of greater than 25 minutes, or were separated by less than ten degrees.

Details on the prey use of the goshawks was obtained by direct observation of feeding of the goshawk young, by collection of prey remains at plucking posts, and by locating goshawk kill sites by radiotelemetry (Johnson 1978). At each goshawk nest tree, a blind was constructed. The daylight period of observation days was divided into equal periods, and the observation period was alternated between these two time periods. Individual prey items were identified to species, and a description of the size and condition of each item was recorded. Radiotelemetry was used to walk in on goshawks and to locate their kill sites on the snow.

Sampling protocols have been developed for sampling goshawk prey base across a range of forest cover conditions present on the FMF. A relative abundance estimate of prey species that are winter residents (including snowshoe hare, red squirrel and ruffed grouse) will be made by counting tracks left following snowfalls (Thompson *et al.* 1989). In the spring and summer seasons, counts of drumming grouse, and point counts of avian populations will be conducted along transects (Anderson *et al.* 1979, Bibby and Burgess 1992). Sampling for prey populations will commence in the winter of 1995-96, and no results of this work will be discussed at this time. The information on prey populations will be coupled with radiotelemetry locations to describe goshawk foraging habitat.

A sampling procedure was used to quantify the structural characteristics of the goshawk nesting areas (Mosher *et al.* 1987). Characteristics of the nest tree that were recorded include: tree species, tree height, nest type, nest position, and tree diameter. The vegetation sampling at the nesting site was conducted in groups of 5 plots. The center plot was centered on the nest tree, and the surrounding plots were each positioned 30 m away from the nest tree in the cardinal directions. The surveys followed the nested subset design outlined by Timony (1993). Overstory vegetation was sampled within the largest nested plot (0.04 hectares), shrubs were sampled at the next level of the hierarchy (0.004 hectares), and four 1 $m^2$ plots were used to sample herbaceous vegetation.

## RESULTS and DISCUSSION

Silent searches for goshawks began on March 13, 1995 and were undertaken until June 2, 1995. The silent searches were conducted at eleven locations in the FMF. Broadcast surveys began on June 2, 1995 and this detection method was used until June 28, 1995. The broadcast surveys were conducted at three locations in the FMF. The detection of raptors is presented in Table 1.

Table 1 - Raptor Detection Efforts.

| Method | Raptors Detected | Area sampled (hectares) |
|---|---|---|
| Silent Searches | 1 Northern Pygmy Owl<br>3 Golden Eagles (*Aquila chrysaetos*)<br>4 Red-tailed Hawks (*Buteo jamaicensis*)<br>1 Cooper's Hawk (*Accipiter cooperii*)<br>1 Northern Harrier (*Circus cyaneus*)<br>1 Sharp-shinned Hawk (*Accipiter striatus*)<br>1 American Kestrel (*Falco sparverius*)<br>1 Merlin (*Falco columbarius*) | 252 |
| Broadcast Surveys | 1 Northern Goshawk (*Accipiter gentilis*) | 686 |
| TOTAL | | 938 |

The findings of stick nest occupancy is presented in Table 2.

Table 2 - Stick nest occupancy (n=17).

| Occupant | Number of Nests |
|---|---|
| Northern Goshawk (*Accipiter gentilis*) | 2 |
| Great Gray Owl (*Strix nebulosa*) | 1 |
| Great-Horned Owl (*Bubo virginianus*) | 1 |
| Red-tailed Hawk (*Buteo jamaicensis*) | 1 |
| Common Raven (*Corvus corax*) | 3 |
| 9 nests unoccupied | |

The success rate for silent searches and broadcast surveys was low. I have discussed these results with the researchers that developed the methodology that was used (Kennedy and Stahlecker 1993). I have been advised that the low effectiveness of the detection methods is in large part due to the low density of goshawks in the study area. In the second field season, a block of time (one to two months) will be devoted to locating stick nests prior to the nesting season, prior to leaf flush. In addition, the use of the broadcast of a snowshoe hare distress call to aid in the detection of goshawks is currently being investigated.

Mist netting (10 trap hours) was used in the vicinity of both the active nests, and resulted in the capture of one goshawk on June 8, 1995. The drop-lid traps were installed at six different trapping locations over the course of the 1995 summer field season. As many as thirteen individual traps were used on a given trap-day. The drop-lid trapping efforts (6329 trap hours) are summarized in Table 3.

Table 3 - Drop-lid trapping Effort.

| Species Captured | Date Captured |
|---|---|
| Northern Goshawk (*Accipiter gentilis*) | June 29, 1995 |
| Cooper's Hawk (*Accipiter cooperii*) | July 19, 1995 |
| Cooper's Hawk (*Accipiter cooperii* | August 3, 1995 |
| Red-tailed Hawk (*Buteo jamaicensis*) | August 4, 1995 |
| Sharp-shinned Hawk (*Accipiter striatus*) | August 14, 1995 |
| Red-tailed Hawk (*Buteo jamaicensis*) | August 16, 1995 |
| Northern Goshawk (*Accipiter gentilis*) | August 18, 1995 |

The mist netting was very successful and this technique will be employed again around goshawk nests. In contrast, the drop-lid traps were not an efficient use of resources. In the second field season, the use of drop-lid traps will be limited to trapping efforts around active nests, or in areas where there is a confirmed goshawk sighting.

In this study, both sexes of goshawks were captured for radiotagging because each contributes unique information. Radiotelemetry observations on the male goshawks provides information on foraging habitat use, and home range size. The males provide 80-90% of the prey deliveries to the family unit until late in the breeding season (Bright-Smith and Mannan 1994). Radiotelemetry observations on the female goshawks provides information on foraging outside the breeding season, and aids in locating nest sites from year to year.

The first goshawk that was captured and radiotagged (June 8, 1995) was a female on territory. The movements of this goshawk were generally restricted to the nest area until the nest failed on June 20, 1995. Five radiolocations were recorded after the nest failure until the adhesive mount for the radiotag failed, and it fell off the bird on July 27, 1995. The second goshawk that was

captured and radiotagged (June 29, 1995) was a male. Radiotelemetry observations have been made on this goshawk during the daylight hours, and at night in an effort to recognize a pattern to movements to discover a nesting area. It is not known whether this bird is paired or supports a nest. The size of the home range of this goshawk is approximately 3900 hectares based on thirty locations. The goshawk forages in a wide variety of habitats from mature trembling aspen and lodgepole pine stands on the top of a ridge, to black spruce lowlands alongside a river. This goshawk did not migrate in the winter, although a winter season home range expansion has been observed. The third goshawk that was captured and radiotagged (August 18, 1995) was a second-year female. Three radiolocations were recorded on this bird before it was observed flying south, out of the study area on August 23, 1995. Efforts to locate this goshawk on the study area, and in the immediate region to the south have not been successful.

The prey use information acquired from observations (71 observation hours) at three goshawk nests (one active 1994, two active 1995), and from one kill site location is summarized in Table 4.

Table 4 - Goshawk Prey Use.

| Prey Species | Number of Prey |
|---|---|
| Red squirrel (*Tamiasciurus hudsonicus*) | 4 |
| Snowshoe hare (*Lepus americanus*) | 3 |
| Meadow vole (*Microtus pennsylvanicus*) | 1 |
| Bushy-tailed woodrat (*Neotoma cinerea*) | 1 |
| Pileated woodpecker (*Dryocopus pileatus*) | 2 |
| Unidentified passerine birds | 2 |

The prey use data suggests that goshawks use a variety of sizes and species of prey, and that their diet is dominated by mammals. The prey population sampling by nest watches was an effective method. Both active nests failed when the chicks were approximately 21 days old due to hypothermia, and malnutrition following a lengthy period of rain. In the second field season, a greater effort will be devoted to nest watches.

The measurements of the goshawk nest tree, and the vegetation conditions in its immediate vicinity are summarized in Table 5.

Table 5 - Goshawk Nest Tree Characteristics.

| Nest | Nest Type | Nest Height (m) | Nest Tree Species | Tree Height (m) | Tree DBH (cm) | Stand Canopy Closure (%) |
|---|---|---|---|---|---|---|
| 1 | Sticknest | 13.6 | Trembling Aspen | 23.2 | 32.5 | 86.15 |
| 2 | Sticknest | 11.8 | Trembling Aspen | 24.4 | 24.4 | 85.27 |
| 3 | Sticknest | 14.8 | Trembling Aspen | 25.4 | 39.4 | 80.67 |

The relative dominance of species in the overstory at goshawk nest sites in presented in Figure 3. The data on overstory composition suggest that goshawks are selecting deciduous-dominated mixedwood stands for nesting. This is consistent studies from other parts of the range of goshawks (Apfelbaum and Seelbach 1983). It has been observed that the deciduous trees are important for supporting the nest structure, providing large primary branch forks in the lower canopy (Johnsgard 1990, Speiser and Bosakowski 1987, Henderson 1924). The conifer component may aid in aid sheltering the nest early in the nesting season (Speiser and Bosakowski 1987, Moore and Henny 1983). The single most important goshawk mortality factor is starvation associated with difficulty or inexperience in gathering food, or changes in local prey species abundance or diversity (Duncan and Kirk 1994). Although the nesting stand comprises only a minuscule amount of the total foraging range of a pair of goshawks, it contributes important food during the nestling and fledgling period (Crocker-Bedford and Chaney 1988). To the extent that vegetation species diversity contributes to the health and viability of goshawk prey species populations, mixedwood stands will benefit goshawk populations (Willson 1974, Hargis *et al.* 1994).

The diameter distribution of overstory vegetation at goshawk nest sites in presented in Figure 4. A comparison of the diameter of the trees selected by goshawks for nesting with those available suggests that they are selecting for the largest trees available on the sites. Larger trees offer a secure podium for nest construction (Moore and Henny 1983, Reynolds 1983).

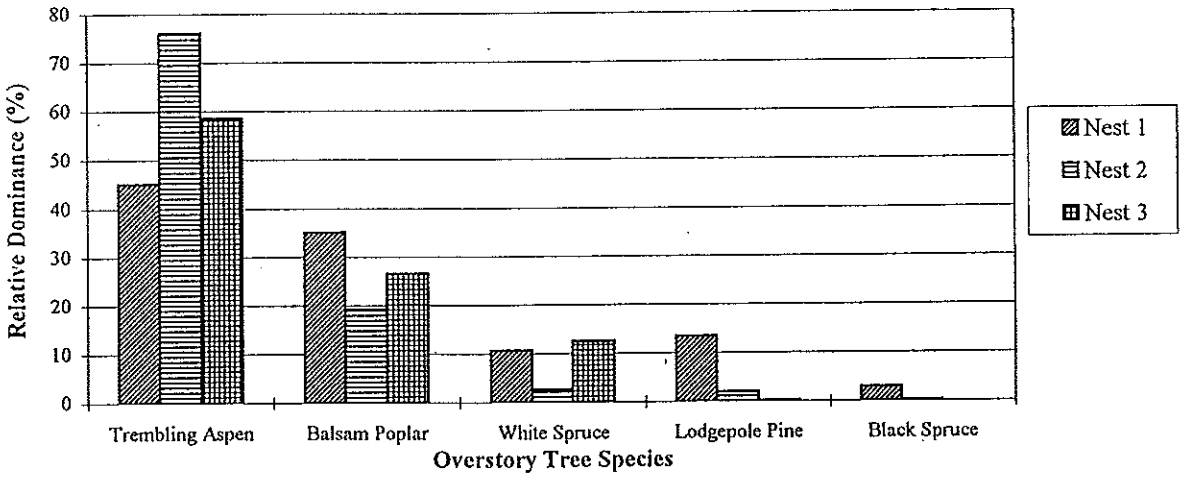


**Figure 3: Relative Dominance of Species in Overstory at Goshawk Nest Sites**

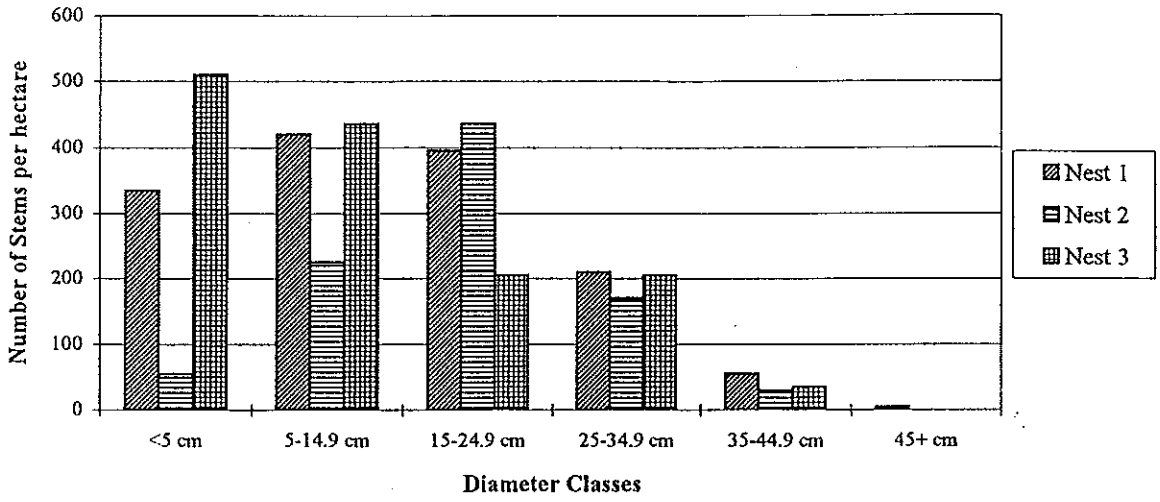


**Figure 4: Diameter Distribution of Overstory Vegetation at Goshawk Nest Sites**

In the second field season the vegetation sampling protocol will be streamlined to place lesser emphasis on sampling the herb layer of vegetation. There was no vegetation sampling at contrast plots in the first field season. The sampling at contrast plots will be conducted in the second field season if the number of nests found allows for non-parametric statistical analysis of the nesting vegetation data (Zar 1984).

## FUTURE WORK

In addition to those innovations already discussed, in the second field season, nesting vegetation will be sampled surrounding thirty goshawk nests, and twenty Cooper's hawk nests that have been located by raptor banders across the boreal forest zone of Alberta. The vegetation data sets will be compared in order to investigate the niche partitioning within the genus *Accipiter*.

## CONCLUSION

In relation to the particular objectives for this study, the first year data suggest the following:
(i) goshawks select large aspen trees for nest placement
(ii) goshawk nesting stands exhibit a forest cover of deciduous-dominated mixedwood
(iii) goshawks forage in a variety of habitats
(iv) goshawk diet is dominated by mammals.

## LITERATURE CITED


Anderson, D.R., J.L. Laake, B.R. Crain, and K.P. Burnham. 1979. Guidelines for line transect sampling of biological populations. Journal of Wildlife Management 43: 70-78.

Apfelbaum, S.I., and P.Seelbach. 1983. Nest tree, habitat selection and productivity of seven North American raptor species based on the Cornell University nest record program. Raptor Research 17(4): 97-113.

Bloom, P.H. 1987. Capturing and handling raptors. pp. 99-123. [in] Giron Pendleton, B.A., B.A. Millsap, K.W. Cline, and D.M. Bird (editors). Raptor techniques manual. National Wildlife Federation, Washington. 367 pp.

Bibby, C.J., and N.D. Burgess. 1992. Bird census techniques. Academic Press Ltd., London. 257 pp.

Bonar, R.L. 1991. The Weldwood-Hinton timber wildlife integrated management project. pp. 25-28. [in] Martel, J.P. (co-chairman). Wildfor 91 - wildlife and forestry: towards a working partnership. Proceedings of a forum, October 7-10, 1991. Jasper, Alberta. 132 pp.

Bright-Smith, D.J., and R.W. Mannan. 1994. Habitat use by breeding male northern goshawks in northern Arizona. Studies in Avian Biology No. 16: 58-65.

Crocker-Bedford, D.C. 1990. Goshawk reproduction and forest management. Wildl. Soc. Bull. 18: 262-269.

Duinker, P.N. 1988. Wildlife in forest management: from constraint to objective. A paper presented at Ontario Forest Research Committee Symposium - "Forest Investment: A Critical Look", November 15-16, 1988. Thunder Bay, Ontario.

Duncan, P., and D.A. Kirk. 1994. Status report on the northern goshawk *Accipiter gentilis* in Canada. Unpubl. manuscript. 41 pp.

Greig, L.A., P.N. Duinker, C.H.R. Wedeles, and P. Higgelke. 1991. Habitat supply analysis and modelling: state of the art and feasibility of implementation in Ontario. ESSA Environmental and Social Systems Analysts, Limited, Richmond Hill. 45 pp.

Guetterman, J.H., J.A. Burns, J.A. Reid, R.B. Horn, and C.C. Foster. 1991. Radio telemetry methods for studying spotted owls in the Pacific northwest. Gen. Tech. Rep. PNW-GTR-272. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 45 pp.

Hargis, C.D., C. McCarthy, R.D. Perloff. 1994. Home range size and habitats of northern goshawks in eastern California. Studies in Avian Biology 16: 66-74.

Henderson, A.P. 1924. Nesting habits of the American goshawk. The Canadian Field-Naturalist 38: 8-9.

Johnsgard, P.A. 1990. Hawks, eagles, and falcons of North America. Smithsonian Institution, Washington, D.C. 403 pp.

Johnson, D.R. 1978. The study of raptor populations. University Press of Idaho, Moscow. 57 pp.

Jones, S. 1981. Habitat management series for unique or endangered species - report no. 17. Technical note. U.S. Department of the Interior - Bureau of Land Management. 51 pp.

Joy, S.M., R.T. Reynolds, R.L. Knight, R.W. Hoffman. 1993. Feeding ecology of sharp-shinned hawks nesting in deciduous and coniferous forests in Colorado. Unpublished manuscript. 22 pp.

Keane, J.J., and M.L. Morrison. 1994. Northern goshawk ecology: effects of scale and levels of biological organization. Studies in Avian Biology No. 16: 3-11.

Kennedy, P.L. 1988. Habitat characteristics of Cooper's hawks and northern goshawks nesting in New Mexico. pp. 218-227. [in] Glinski, R.L., B. Giron Pendleton, M.B. Moss, M.N. LeFranc, B.A. Millsap, S.W. Hoffman. (editors). Proceedings of the Southwest Raptor Management Symposium and Workshop. National Wildlife Federation Sci. and Tech. Series No. 12.

Kennedy, P.L. and D.W. Stahlecker. 1993. Responsiveness of nesting northern goshawks to taped broadcasts of 3 conspecific calls. J. Wildl. Manage. 57(2): 249-257.

Kenward, R.E. 1987. Wildlife radio tagging. Academic Press, Toronto. 222 pp.

Kenward, R.E. 1985. Raptor radio-tracking and telemetry. pp. 409-420. [in] Newton, I., and R.D. Chancellor. Conservation studies on raptors. International Council for Bird Preservation, Cambridge. 482 pp.

Kenward, R.E. 1983. Management of western coniferous forest habitat for nesting accipiter hawks. Gen. Tech. Rep. RM-102. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 7 pp.

Kenward, R.E., M. Karlbom, and V. Marcstrom. 1983. The price of success in goshawk trapping. Raptor Research 17(3): 84-91.

Moore, K.R., and C.J. Henny. 1983. Nest site characteristics of three coexisting Accipiter hawks in northeastern Oregon. Raptor Research 17(3): 65-76.

Mosher, J.A., K. Titus, and M.R. Fuller. 1987. Habitat sampling, measurement, and evaluation. pp. 81-97. [in] Giron Pendleton, B.A., B.A. Millsap, K.W. Cline, and D.M. Bird (editors). Raptor techniques manual. National Wildlife Federation, Washington. 367 pp.

Naylor, B.J. 1993. Habitat supply analysis. pp. 147-154. [in] Davis, R. (editor). Analytical approaches to resource management. Proceedings of the first annual symposium. November 24-26, 1992, Sault Ste. Marie, Ontario.

Patch, J.R. 1987. Habitat supply analysis and forest management. pp. 53-59. [in] McCabe, R.E. (editor) Trans. 52nd N. A. Wildl. and Nat. Res. Conf.

Reynolds, R.T. 1989. *Accipiters.* pp. 92-101. [in] Pendleton, B.G. C.E. Ruibal, D.L. Krale, K, Steenhof, M.N. Kochert, and M.N. LeFranc. (editors). Proceedings of western raptor management symposium and workshop. Natl. Wildl. Fed. Sci. Tech. Ser. No. 12.

Reynolds, R.T., R.T. Graham, M. Hildegard Reiser, R.L. Bassett, P.L. Kennedy, D.A. Boyce, G. Goodwin, R. Smith, and E.L Fisher. 1992. Management recommendations for the northern goshawk in the southwestern United States. Gen. Tech. Rep. RM-217. Ft. Collins, CO.: US Department of Agriculture, Forest Science, Rocky Mountain Forest and Range Experiment Station. 90 pp.

Reynolds, R.T. , E.C. Meslow, and H.M. Wight. 1982. Nesting habitat of coexisting Accipiter in Oregon. J. Wildl. Manage. 46(1): 124-138.

Schaffer, W.W., B. Beck, J. Beck, R. Bonar, L. Hunt. 1995. Northern goshawk (*Accipiter gentilis atricapillus*) breeding season - habitat suitability index (HSI) model. Unpublished report. 14 pp.

Speiser, R., and T. Bosakowski. 1987. Nest site selection by northern goshawks in northern New Jersey and southeastern New York. The Condor 89: 387-394.

Stelfox, H.A. 1991. Assessing land/wildlife relationships via the ecological land evaluation. pp. 29-46. [in] Stelfox, H.A., G.R. Ironside, and J.L. Kansas. (editors). Guidelines for the integration of wildlife and habitat evaluations with ecological land survey. Wildlife Habitat Canada and Canadian Wildlife Service (Environment Canada), Ottawa. 107 pp.

Thompson, I.D., I.J. Davidson, S. O'Donnell, and F. Brazeau. 1989. Use of transects to measure the relative occurrence of some boreal animals in uncut forest and regeneration stands. Can. J. Zool. 67: 1816-1823.

Timony, K. 1993. Timber berth 408 ecosystem monitoring plan. Unpublished paper. 14 pp.

Widen, P. 1988. Hunting habitats of goshawks (*Accipiter gentilis*) in boreal forests of central Sweden. Ibis 131: 205-213.

Willson, M.F. 1974. Avian community organization and habitat structure. Ecology 55: 1017-1029.

Zar, J.H. 1984. Biostatistical analysis (2nd ed). Prentice-Hall, Englewood Cliffs, New Jersey. 718 pp.