COMMITTEE ON THE
STATUS OF ENDANGERED
WILDLIFE IN CANADA

OTTAWA, ONT. K1A 0H3
(819) 997-4991

COMITÉ SUR LE STATUT
DES ESPÈCES MENACÉES
DE DISPARITION AU
CANADA

OTTAWA (ONT.) K1A 0H3
(819) 997-4991

STATUS REPORT ON THE QUEEN CHARLOTTE GOSHAWK *ACCIPITER GENTILIS LAINGI*

AND

NORTHERN GOSHAWK *ACCIPITER GENTILIS ATRICAPILLUS*

IN CANADA

BY

PATSY DUNCAN

AND

DAVID A. KIRK

STATUS ASSIGNED IN 1995
QUEEN CHARLOTTE GOSHAWK - VULNERABLE
NORTHERN GOSHAWK - NOT AT RISK

REASON: QUEEN CHARLOTTE GOSHAWK: RELATIVELY SMALL POPULATION SUBJECT TO HABITAT FRAGMENTATION ON THE ISLANDS.
NORTHERN GOSHAWK: NO OBVIOUS THREATS.

OCCURRENCE: QUEEN CHARLOTTE GOSHAWK: BRITISH COLUMBIA
NORTHERN GOSHAWK: ALL PROVINCES AND TERRITORIES

COSEWIC - A committee of representatives from federal, provincial and private agencies which assigns national status to species at risk in Canada.

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JUNE 1994

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VULNERABLE: (V)	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
THREATENED: (T)	A species likely to become endangered if limiting factors are not reversed.
ENDANGERED: (E)	A species facing imminent extirpation or extinction.
EXTIRPATED: (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
EXTINCT: (X)	A species that no longer exists.
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ACCIPITER GENTILIS LAINGI

AND

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IN CANADA

BY

PATSY DUNCAN
C/O MANITOBA CONSERVATION DATA CENTRE
1007 CENTURY STREET
WINNIPEG, MANITOBA
R3H 0W4

AND

DAVID A. KIRK
AQUILA APPLIED ECOLOGISTS
C.P. 47
WAKEFIELD, QUEBEC
J0X 3G0

AND

C/O NATIONAL WILDLIFE RESEARCH CENTRE
CANADIAN WILDLIFE SERVICE
100 GAMELIN BOULEVARD
HULL, QUEBEC
K1A 0H3

STATUS ASSIGNED IN 1995
QUEEN CHARLOTTE GOSHAWK - VULNERABLE
NORTHERN GOSHAWK - NOT AT RISK

Contents

Executive Summary

Description. The Northern Goshawk *Accipiter gentilis* is a large (males 0.915 kg, females 1.13 kg), hawk with broad wings and a long tail. The plumage is almost identical in both sexes; the most notable distinguishing character is the bold white superciliary stripe (above the eye), and blackish gray (sometimes mottled white) auriculars. The top of the head is blackish slate coloured, the iris reddish to scarlet (adults only), the cere yellow (sometimes tinged greenish) and the bill, blackish blue. The upperparts are medium to dark gray and often appear bluish, while the underparts are white to pale gray. The latter are streaked with blackish to medium gray shafts and dark transverse bars which vary in width and density (they are most dense on the lower breast, lower belly and tibiae). Apart from the white eye stripe and dark mask, the second most important distinguishing feature of the goshawk is its conspicuous white undertail coverts. The tail of the Northern Goshawk is similar to that of the Cooper's Hawk *Accipiter cooperii*; the barring is sometimes faint but there are at least four dark transverse ventral bars that are narrower than the intervening lighter areas. Both the legs and feet of the goshawk are yellow, while the talons are black.

Distribution. The goshawk breeds north to the tree line from Alaska east to Newfoundland. The breeding distribution extends to southern New Mexico and the mountains of Mexico in the west; in the east the range extends south through the Appalachians and locally in montane habitats in West Virginia and probably eastern Tennessee and western North Carolina. It is largely absent as a breeding bird in the mid-western states. It winters throughout the breeding grounds, as well as south to southern California, northern Mexico and Texas, sometimes to the northern part of the Gulf states, and rarely, Florida.

Population size and trends. Goshawk populations in Canada are apparently stable, but trends are difficult to assess because of the irruptive nature of the species, and because traditional surveys are inadequate. Although Breeding Bird Survey (BBS) data are likely inadequate to estimate trends in this forest raptor, the latest analysis (1966-1991) based on 61 routes indicated that goshawk populations were stable. Similarly, Christmas Bird Count (CBC) data analysed over the whole of North America, and therefore include Canadian goshawks, showed no significant change in populations between 1959-1988. Fluctuations in numbers of goshawks passing through hawk look-out sites in eastern North America due to irruptive invasions limits the use of migration counts for this species. Migration counts at Hawk Mountain indicated that goshawks decreased prior to the DDT era (1934-1942), increased in the DDT era (1946-1972) and a showed a non-significant decrease in the post-DDT era. Similarly, non-significant trends were found at five out of six hawk look out sites between 1972-1987. However, there were significant declines between 1983-1991 at four western hawkwatches, but these may have little meaning because of the 8-11 year cyclic fluctuations in northern goshawk populations. In the North West Territories, the Northern Goshawk is a rare but ubiquitous breeder; in British Columbia it is a rare to uncommon

resident and widespread breeder; in Alberta it is also widespread but its status is unknown; it is widely distributed in Saskatchewan (especially common in the east-central part of the province); goshawks are found throughout Manitoba and there is no evidence of declines; in Ontario it is found in all forest types and is probably most abundant in the north; in Québec it appears to be a abundant breeding species, but may have declined locally due to deforestation; it is considered very uncommon in Newfoundland and finally the species is scattered at low density throughout forests in the Maritimes. The subspecies *A. g. laingi* is restricted to the Queen Charlotte Islands and Vancouver Island (as well as possibly southeast Alaska), it is apparently declining because of loss of old growth habitat and should therefore be considered threatened.

Habitat. The Northern Goshawk uses a range of forest types varying in age and structural conditions for foraging, but mature or old growth forests are preferred for nesting. Its large body size prevents hunting in very dense young forests, but some early successional stages are used. Goshawks nest in a wide variety of coniferous forest types from northern subarctic spruce forests to high elevation pine forests. Deciduous and mixedwood forests are also used extensively. Six factors are characteristic of nest sites; 1) a closed canopy, 2) a large tree basal area, 3) a northeastern exposure (except in Alaska, and possibly coastal British Columbia), 4) slopes of a gentle to moderate incline, 5) on the lower third or bottom of slopes and 6) in mature or old growth forest. It has been suggested that forest cutting has reduced populations of goshawks, particularly in the southwestern United States and Alaska. However, one recent study found no difference in reproductive parameters between control and treatment plots which had been cut. During winter, goshawks have been observed in a variety of habitats, including alpine areas, farmland, prairies and deserts, usually in association with trees or shrubs. However, there have been very few published studies which have followed goshawks year-round (except those in Alaska) hence information is lacking on habitat use outside the breeding season.

General biology In years when prey is abundant juvenile female goshawks can breed. Goshawks are the earliest nesting Accipiter; most clutches are complete by the last week in April. Most clutches are from 2-4 eggs (occasionally 1 or 5) and incubation is from 35-38 days. When prey populations are low, small clutches are found or hawks do not attempt to breed. Fledging success depends on prey densities (e.g. Snowshoe Hares *Lepus americanus*). Nesting densities vary geographically and depend on the abundance of prey species. The goshawk requires large forest tracts for its extensive home range. The main prey of goshawks are small to mdeium-sized birds and mammals. Grouse and ptarmigan are the most important avian prey; east of the Rocky Mountains, Snowshoe Hares and Red Squirrels *Tamiasciurus hudsonicus* are the most important prey, while to the west and north ground squirrels are also very important mammal prey. Because of their larger body size, females can kill larger prey than males. Goshawks are relatively sedentary and adults generally remain on established territories in parts of their range. However, this likely varies

greatly across North America. In northern areas, goshawks are much less sedentary; during lows in prey populations they may irrupt and never return. In the north the goshawk is a highly irruptive migrant and most migrating birds are juvenile. Invasions occur every 8-11 years, corresponding with the Snowshoe Hare cycle or fluctuations in grouse populations.

Limiting factors. Loss of suitable nest trees and loss of foraging habitat from timber harvest may cause population declines in parts of the species' range, and constitutes the most important limiting factor. There are few data on survival. The main direct mortality factor (especially in northern Europe) is from persecution by gamekeepers to protect Ring-necked Pheasant *Phasianus colchicus*. In Europe, Eagle Owls *Bubo bubo* have been recorded preying on goshawks, including adult females. Likewise Great Horned Owls *Bubo virginianus* are a significant predator in North America, as well as Raccoons *Procyon lotor* and Fishers *Martes pennanti*. Other direct threats include, falconers raiding nests, human disturbance and shooting. In contrast to the other two North American Accipiters the Northern Goshawk is less affected by pesticides, probably because of its tendency to feed on mammals in non-agricultural areas. Overall goshawk populations are limited by nesting habitat and prey availability.

Special significance of the species. The Northern Goshawk is an important large predator in forest ecosystems. It has special nest requirements which need to be considered during planning for timber harvest. Goshawks are also taken by falconers, although they are temperamental and difficult to handle.

Conclusions. Apart from a recent study at Kluane Lake in the Yukon, there is a paucity of data on goshawks in Canada. Needed are long-studies of population trends by examining nest reoccupancy and adult turnover rates. Given its widespread distribution the *atricapillus* race of the Northern Goshawk is not at risk. However, we recommend that the Queen Charlotte Island race be considered threatened.

A Abstract

The Northern Goshawk *Accipiter gentilis* is a large forest-dwelling raptor that is widely distributed throughout North America. In many parts of its range the species undergoes cyclic fluctuations in relation to prey abundance, particularly Ruffed Grouse *Bonasa umbellus* and Snowshoe Hare *Lepus americanus*. This makes estimates of population status and trends difficult. According to the Breeding Bird Survey (BBS) for Canada, populations were stable overall between 1966-1991, but this survey is not suited to survey forest raptors like the goshawk. Christmas Bird Count (CBC) data from the whole of North America also indicate no change in populations between 1959-1988. Goshawks use a wide variety of forest types in different parts of their range; however, throughout their range mature forests are used for nesting. In relation to nesting, certain features are similar throughout their range. Nests are located in areas with closed canopy cover, large tree basal area, northerly or northeasterly aspect, on a gentle to moderate slope (usually lower third) and in a mature or old growth stand. Nest failures have been attributed to Great Horned Owl *Bubo virginianus*, Racoon *Procyon lotor* and Fisher *Martes pennati* predation (Erdman et al. in press). Unlike other accipiters the Northern Goshawk was little affected by pesticides during the DDT era. Because of its widespread occurrence in a variety of forest types the Northern Goshawk likely does not require designation by COSEWIC. However, it requires mature forests for nesting, and thus may be adversely impacted by timber harvest. Thus, a subspecies designation of vulnerable is required for the "Queen Charlotte Goshawk" *A. g. laingi.*

B Distribution

1. Current North American breeding distribution

The Northern Goshawk "breeds in North America from western and central Alaska, northern Yukon, eastern and southern MacKenzie, southern Keewatin, northeastern Manitoba, northern Ontario, central and northeastern Québec, Labrador, and Newfoundland south to southern Alaska, central California, southern Nevada, southeastern Arizona, southern New Mexico, the eastern foothills of the Rockies and the Black Hills, central Alberta, central Saskatchewan, southern Manitoba, northern Minnesota, central Michigan, Pennsylvania, central New York, and northwestern Connecticut, and locally south in montane habitats at least to West Virginia and probably to eastern Tennessee and western North Carolina, local resident in the mountains of northwestern and western Mexico". (Johnsgard 1990, Fig. 1). Terres (1982) included Maryland, and Bent (1937) included Massachusetts, Maine, New Hampshire, probably Colorado, Washington and Oregon in the breeding range.

According to Johnsgard (1990) the goshawk winters throughout the breeding range and south regularly to southern California, northern Mexico and Texas, occasionally to the northern portions of the Gulf States, and rarely to Florida. Terres (1982) added Montana, Tennessee, Kentucky and Virginia as part of its winter range.

2. Canadian breeding distribution. The Canadian breeding distribution is described by Godfrey (1986) as:

> "Breeds in wooded parts of Yukon (north to Old Crow Flats); western MacKenzie (MacKenzie Delta, Grandin River, Wood Buffalo National Park); British Columbia; Alberta (except southern prairies south of Rosedale but including Cypress Hills); northern and middle Saskatchewan (south at least to Beaver, Spruce, and Carrot rivers, locally Cypress Hills; Manitoba (except extreme southwest part; breeds south to Aweme); Ontario (south to Thunder Bay district, Mount Albert, north of Toronto; and Mallory Town landing on St. Lawrence River); Québec (near Kisujjuag, Grande rivière de la Baleine, Pointe-des-Monts, Old Chelsea, Ile Jésus); Labrador (Hopedale; probably north to near tree limit); Newfoundland; New Brunswick; Prince Edward Island; and Nova Scotia; possibly southwestern Keewatin (Nueltin Lake)." (Fig. 1).

Birds have been reported as stragglers (north of breeding range) to Horton River and southeastern Baffin Island (Godfrey 1986, Palmer 1988). Palmer (1988) also called it a straggler in Alaska to Semenof Island and west to Dutch Harbor.

The darker-coloured (Taverner 1940) and slightly smaller (Johnson 1989, Whaley and White 1993) subspecies, *A. g. laingi*, occurs in the Queen Charlotte Islands and Vancouver Island, British Columbia. Palmer (1988) suggests that it may intergrade with mainland birds on southern Vancouver Island. [Bent (1937) stated that this subspecies breeds south to the Sierra Nevada of California and wintered east to Colorado]. Crocker-Bedford (1990 a, 1994) also considers that the Queen Charlotte subspecies breeds only in southeast Alaska and coastal British Columbia (but not on the mainland coast - T. Ethier pers. comm., R.W. Campbell in pers. comm. to Crocker-Bedford 1994). Crocker-Bedford (1994) recognized five subpopulations; northern southeast Alaska, southern southeast Alaska, Queen Charlotte Islands, Vancouver Island and the Olympic Peninsula. They possibly occur rarely as incursion visitants away from their presumed range (Palmer 1988). However, the subspecies designation of the Alaskan birds is equivocal (T.C. Erdman pers. comm.). For example, wing chord measurements from living birds in Alaska (ADF&G 1994) were longer than museum specimens of *A. g. laingi* measured by Whaley and White 1993), but this may be because of shrinkage of museum specimens (Crocker-Bedford 1994).

3. United States - Breeding. In the United States, the Northern Goshawk nests in the west to the Sierra Nevadas, Rocky Mountains, Arizona and northern Mexico. To the east it breeds in northern Minnesota, Wisconsin, central Michigan, New York, Pennsylvania and southern New England. Goshawks can be found nesting in the Appalachians (Marshall 1991, Johnsgard 1990) locally south in montane habitats to West Virginia and probably eastern Tennessee and western North Carolina.

C Protection

In Canada all raptors are protected by legislation drafted by individual provinces and territories between 1957 and 1967 (Hilton 1977). In the United States and Mexico, raptors are protected by an agreement signed by the two countries on 10 March 1972 (Olendorff et al. 1980).

D Population size and trends

Because of cyclic population fluctuations characteristic of the goshawk it is difficult to determine both overall population size and trends. Overall, Kirk and Hyslop (in review) estimated that there were 10,000-50,000 pairs of goshawks in Canada. There are at least four sources which provide some indication of overall population trends: Breeding Bird Survey (BBS), Christmas Bird Counts (CBC), migration counts and breeding bird atlases (BBA).

According to the latest analyses from the Breeding Bird Survey (BBS) for 1966-1991, populations of Northern Goshawks are stable (% annual change 0.3, n = 61 routes, mean abundance 0.02 birds/route). Analyses of data from a recent decade (1982-1991) indicated an increase in populations (% annual change 2.1, n = 34 routes, $P < 0.1$; mean abundance 0.03 birds/route; B. Peterjohn pers. comm.). However, for a variety of reasons, population trend data for goshawks cannot be adequately determined from Breeding Bird Surveys (see Sauer et al. 1991). Instead some authors have recommended that all observations be combined to compute a trend for the total population of hawks (Robbins et al. 1986).

Over the whole of North America, goshawk populations also showed no significant trends according to Christmas Bird Counts conducted between 1959-1988 (% annual change 0.2, n = 1007 circles, mean relative abundance 0.11 hawks/100 party hours; B. Hoover pers. comm.). However this overall analysis of the CBC does not take into account regional declines or increases.

Nagy (1977) reported that goshawk counts from Hawk Mountain, Pennsylvania were relatively stable except during dramatic fluctuations (incursions). However, Bednarz et al. (1990) stated that these fluctuations rendered analysis of population trends from migration count data invalid. Changes at Hawk Mountain are not detected unless they are of great magnitude (due to low annual mean counts). No significant change was apparent in long-term trends (1934-1986; % annual change 0.023, $P > 0.1$), but there was a significant short-term decline (1971-1986; -0.303, $P = 0.046$; Bednarz et al. 1990). Contrary to expectations, counts of Northern Goshawks decreased prior to the DDT era (1934-1942, % annual change -0.678, $P < 0.01$), increased in the DDT era (1946-1972, % annual change 0.153, $P < 0.01$), and showed a nonsignificant decrease in the post-DDT era period (1973-1986, % annual change -0.208, $P = 0.07$; Bednarz et al. 1990). The decline in the first period is probably attributed to shooting at hawk lookouts in the eastern United States during the 1930s when thousands of birds were killed. Irruptive population years occurred in the mid-1930s and early 1970s. A non-significant negative trend was also found for the goshawk between 1972-1987 at five of six hawk look-outs in eastern North America (% annual change -3.76, $P = 0.282$; Titus and Fuller 1990). Hussell and Brown (1992) did not present trend data for this species because they believed such analyses are invalid given the cyclic nature of goshawk populations. Finally, recent analyses of migration count data from four western hawkwatches indicated a decline in goshawks between 1981-1987 (% annual

change -4.36, P > 0.1), but again the significance of these declines is difficult to evaluate (Hoffman et al. 1992).

Northwest Territories. In the Northwest Territories, winter records of goshawks are related primarily to the number of ptarmigan and hare. According to C. Shank (pers. comm.), goshawks can be considered as rare but ubiquitous breeders in forested areas. They are most commonly seen during flights when immatures pass over Great Slave Lake in mid-late August through to mid-September.

British Columbia. Campbell et al. (1990) report the goshawk as a rare to uncommon resident throughout the province, including Vancouver Island and the Queen Charlotte Islands. In British Columbia, it is an irregular migrant, rare to uncommon in the spring, and rare to fairly common in autumn. It is considered to be a widespread breeder. It is essentially non-migratory and widely distributed, being least numerous on the coast and more abundant in the northern interior (Campbell et al. 1990). There are 33 nest records for the province. Two goshawk subspecies occur in British Columbia; *A. g. atricapillus* is the mainland subspecies and *A. g. laingi*, which occurs on Vancouver Island and the Queen Charlottes where it is probably a resident. The British Columbia Conservation Data Center ranks the mainland subspecies between S4 and S5 (S4 representing species that are apparently secure and with many occurrences, and S5 representing species that are demonstrably secure in state and essentially ineradicable under present conditions; S. Cannings pers comm.). However, the 'island' subspecies, *A. g. laingi,* is ranked S1/S2 (species that are either critically imperilled in the province or imperilled because of rarity - 6-20 occurrences). Although the *atricapillus* race is not currently considered at risk in British Columbia, there is now considerable concern about the status of birds in southeast Alaska, considered to be *laingi* and there is a petition to list it as endangered in the United States (Suckling et al. 1994).

Most of the world range of the Queen Charlotte Goshawk is in British Columbia (BC Ministry of Environment, Lands and Parks and Ministry of Forests 1994 draft). Here the subspecies is on the provincial red list because its sparse population is restricted to coastal forest and is probably threatened by logging (BC Ministry of Environment, Lands and Parks and Ministry of Forests 1994 draft, M. Chutter pers. comm.).

Only three nest sites of *A. g. laingi* are known on the Queen Charlotte Islands; there have been no breeding records for six years (R. W. Campbell in pers. comm. to D.C. Crocker-Bedford 1994). A common prey species of *A. g. laingi* in the Queen Charlotte Islands, Steller's Jay Cyanocitta stelleri, has declined dramatically (West 1993). On Vancouver Island, a total of 14 breeding attempts have been confirmed, including six nest sites (T. Ethier pers. comm.).

In 1994 a three year research project began to investigate goshawk breeding densities and productivity in forests on Vancouver Island subject to different levels of timber harvest in response to concerns about the effects of logging on laingi populations (T. Ethier

pers. comm.). Preliminary results have provided nest site characteristics of four nests and productivity in stands with heavy fragmentation (2 breeding areas), light harvesting (n = 7) and old second growth (n = 3; Ethier 1994). A species prescription has now been developed for the Queen Charlotte Goshawk (BC Ministry of Environment, Lands and Parks and Ministry of Forests 1994 draft).

Alberta. Based on guidelines issued in a report on the status of Alberta wildlife (Government of Alberta March 1991), the goshawk is on the Yellow List. This means, 'Sensitive species that are not at risk. They may require special management to address concerns related to low populations, limited provincial distribution, or particular biological features". Although the goshawk is widespread throughout forest habitats, its current status is unknown. There is concern regarding the impact of industrial development in key boreal forest habitats, and the effect of northern logging on goshawk populations. Favoured areas in the province are in the boreal forest region, foothills region, and Rocky Mountain region (Semenchuk 1992). Salt and Salt (1976) report extralimital breeding records from the Cypress Hills. There are 33 confirmed (1.5% of the total of 2,206 squares surveyed), 14 probable (0.6%), and 18 possible (0.8%) breeding records for the province.

In Banff and Jasper National Parks, the goshawk is reported as a rare resident in spring, summer and autumn, and a very rare resident in winter. The species is frequently found in forest areas in the montane and lower alpine ecoregions and, less frequently, in the upper subalpine ecoregion. Preferred areas include steep slopes with open coniferous or deciduous forest, or forest with patches of meadow or adjacent meadow (Holroyd and Van Tighen 1983). According to W. Roberts (pers. comm.), goshawks are present in low numbers but their population appears stable.

Saskatchewan. W. Harris (pers. comm.) reports that goshawks are widely distributed throughout the province, being especially common in the east-central portion of the province. As in many other raptor species their populations fluctuate, but there is no indication that numbers are declining so as to warrant concern. The highest Christmas Bird Count for North America is in Squaw Rapids, where 16 were sighted in 1980 (A. Smith, pers. comm.). There are 17 confirmed (2.3% of provincial squares), three probable (0.4%), and 75 possible (10.3%) breeding records (giving a total of 95 breeding records or 13% of the provincial squares; Smith in press).

The goshawk is ranked by the Saskatchewan CDC as S4 (i.e. apparently secure with many occurrences). Globally it is ranked as G4, meaning it is not rare and apparently secure, but with cause for long-term concern (usually more than 100 occurrences) (J. Duncan pers. comm.).

Manitoba. In the Churchill area, the goshawk is very rare and irregular (Chartier 1988). In the Pinawa -Lac du Bonnet area it is a rare summer resident and a rare to uncommon winter visitant. It is most frequently seen between September and April along forest edges

and clearings. Numbers appear to be higher during years of high Ruffed Grouse and Snowshoe Hare populations. It is probable that a few pairs nest each year in this area (Taylor 1983). In southeastern Manitoba from January to mid-March, they are seldom observed but can be expected to occur annually. In the remaining part of the year they are infrequently observed in preferred habitat and are usually in low numbers. Goshawks range across the region in late fall and early winter, and may be encountered anywhere, especially in the boreal forest (Cleveland et al. 1988). The goshawk is found throughout the province, and there is no indication that populations are declining (R. Nero pers. comm.).

Ontario. R. James (pers. comm.) reports that although there is a definite lack of information on goshawks in the province, he is not presently concerned about populations. They probably occupy all forested areas of the province, and even in heavily logged areas they are still present. According to R. James (pers. comm.), in logged areas they will hunt grouse when trees reach 15 years old, and only a patch of mature trees is needed for nesting. Although logging may have thinned them a little, there may be more than 5,000 pairs in northern Ontario. In the south, where there are few woodlots for breeding, they are still surprisingly widespread. The species likely breeds sparingly in the forests throughout most of the province, but no longer breeds in the extreme south due to the lack of contiguous forest habitat over large enough areas (Peck and James 1983). Suitable habitat is available in most of the remainder of its range as these areas (such as the Canadian Shield) have been relatively undisturbed. It is reported to be an uncommon to rare breeder in Ontario (Weir 1987). Breeding data from 1981-85 show an uneven distribution, probably as a result of habitat availability. In southern Ontario, there were 219 records of Northern Goshawks (16% of 1,824 squares); of these, 165 were confirmed (55%), 38 were probable (13%) and 95 were possible nesting records (32%, Weir 1987). In Ontario as a whole, the species was reported in 65 blocks (10 x 10 km, 47% of total); of these 29 had confirmed evidence of breeding (45%), 10 were probable (15%) and 26 were possible (40%). The species is highly irruptive, with large variation in numbers evident from data gathered at lookouts in Ontario (Hawk Cliff and Holiday Beach; Duncan et al. 1992; R. Weir, pers. comm.).

Québec. Apparently goshawk populations have not changed markedly over the years throughout the province, except perhaps locally due to deforestation. Goshawk populations are known to fluctuate cyclically following fluctuations in hare and grouse (M. Gosselin pers. comm.). It appears to be a common breeding species, and " is not particularly likely to become threatened, or endangered, even though there may have been some decline in numbers in some cases" (Robert 1989). During Québec's breeding bird atlas, Northern Goshawks were recorded as confirmed breeders in 27 squares (1.1% of the total of 2,464 squares), as probable in 16 squares (0.6%) and possible in 129 squares (5.2%). The Québec CDC ranks the goshawk as S4 (M. Huot pers. comm.).

Newfoundland. The goshawk is considered to be very uncommon in the province. It is likely to be found annually in the appropriate season/habitat, and is probably only locally uncommon. Its nesting abundance is significantly lower than suggested by sightings. It has been recorded in all seasons (Mactavish et al. 1989).

Nova Scotia and New Brunswick. Northern Goshawks are found 'scattered throughout the forests of the Maritimes' (Erskine 1992). The species was probably under-represented, but Erskine suggests that even areas that were well covered produced few goshawks during tbe atlas and he attributes this to possible persecution in the past. Evidence of breeding was found in 214 (14.0% of surveyed squares, n = 1,529) during the Maritime breeding bird atlas. Of these, 55 were confirmed breeders, 13 were probable and 142 possible breeders (Erskine 1992).

Overview. Due to low densities, adequate raptor population data is difficult to obtain. Many raptor populations are stable both in terms of overall numbers and distribution for extensive time periods (Newton 1976, Boyce 1993). Fyfe (1976) reported what he believed to be a reasonably accurate account of the status of some bird of prey populations in Canada, including the goshawk. In the Maritimes the population trend was stable and relative abundance rare to medium. For Ontario and southern Québec, and the prairie provinces the trend was stable, with relative abundance medium to high. In British Columbia populations were reported as stable and of medium to high relative abundance. Finally, in the Northwest Territories and Yukon goshawk populations were regarded as fluctuating and of medium to high relative abundance.

In Alaska, a part of the goshawk population considered to be *A. g. laingi* has been reported to be severely impacted by the harvest of old growth forest and has a decreasing population (Thomas et al. 1990, Crocker-Bedford 1994, Suckling et al. 1994). Of 30 confirmed, probable and possible nest sites found in 1992, 70% were either harvested or close to planned harvest areas (ADF&G 1993 a). The subspecies is ranked T1/T2 by the Alaska Natural Heritage Progam, meaning that it is either 'critically imperiled globally' or 'imperiled globally' (West 1993).

In 1990, Crocker-Bedford (1990 a) reported that "the total habitat capability for goshawks in coastal British Columbia and southeast Alaska combined may once have been 5,060 pairs. Calculated habitat capability is now down to 2,560 pairs. The paucity of observations of breeding pairs is further evidence that the current habitat capability is well below the modelled 2,560 pairs for southeast Alaska and coastal British Columbia combined". However, these original estimates by Crocker-Bedford are now believed to be much too high. Iverson (1990), included all of coastal British Columbia in the range of the *laingi* subspecies and failed to recognize the extent of habitat loss in British Columbia (Suckling et al. 1994). Crocker-Bedford's more recent (1992) estimate of population size was 200-500 pairs or fewer and Suckling et al. (1994) suggested that there were in addition, 25 pairs in the Queen Charlotte Islands, 50 pairs on Vancouver Island and 50 pairs on the

Olympic Peninsula in Washington. Thus, assuming that there were previously 1,160 pairs according to Crocker-Bedford's (1990 a) habitat capability model, the population in southeastern Alaska has declined by 57-83%. This decline is even more drastic given Crocker-Bedford's latest (1994) population estimate of 100-200 pairs for southeastern Alaska, which is based on the 120 pairs calculated by K. Titus (K. Titus in pers. comm. to Crocker-Bedford 1994).

Because subpopulations of coastal birds are isolated (Alaskan birds are largely separated from those in Canada), and declining, this increases the chance of extinction of the subspecies (see Mace and Lande 1991). In the long-term the coastal subspecies may be below the threshold of viability (Reed et al. 1986 calculated that a minimum of 610 interbreeding pairs were required for genetic viability). Crocker-Bedford (1994) believed that the coastal subspecies met Mace and Lande's (1991) criteria as 'vulnerable' to extinction (< 5,000 pairs and over 1% annual decline in habitat capability). Given the current population estimates Crocker-Bedford (1994) recommended that the coastal subspecies should be listed as 'endangered'.

By 1992, the Northern Goshawk was listed as a "sensitive species" in the southwest region, the intermountain region and pacific southwest of the United Statees (Crocker-Bedford 1994). All three subspecies are now category 2 candidates for threatened or endangered status in the United States (USDI FWS 1992). In January 1994, the coastal population considered to be the 'Queen Charlotte' Goshawk was included in the 'sensitive' species list in Alaska (Crocker-Bedford 1994). There is now a petition to list the 'Queen Charlotte' Goshawk as 'endangered' in the United States (Suckling et al. 1994). There is growing concern that goshawk populations and productivity may be declining in the southwestern region and elsewhere in western North America, particularly Alaska (Kennedy 1988, Crocker-Bedford 1990 a, Crocker-Bedford 1994). It has been suggested that population declines are associated with timber harvests. Other factors that could be involved in the southwestern states are toxic chemicals, drought, fire (and fire control), disease and effects of tree harvest on prey species (Reynolds 1989).

From the information summarized previously, goshawk populations in Canada appear to be stable. It seems that populations may only suffer locally due to forest fragmentation. However, this does not appear to be the case for the Queen Charlotte Goshawk, which is believed to be declining in British Columbia (Crocker-Bedford 1990 a, Crocker-Bedford 1994, BC Ministry of Environment, Lands and Parks and Ministry of Forests 1994 draft).

E Habitat

General description. Goshawks nest in a wide range of coniferous, mixed wood and deciduous habitats from northern subarctic spruce forests, to high elevation coniferous forests (mostly pine) of the Mexican Cordillera (Johnsgard 1990). They forage in forests differing widely in age (successional stage) and structural conditions (Kenward and Widén

1989, Reynolds et al. 1991). The extent to which the goshawk uses these different forest conditions is poorly known (Reynolds 1989). However, they prefer mature or old growth forests for nesting, with closed canopy cover.

Hunting. Goshawks are recognized as superlative predators both below and within the forest canopy. Because of their large body size, they generally do not use dense young forests for foraging. Although they compete poorly with other raptors for prey in treeless habitats, open areas near old growth forests may be used if they contain high prey densities (e.g. muskeg in Alaska, Crocker-Bedford 1994). That the species is frequently described as preferring edges for hunting (e.g., where brush, burned areas, streams and wetlands meet forest), may be because goshawks are more easily observed hunting in such habitats. Radiotelemetry data provides some of the best indications of preferred foraging habitat. In Alaska, 92% of relocations of 30 radiotagged goshawks were in old growth forest (only 1% were from clear-cuts and second growth, 3.3% from natural openings and scrub and 3.6% from mature second growth; ADF&G 1994). In northern Arizona (summer), radiotracked male goshawks (n = 11) preferred to forage in stands with increased canopy cover and significant differences were found between stands of < 15%, 15-33%, 34-55% and > 55% (Mannan and Smith 1993). Similarly in northern California, radiotagged birds (n = 10) preferred dense stands of mature or old growth trees (> 40% canopy cover) and avoided openings, early successional stands and sparse stands of sawtimber (< 40% canopy; Hargis et al. 1993). A further 10 goshawks radiotracked in eastern California foraged more frequently than expected by chance in stands with higher tree basal areas, higher canopy cover and where there were more dense, large-sized trees (Hargis et al. 1993). Two radiotagged goshawks in Utah foraged in stands of mature and overmature trees (Fischer 1986).

Variation in prey species and other factors mean that these generalizations are not necessarily true in all parts of the species' range; because of differences in forest type, forest structure and prey populations there are apparently large differences in foraging habitat between eastern and western goshawk populations. While some authors have stated that the goshawk's hunting niche is closely related to prey availability and its hunting capabilities rather than habitat preferences *per se* (Marshall 1991, Reynolds et al. 1991), others maintain that goshawks prefer habitats with large trees, dense canopies and relatively open understories (USFWS 1992, AG&F 1993). The latter view purports that goshawks are selecting for habitat structure not prey abundance (USFWS 1992, AG&F 1993). However, because prey densities are higher in such forests in western North America (see Reynolds et al. 1992), this controversy is difficult to resolve. Crocker-Bedford (1990 b) stated that 'considerable habitat within the home range of a pair of goshawks must be of high enough quality to provide sufficient and accessible prey relative to the time and energy expended while hunting'. The first argument seems more likely given that goshawks will forage in younger forests (with smaller trees) in eastern North America. Also, in Europe high breeding densities of goshawks occur in prey rich areas that are only 12-15% wooded

(see references in Widén 1989, Kenward and Widén 1989). Crocker-Bedford (1994) noted that the deciduous and mixed wood forests of northeastern North America harboured potential goshawk prey at earlier successional stages than in western North America. For example, in Ontario, a major prey species of goshawks, Spruce Grouse (Dendragapus canadensis), attain maximum abundance in 6 m high jack pine (*Pinus banksiana*), and provided goshawks can gain access below the canopy, they are able to pursue grouse in such situations (B. J. Naylor, pers. comm.). However, the open understorey in mature forests can provide more flyway space and increase vulnerability of prey (see Speiser and Bosakowski 1987). This is also suggested by the fact that nesting stands have less shrub cover than those of the closely related, but smaller, Cooper's Hawk *Accipiter cooperii* (Bosakowski et al. 1992).

Typical breeding habitat. Throughout its range in North America and Europe, the consistent characteristic of accipiter nest sites is their high foliage density (Bent 1937, Schnell 1958). Such dense vegetation provides screening cover and physical protection from predators, as well as a milder climatic environment (e.g. the shade provided in northerly aspects). Most studies in the western United States (e.g. Shuster 1980, Moore and Henny 1983, Crocker-Bedford and Chaney 1988, Kennedy 1988) and elsewhere in North America (McGowan 1975, Speiser and Bosakowski 1989) demonstrate that goshawk nest sites are characterized by six factors: they occur in sites 1) with a closed canopy, 2) a large tree basal area, sites with specific topographic characteristics such as 3) northeastern exposure, 4) with slopes of a gentle to moderate incline, 5) on the lower third or bottom of slopes (Hennessey 1978, Reynolds et al. 1982, Moore 1980, Shuster 1980, Hall 1984), 6) in mature to old growth forests.

Tables 1 and 2 show characteristics of nest trees and nesting stands, respectively. Of 64 nests from various areas in North America, 44% were located in mixed woodlands, 34% in deciduous trees and 22% in coniferous forests (Apfelbaum and Seelbach 1983). In Alaska, paper birch *Betula papyrifera* was an important component of nesting habitat; pure stands of this species were used more frequently than any other forest type (McGowan 1975). Although about half of the nests studied by McGowan (1975) occurred in mixed forests, in 78% of these birch was an important component. The preference for birch was also reflected in nest site location. In mixed stands, where two or more tree species suitable for nesting occurred, birch was preferred in 94% of cases. Although birch woodlands are preferred breeding habitats, both yearling and adult goshawks have nested in aspen. However, 90% of the nest sites in aspen were in pure stands, thus precluding choice of another tree species for nest sites (McGowan 1975). Mature birch may be preferred because of its tendency to have large forks providing a stable foundation for nest structures, in contrast to aspen. All but eight of 45 nests in Alaska were located on hillsides; 46% were at middle slope, 38% on the lower slope and 16% on the upper slope. Nest site elevation ranged from 195 m to 540 m, 66% had a southern exposure and 36% were situated on northern slopes (McGowan 1975).

In Oregon, goshawks nest in dense stands of mature or old growth conifers, with a mean density of 482 trees/ha (Reynolds et al. 1982). The stands where nests were found ranged from those containing few mature trees with numerous understory conifers (and a multi-layered canopy with green foliage from ground level to 40 m height) to those with mature trees with closed canopy and few understory trees. Most nests were found in old growth stands. Nest elevation ranged from 580 m on the western slopes of the Cascades to 1,860 m in the Bly Mountains. Mostly gentle slopes were used (0-30°), although some slopes of 75° were used. There was also a tendency for nests to occur at sites with a northerly aspect. Goshawks nested in stands that either contained or were close to springs or quiet streams, presumably for bathing and drinking (Reynolds et al. 1982).

In Utah and Colorado, goshawks preferred mature forest and nested in trees surrounded by canopy cover (Hennessey 1978). The breeding range of the species was restricted to areas with woodlots or forests harbouring sheltered nest sites; goshawks showed a preference for areas with larger stands containing large trees. An important factor was the distance from the nest to the edge of cover; in this respect compared to the other two accipiters, goshawks showed greater preference for sites distant from the edge of cover (mean of 56 m; Hennessey 1978). Another important factor was the degree of visibility from the nest; most had considerable horizontal visibility. Sites were also close to water (mean of 394 m). Nests were usually at least 30 m higher than those of the other accipiters, and thus situated in dense canopy cover. The species was quite specific in its nest height requirements. Nests were also typically located further from human disturbance than nests of the other accipiters (mean of 250 m). A greater number of nests were also on north-facing slopes and situated at the lower end of the slope.

In western Montana and northern Idaho, goshawk nesting habitat is typically mature to 'overmature' conifer forest with a closed canopy (75-85% cover) on a moderate slope (15-35°) with a northern aspect at or near the bottom of a hillside (Hayward 1983). Nest sites are usually located in older stands. The relatively large diameter and the wide spacing of trees in such stands allows goshawks to fly beneath the upper canopy. Both water bodies and a large forest opening occurred within 0.5 km of the nest site (Hayward 1983). Typically, nests were built close to the bole of a live conifer in the lower third of the living crown. Nest trees had open canopies to allow access by birds and a whorl of large branches supporting the nest structure. Nest height generally ranged from 12 m to 26 m and there was a distinct flight path to the nest.

In northern New Jersey and New York goshawks generally nested on flat areas, lower gentle slopes or in depressions (frost pockets; Speiser and Bosakowski 1987). They avoided southern aspects as found in other studies (but see McGowan 1975). A recent analysis of goshawk habitat in Pennsylvania at the landscape level indicated that nest sites were on gentle slopes, and far away from medium duty roads and non-forest edges.. Nests were associated with extensive forests, more coniferous or mixed stands and areas with little residential land use (Kimmel and Yahner 1994).

Essential habitat. Closed canopy cover is apparently essential for nesting of goshawks. For example, in the North Kaibab forest in Arizona, goshawks nested in the densest stands available (> 80% canopy cover) and avoided stands with less than 60% canopy cover (Crocker-Bedford and Chaney 1988). Canopy cover was also apparently much higher at nest sites than in surrounding areas in other studies (e.g., Hennessey 1978, Reynolds et al. 1982, Hall 1984). This may be because of the cooler microclimate beneath dense canopies in summer (Hennessey 1978, Reynolds et al. 1982, Hall 1984). Most nests are located in areas with a northerly aspect. Findings were similar in ponderosa pine *Pinus ponderosa* in Arizona, where topography protected nests from intense insolation and the prevailing southwesterly winds. Another explanation is that canopy cover may protect goshawks from predation, as well as affecting their food supply (Moore and Henny 1983).

Outside the breeding season. During migration and winter goshawks are observed in alpine areas, farmland, prairies and deserts, usually in association with trees or areas of brush. Even outside the breeding season they are more likely to use woodland or forests (Palmer 1988).

F General Biology

Reproductive Biology. Nest site characteristics and breeding habitat were discussed in the previous section. In several studies, goshawk breeding home ranges contained more than one nest (e.g. Reynolds et al. 1982). Many pairs used the same nest site for two or more years while some pairs alternated between two or more nests. Generally three alternate nests within a territory are used, but there may be as many as five nests in a territory (Crocker-Bedford 1990 b). These alternate nests were 15-150 m apart in Oregon (most were 60-90 m apart; Reynolds et al. 1982). In California the mean distance between alternate nests was 610 m (median 235 m; Woodbridge 1988), while in northern Arizona they were closer than 305 m, but up to 1,006 m apart (Crocker-Bedford 1990 b).

Although it was previously believed that goshawks pairs remain together for life (Palmer 1988) recent work in Alaska demonstrates frequent divorce (ADF&G 1993 a). Goshawks are sexually mature during their first spring after hatching (about one year of age, when still in juvenile plumage), although not all begin to breed at this time (Dementiev 1951). Females have been found nesting in juvenile plumage occasionally in Finland (Höglund 1964 in Reynolds and Wight 1978), and in Alaska during years of food abundance (McGowan 1975). It appears that in years when there are many well-fed yearlings, some of these juvenile females will enter the breeding population (Palmer 1988). In North America, male goshawks in juvenile plumage have not been found breeding (Palmer 1988). Examination of testes from 10 immature male goshawks in Finland indicated that immature males are normally incapable of breeding (Höglund 1964 in Reynolds and Wight 1978). However, Glutz von Blotzheim et al. (1971 in Reynolds and Wight 1978) found immature male goshawks nesting in central and southern Europe.

Although polygamy has not been documented, McGowan (1975) stated that it is possible and may explain the absence of males at nests occupied by yearling females.

Clutch size is usually 2-4 eggs, with occasionally 1 and rarely 5 (Palmer 1988). In times of insufficient food resources, small clutches or no egg production occurs (Reynolds 1972). According to Johnsgard (1990), few, if any significant regional variations in clutch sizes occur in North America, except that clutches may increase slightly towards the north. In temperate and northern Europe, clutch sizes averaged 3.5 (Cramp and Simmons 1980). Eggs are laid at 2-3 day intervals, with an incubation period of 35-38 days (Newton 1979). The female incubates (Brown and Amadon 1968), and the eggs are gradually warmed resulting in embryonic development beginning late during the laying of the clutch (Palmer 1988). If the initial clutch is lost, a replacement clutch is normally laid 15-30 days later (Johnsgard 1990). Overall, dates of laying and incubation are variable. The goshawk is the earliest nesting Accipiter, laying about one month earlier than the Cooper's Hawk *Accipiter cooperii*, and even earlier than the Sharp-shinned Hawk *Accipiter striatus* (Palmer 1988). Most clutches are complete within the last week of April and the first two weeks of May (Reynolds and Wight 1978). While the female incubates and broods, the male provides her and the brood with prey (Palmer 1988).

Breeding success. Breeding success in raptors, such as the goshawk, that eat game birds or hares, follows periodicity in prey populations (Newton 1979). According to Johnsgard (1990), there seems to be considerable differences in nesting and fledging success both annually and geographically, and these are influenced by prey availability (McGowan 1975). Cramp and Simmons (1980) agreed that fledging success is highly variable, but a typical range of 2.7 to 3.1 young per successful nests was representative of European studies. In Alaska, McGowan (1975) showed that fledging success rates varied with the density of Snowshoe Hares, and that this situation may be more common in northern areas where prey populations are more cyclic. Table 3 is a summary of the number of young fledged per nest attempt of goshawks for 10 different studies. In general, the number of young that attain flight is somewhat more than 1 fewer than the number of eggs/clutch (Palmer 1988).

Breeding density. In Alaska, McGowan (1975) found breeding densities of 1 pair per 46-55 km^2 (1971-1973, average of 8 active nests) and 1 pair per 372 km^2 in 1974 with 1 active nest. The closest distance between nests was 2.4 km in 1971 and 3.1 km in 1972. In Finland, Hakila (1969 in McGowan 1975) found nesting densities as high as one pair per 16.4 km^2. In Colorado, Shuster (1977) found goshawks nesting at a minimum density of 1 nest per 13.3 km^2 (6 nests). The mean distance between nests were 2.4 km in 1974 and just 0.8 km apart in 1975 (Shuster 1977).

In Oregon, Reynolds and Wight (1978) found a density of 1 pair per 27.5 km^2 in 1974 (4 nests), with a mean distance between nest sites of 4.3 km. Crocker-Bedford and Chaney (1988) found 11.0 pairs/100 km^2 in Arizona. Apparently goshawk nesting densities

are considerably lower in Alaska and Finland, and higher densities may be the rule further south (Marshall 1991).

Home range. Goshawks require extensive home ranges and therefore large forest stands are favoured as nesting habitat (Johnsgard 1990). In Wyoming, Craighead and Craighead (1956) estimated range size at 212 ha (0.82 km^2; all range sizes here are converted into km^2), while in Minnesota, Eng and Gullion (1962) found a large breeding home range of 13 km^2, with an area of radius 2 km from the nest used as foraging range. In Europe, home ranges for a pair have been estimated at up to 50 km^2 (Cramp and Simmons 1980).

A review of literature up to 1983 recorded ranges of 20.2 - 32.4 km^2 (Reynolds 1983). Although most recent estimates rely on radiotelemetry they vary not only according to region and habitat but also because of differing methods used for calculating home range. Using 95% harmonic mean ranges, Kennedy (1989) found that home range size of three males was 17, 17.8 and 28.3 km^2 and five females, 5.7 km^2 (range 0.9 - 13.0 km^2) in northern New Mexico (June to September). Based on 95% harmonic mean techniques in northern Arizona (June - August), Mannan and Smith (1993) found that mean range size of 11 males was 15.4 km^2 (range 8.5 -23.1 km^2), whereas minimum convex polygon (MCP) ranges were 17.8 km^2 (range 8.9 - 25.1 km^2). In northern California, Austin (1993) found the mean MCP home range size between July and August was 24.3 km^2 km^2 for males (range 10.9 - 38.9 km^2), 37.6 km^2 for females (range 20.2 - 69.2 km^2; n = 5 for each sex, respectively) and 47.8 km^2 for pairs. In eastern California, Hargis et al. (1991) found home ranges of 0.7 to 7.8 km^2 for 8 radio-marked females and 3.4 to 9.5 km^2 for 2 radio-marked males.

Estimates of home range size from Alaska indicate huge summer home ranges (June to August) of 189 km^2 for an adult male (n = 32; 107 km^2 of this was land), and 240 km^2 for an adult female (n = 24; 104 km^2 was land, ADF&G 1993 a). The combined range of this pair was 411 km^2 (206 km^2 of which were land). When observations from June through to March were included, respective home ranges for the male were 685 km^2 (306 km^2 land) and for the female, 987 km^2 (707 km^2 land). Combined ranges were estimated at 1,578 km^2 (789 km^2 land; ADF&G 1993 a). A further two pairs were radiotracked during the breeding season; in one pair, the male had a home range of 63 km^2, the female, 108 km^2 (73% land), giving 149 km^2 for the pair (81% land). In the other pair, the male's range was 85 km^2, the female's range 1,114 km^2 (67% land) and the combined range of the pair 1,168 km^2 (68% land; ADF&G 1994). However, these estimates were obtained by aerial radiotracking, and so error polygons may be larger than from goshawks tracked on the ground. Also sample sizes are small, few birds were radiotracked, and post-breeding dispersal areas were included in the ranges of some birds, which may not be valid (T. C. Erdman pers. comm.).

Adjacent pairs of goshawks can have overlapping home ranges. A breeding home range may contain alternate nest sites and the post-fledging family area (Volk 1991). It appears that after nesting, both males and females expand their home ranges (Hargis et al.

1991). Outside the breeding season, a single bird or a pair occupies a hunting territory which may shift during winter. In the process, individual territories may overlap (Palmer 1988).

Food habits. Goshawk prey varies with region, season and availability, but consists primarily of medium-sized birds and mammals (Johnsgard 1990, Marshall 1991) as in Europe (Cramp and Simmons 1980). Although a generalist and an opportunist, the goshawk favors a few prey species at any time and place (Palmer 1988). Jones (1979) compiled a list of representative prey species of the goshawk in North America (see Table 4). The largest avian prey taken are the Mallard *Anas platyrhynchos* and American Black Duck *Anas rubripes*, with the smallest being sparrow-sized birds. The largest mammals are Snowshoe Hares and Cottontails *Sylvilagus floridanus* (Palmer 1988). Because the female is larger and stronger than the male she can handle heavier prey (Palmer 1988); Storer (1966) demonstrated measurable differences in the average prey weight taken by the two sexes. Johnsgard (1990) stated that grouse and ptarmigan are the most important avian prey for goshawks. He concluded that east of the Rocky Mountains, Spruce Grouse *Dendragapus canadensis*, Ruffed Grouse, Snowshoe Hare and Red Squirrel *Tamiasciurus hudsonicus* represent the four main prey of the goshawk (two of which are cyclic - the Ruffed Grouse and hare). To the west and north, more reliable food sources occur - such as Willow Ptarmigan *Lagopus lagopus*, Blue Grouse *Dendragapus obscurus* and Arctic Ground Squirrel *Spermophilus undulatus*. A more diverse range of prey species is also taken in western North America (66 prey species), than east central North America (20 prey species; Marti et al. 1993). Mean prey mass is also higher in the west (geometric mean 231.8 g) than the east (197.8 g; Marti et al. 1993).

Summarizing various studies across North America, Sherrod (1978) found mammals to represent 21 to 59% (numerically) of food intake and birds from 18 to 69%, followed by reptiles and invertebrates. Stomach contents (n = 223), mostly from goshawks collected during winter indicated that 55% of prey were mammals (mostly Cottontails, hares, and Red Squirrels, as well as Grey Squirrels, ground squirrels, White-footed Mice (*Peromyscus* spp.), voles (*Microtus* spp.), and redback voles (*Clethrionomys* spp.; Storer 1966). The remaining prey were birds, mainly Ruffed Grouse, Ring-necked Pheasants and Bobwhite Quail (*Colinus virginianus*), as well as ptarmigan (*Lagopus* spp.), flickers and thrushes (*Catharus* spp.).

A recent study in northern Arizona demonstrated that diet was composed of over 94% mammals between late incubation and fledging (Cottontails (26%), Golden-mantled Ground Squirrels (*Spermophilus lateralis*), 10% Rock Squirrels (*S. variegatus*), 15% Tassel-eared Squirrels (*Sciurus aberti*), 6% Red Squirrels and 22% other mammals (Mannan and Boal 1993). The high proportion of mammals may be because this analysis was based on nest observations (and were therefore biased), forestry practices had increased mammal densities or open forest types were located closeby (Crocker-Bedford 1994). In New Mexico, Kennedy (1989, 1990) found birds (mainly Northern Flickers *Colaptes auratus*,

Steller's Jays *Cyanocitta stelleri*, American Robins *Turdus migratorius*) and mammals (Tassel-eared Squirrels, Red Squirrels and Cottontails) composed similar numerical contributions to the diet.

Queen Charlotte Goshawks feed on Northwestern Crows (*Corvus caurinus*), while those on Vancouver Island prey mainly on Steller's Jays and Varied Thrushes (*Ixoreus naevius*; Beebe 1974, Johnsgard 1990). Recent data on diet of the Queen Charlotte subspecies from Vancouver Island indicate that Red Squirrels, Steller's Jay, Varied Thrush, Hairy Woodpecker and Blue Grouse were all taken (Ethier 1994). An analysis of pellets and prey remains has yet to be completed (T. Ethier pers. comm.).

Hunting. Goshawks typically hunt dense woodlands, clearings and open fields (Palmer 1988). In wooded areas, they hunt low in the forest canopy. Most hunting is done from an inconspicuous perch which is shifted at intervals. Kenward (1982) described this as 'short-stay-perched-hunting'. Little time is spent on the wing, but this may vary by region or habitat. The attack is sudden, occurring at tremendous speed and over short distances. Goshawks are reckless and very persistent in pursuit, and will crash into bushes after birds or rabbits and then walk on the ground to reflush the prey (Bent 1937, Jones 1979). Less frequent, fast searching flights occur along forest edges, openings or other vegetation (Johnsgard 1990). Flights rarely last more than one kilometer (Beebe 1974). There is one observation from Sweden of goshawks 'fishing' (Bertilsson 1983, in Palmer 1988).

The fact that goshawks forage outside forested areas during winter and on migration is clearly indicated by the prey identified by Storer (1966), Bent (1937) and others.

Survival. There are no useful data on goshawk survivorship in North America. According to European studies, goshawks show a high mortality in their first year, falling to half as high in the second year, and a gradual decline for several years until it levels off (Palmer 1988). In the wild in Europe, the goshawk is known to live up to 19 years (Newton 1979), and Palmer (1988) suggests 20 years to be about the normal lifespan in North America.

Reasons for nest failure. Logging may cause territories to be abandoned and can remove nest trees and nesting stands directly. In Utah and Idaho, nest failure was caused by human disturbance, Great Horned Owls and other predators. Great Horned Owls and Raccoons *Procyon lotor* were the most significant predators (Hennessey 1978). Reynolds and Wight (1978) found human disturbance to cause nest desertion by the same pair of goshawks during two consecutive years, and the cause for failures in two other nests were unknown. In Wisconsin, dramatic increases in populations of Fisher *Martes pennanti* have resulted in extensive predation on nesting goshawks, including both adult females and young. Fisher populations have increased because of current logging practices resulting in monocultures of aspen *Populus tremuloides* and fragmented landscapes (T. C. Erdman pers. comm.).

Movements. Southern and western goshawk populations are fairly sedentary; most do not usually migrate or wander appreciable distances (Mueller and Berger 1967, Brown and Amadon 1968). Adults with established nesting territories usually remain near or on their territories. Immatures or others vacate territories due to food shortages and establish "hunting territories" (Palmer 1988). There are likely considerable differences in the nature of movements between goshawk populations in central and eastern Canada and those in western Canada and the western United States. In northern areas, goshawks are much less sedentary and during lows in prey populations they may irrupt. These birds may never return (T. C. Erdman pers. comm.). Despite the demonstrated occurrence of cyclic irruptions in many regions, this is still not recognized by some researchers working on this species in the western United States (T. C. Erdman pers. comm.). Also, some recent research in Alaska has not considered the existence of population cycles or irruptive movements.

In northern, eastern and central parts of North America, goshawk populations are highly irruptive. Declines in major prey resources is the main stimulus forcing them southwards in some years (R. D. Weir pers. comm., Newton 1979). In North America, goshawk invasions occur approximately every 8-11 years, corresponding with the Snowshore Hare cycle (Keith 1963, Krebs et al. 1992, Doyle and Smith in press). "Although the extent to which the goshawk depends on Snowshoe Hares and grouse species for sustenance has not been demonstrated, relatively good indices of abundance are available for these two prey species and these invite comparisons with indices of goshawks" (Mueller and Berger 1967).

Mueller and Berger (1967, 1968) and Mueller et al. (1977) counted goshawks migrating through Cedar Grove, Wisconsin between 1950-74. Overall, few birds were recorded except during invasion years when large numbers occurred at 10-year intervals. Peak invasions were preceeded by a decrease in Ruffed Grouse and Snowshoe Hare populations, such as during the invasion of 1962-63. Mueller et al. (1977) found that in most years, more juveniles migrate than adults. They believed that older birds displace younger birds when prey populations are too low to support the entire goshawk population within the normal range of the species. Furthermore, because juveniles would not have established territories or home ranges they would probably be the first to be displaced (Mueller and Berger 1967). With regard to juvenile sex ratios from 1950-71, males predominated, indicating that the larger females displace males from the breeding range during fall and winter. However, the sex ratio was about 1:1 in 1972-73 suggesting virtually all juveniles migrated.

D. L. Evans (pers. comm.) found that in non-invasion years, juvenile males predominate at Hawk Ridge, Minnesota. He suspects that these may represent relatively local dispersing birds. During peak invasion years, adults predominate, with juveniles comprising less than 15% of birds captured. Initially the proportion of males is higher, followed by an increase in the proportion of females (R. F. Green pers. comm.). Green et al. (1986) and R. F. Green (pers. comm.) suggest that when food is scarce, females

displace males, and during extremely low food availability, females are also forced elsewhere. Alternatively, he believes that whichever sex invades in greater numbers is determined by the sex that first reaches low numbers. This may be because of different prey bases, males responding to availability of grouse and females to hares.

Behavior/adaptability. Goshawks are easily livetrapped, and in the hand some appear unconcerned, while others appear shy and fearful (Beebe 1974). Campbell et al. (1990) stated that the species "frequents man-influenced habitats such as farmland, parks, cemeteries, airports, orchards, ornamental gardens and infrequently, residential areas." Goshawks are sometimes found in areas with interspersed clearings or cultivation.

G Limiting factors

Goshawk populations are threatened by human disturbance, poaching, pesticides, loss of suitable nest trees, and loss of nesting foraging habitat due to timber harvesting and livestock grazing (Reynolds 1983, Kennedy 1988). It is believed that goshawk populations are limited by a combination of nesting habitat requirements and the abundance and availability of prey (Marshall 1991).

Habitat loss. Because goshawks almost invariably nest in mature or old-growth stands, they may be negatively impacted by timber harvest (Reynolds et al. 1982, Moore and Henny 1983, Mannan and Meslow 1984, Woodbridge 1988, Marshall 1992, Crocker-Bedford 1990 b, 1991, 1994, Patla 1991, Reynolds et al. 1992, Ward et al. 1992, see references in Block et al. 1994). They are thus management indicator species in most parts of their range, especially in western North America, where most studies have been published on goshawks. Timber harvest can affect goshawk habitat at two levels; at the level of the nesting stand (i.e. removing nesting trees causing loss of sites for individual pairs) and at a landscape level (affecting local populations). Numerous studies indicate that goshawks require mature or old-growth forests for breeding habitat. In much of their range such habitats are also needed for foraging, although in the east and elsewhere in their range goshawks may forage in young stands.

At the forest stand level timber harvest can cause direct loss of nest sites or abandonment of nests (if conducted during the breeding season). Changes in the structural composition of stands (reductions in canopy cover, altering the size class distribution of trees, decreasing basal area or the number of snags or downed logs used as plucking posts) may render stands unsuitable for breeding goshawks. At the landscape level, logging reduces the supply of mature forest required by goshawks for nesting; because the commercial rotation age of forests is less than that occurring naturally, logging reduces the average age of forests. Fragmentation of forests caused by logging also reduces the habitat suitability of habitats for goshawks, as demonstrated by higher re-occupancy rates of large forest blocks (e.g. stands larger than 61 ha; Woodbridge 1988,

Woodbridge and Detrich 1993). Timber harvest also affects prey abundance, hunting success and interactions with predators or competitors at both the stand and landscape level (Reynolds et al. 1992).

The evidence for the negative impacts of timber harvest comes from declines in occupancy and productivity following logging (e.g. Woodbridge 1988, Crocker-Bedford 1990 b, 1991, Patla 1991, Woodbridge and Detrich 1993, Erdman et al. in press). These reductions occur even if nest sites or stands are protected. Crocker-Bedford (1994) suggests that loss of foraging stands might have the greatest effect on reproduction. Variation among studies in the effects of timber harvest can be explained by the fact that goshawks do not use all parts of their home ranges equally (Kennedy 1989, Widen 1989, ADF&G 1993 a, 1994, Austin 1993, Hargis et al. 1993, Mannan and Smith 1993), and that some harvest operations occur in key foraging areas, while others do not. Also some home ranges may have adjacent, alternative foraging stands (Crocker-Bedford 1994).

Crocker-Bedford (1990 b) showed that selective cutting in the North Kaibab Ranger District of northern Arizona caused a decline in goshawk reproduction. In areas where one-third of the timber was harvested, goshawk occupancy decreased by 75% relative to control plots. Buffer zones (1.2-202 ha, mean 38.4 ha) around nests had no effect on these decreases. Assuming circular home ranges of 2,347 ha, Crocker-Bedford (1991) then calculated the decline in reproduction from 1973-1986. Selective logging of 10-39% of stands within home ranges caused a 50% decline in reproduction than home ranges with minimal or no harvesting. When 40-69% of stands were selection harvested, there was an average decrease of 80% in reproduction. Where timber harvest affected 70% or more of the stands within a home range, occupancy was only 11% of unharvested home ranges and no reproduction occurred (Crocker-Bedford 1991). However, whether or not selection harvesting occurred in the nesting stand itself did not affect occupancy or productivity. In 1972, 170 $\pm$ 40 pairs were estimated for the North Kaibab Ranger District, but by 1992 only 58 pairs were recorded, representing a decline of 50%.

Recently Boyce et al. (1993) found no difference in goshawk demographies between control and treatment plots on the same territories examined by Crocker-Bedford, despite the fact that 89% of those not yet harvested were active (1991-1992), while only 40% of those with timber harvest (1988-1992) remained active (Crocker-Bedford 1994). They re-analysed Crocker-Bedford's data and suggested that his previous conclusions were equivocal. However, a number of methodological differences render this comparison suspect (T.C. Erdman pers. comm.).

Given the dramatic loss of coastal rainforest in British Columbia due to logging, this may have serious effects on goshawk populations, in particular the Queen Charlotte Goshawk. The effect of large scale cutting of boreal forest in Canada is unknown (see Kirk 1994). It is important to stress that goshawks differ in their hunting habitat requirements in different parts of their range, and that the prey base differs between regions (Kenward and Widén 1989). Also, the food base of goshawks may be the most important factor determining preferred hunting habitats (Kenward and Widén 1989).

Mortality/Survival. Although North American data are scarce, several studies in Europe show a high mortality of goshawks in their first year (+ 80% in Sweden, where large numbers are shot), then half as high in the second year, and a gradual decline for several years before levelling off. Haukioja and Haukioja (1970 in Newton 1979) in Finland/Sweden reported the following mortality rates for different age classes: first year; 63%, second year; 33%, third year; 19%, fourth year; 17%, and 11% thereafter.

Eagle Owls *Bubo bubo* prey on young and adults of almost all the European raptors, including female goshawks (Newton 1979). In North America, goshawks are preyed on by Great Horned Owls *Bubo virginianus*, and this predation increases when timber harvest opens up large areas (Erdman et al. in press). Goshawks also compete poorly with Red-tailed Hawks *Buteo jamaicensis* (Erdman et al. in press). The major mortality in Europe is from persecution. An extreme example of this is in northern Europe where, in one analysis, more than 90% of the recoveries were of birds killed by humans (Haukioja and Haukioja 1970 in Newton 1979). For Accipiters, apparently the single most important mortality factor is starvation associated with difficulty or inexperience in gathering food or changes in local prey species abundance and diversity (Snyder and Wiley 1976 in Palmer 1988).

Starvation, disease, predation, electrocution, shooting, trapping, poisoning, collisions and other accidents all kill birds of prey, but for any one population it is difficult to evaluate the relative importance of each cause. This is partly because most mortality goes unobserved in the wild (Newton 1979).

Although a wide variety of diseases and parasites have been found in raptors, with effects from slight to fatal, their significance to wild populations is far from clear. Almost certainly, disease plays an insignificant role in the control of raptor populations, and accounts for only a small part of the total mortality (Newton 1979). Goshawks do fall victim to frounce, a disease caused by the microorganism *Trichonoma gallinae*, which is endemic at a sublethal level in birds of the pigeon family. During an invasion year, Beebe (1974) thought it possible that pigeons indirectly caused more goshawk deaths than human persecution, yet food habit studies generally do not reveal a predeliction for a diet of pigeons and doves.

That annual mortality declines with increased body size is well established for raptors, as is the trend within species for greater mortality in immatures than in older birds. In practice, the vulnerability of any species depends partly on how easily it can be killed. Some species are fairly bold and easy to shoot - carrion feeders are easier to kill - a third factor influencing vulnerability is the size and distribution of the population to begin with. Any small population that occurs in a restricted habitat is more easily eliminated than a large population that extends into wild country where it is hard to reach. Most raptors show an extremely high mortality rate the first year and then lower rates thereafter. For Accipiters, shooting has always been an important mortality factor and recently, poisoning by organochlorine pesticides (causing decreased productivity) has also been important (Jones 1979, Newton 1979). Craighead and Craighead (1956) found that the goshawk preyed on several species of raptors, and killed adult hawks on the nest as well as nestlings. Great

Horned Owls and Racoons (replaced by Fishers in the north) are the most significant predators of goshawks. Human threats include indiscriminate killing and the raiding of nests by falconers, but the latter probably has a negligible effect on populations.

Pesticides. In contrast to the other two North American Accipiters, there is no hard evidence to indicate that the goshawk has suffered significant population declines in recent decades, and this is perhaps in part related to a seemingly rather low pesticide burden in the species (Snyder et al. 1973, Reynolds and Wight 1978).

A few goshawk eggs were collected in Oregon and analyzed for pesticides. All had relatively low levels, a fact that is consistent with the lack of any historical population decline in any region of North America (Snyder et al. 1973). There seems to be no evidence that pesticide levels have affected goshawk numbers in North America (Palmer 1988).

In general, goshawks tend to feed at lower levels of the food chain than do Cooper's Hawks (i.e. they feed more on mammals than birds), and the latter tend to feed at lower levels than do Sharp-shinned Hawks, which feed almost exclusively on birds (Storer 1966). As well, goshawks feed largely in non-agricultural areas and are often non-migratory. Therefore it would be predicted that biological magnification of pollutants such as DDE is correspondingly most severe in Sharp-shinned Hawks and least severe in goshawks. These generalizations are supported by data from Arizona - New Mexico data. In the two goshawk eggs analysed from this region DDE levels were 3.12 and 0.79 μg/ml, respectively. From Oregon, one addled and two infertile eggs of goshawk contained only low levels of DDE (mean 0.36 μg/ml). Recent data from Canadian goshawk populations (Noble et al. 1993) indicated that levels of DDE, DDD, DDT, dieldrin and heptachlor epoxide were below levels causing reproductive failure in other accipiters. These data present a generally consistent picture of DDE stress for Cooper's and Sharp-shinned Hawks, but not for Northern Goshawks. Levels of DDE in the goshawk eggs analyzed have been relatively low, and we know of no cause of egg breakage in this species (Noble et al. 1993). Apparently protected by its generally low position in food chains, this species is not known to be suffering a general population decline in any region due to pesticides. Part of the reason for this is that goshawks tend not to be associated with agricultural areas and are mostly non-migratory so they are not part of the contaminated food chain. However, one study demonstrated that goshawks had a level of DDT 2.6 times that of American Kestrels *Falco sparverius* in an area sprayed with DDT (Henny 1977). Levels of DDE above 3-4 μg/ml in eggs were found to represent significant levels of contaminants, associated with frequent egg breakage and possibly disturbed behavior. Of two eggs analyzed in Toledo Mountains in Spain, unexpectedly high levels of PCBs were present (10.5 and 16.0 ppm). However, organochlorine pollutant and heavy metal levels in these eggs were generally below those known to cause direct effects on avian survival or reproduction (Hernandez et al. 1986). Areas that have tall and very dense understories may diminish goshawk populations due to reduced visibility, and restricted flight access to prey and greater escape cover for prey (Boyce 1993).

H Special significance of the species

Because of its position at the top of the food chain the goshawk plays an important role in forest ecosystems. It has specific habitat requirements that require planning of timber harvests at a stand and landscape level to provide a continuing supply of mature or old growth forests for nesting and a variety of successional stages for foraging (depending on the region). The species is a 'management indicator' or featured species of mature and old growth forests in the western part of its range, and also to some extent in the east.

I Evaluation and proposed status

Long-term studies of population trends, breeding density, reproductive success and dispersal are needed in Canada to establish the status of Northern Goshawk populations (Rosenfield et al. 1991). Nest reoccupancy and adult turnover rates indicate population trends (e.g. in Wisconsin, T.C. Erdman unpubl. data), but few of these data are available in Canada or much of the United States. Given its apparent widespread distribution, the *atricapillus* subspecies of the Northern Goshawk likely does not require a designation by COSEWIC. However, the *laingi* subspecies on the west coast should be considered 'threatened' since its small populations are isolated and they inhabit old growth forests that are affected by logging.

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K Acknowledgements

We thank Environment Canada for funding and C. Hyslop for the opportunity to prepare this summary. B. Peterjohn and B. Hoover and J.R. Sauer provided BBS and CBC data, respectively, and J.R. Sauer performed the trend analyses on CBC data. S. Cannings, J. Duncan, M. Huot and D. Sutherland provided nature conservancy rankings for the species. In particular, we also thank M. Chutter, T. Ethier and B. Harper for current information on the Queen Charlotte Goshawk in British Columbia. We thank T.C. Erdman for useful discussions and F. Doyle for pre-prints of manuscripts. We thank many other people, too numerous to be mentioned here, for information about goshawks. We are very grateful to J. Duncan, T.C. Erdman, T. Ethier, C. Hyslop and R. D. James who pointed out inconsistencies and improved earlier versions of the manuscript by their comments.

List of Authorities

Dr D. Coleman Crocker-Bedford, Tongass National Forest, Ketchikan Area, Federal Building, Ketchikan, AK, USA 99901

Dr Frank Doyle, Kluane Lake Research base, Mile 1054 Alaska Hwy, Kluane Lake, Yukon Y1A 3V4 Canada

Mr Thomas Erdman, Richter Museum of Natural History, University of Wisconsin-Stephen's Point, Green Bay, Wisconsin 54311-7001 USA

Mr Tom Ethier, Wildlife Branch, Ministry of the Environment, 780 Blanchard St., Victoria, BC V8V 1X5

Dr Robert Kenward, Institute of Terrestrial Ecology (ITE), Furzebrook, Wareham, Dorset, UK BH20 5AS

Dr Richard T. Reynolds, USDA Forest Service, Rocky Mountain Station, 240 W Prospect, Fort Collins, CO, USA 80526

Figure 1. Distribution of the Northern Goshawk in North America (taken from Johnsgard 1990)

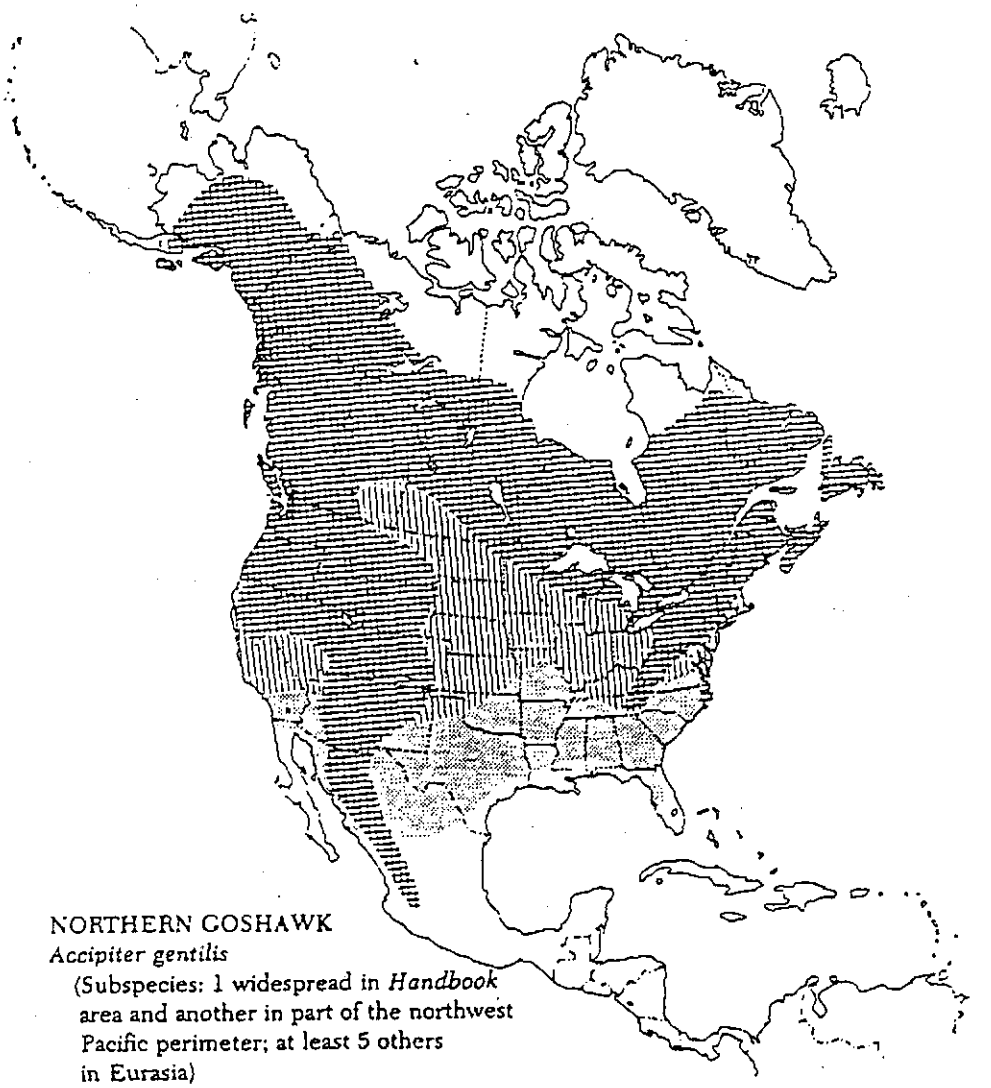

Table 1 Goshawk nest tree characteristics (values show means ± 1 SD, except where indicated [b] = 95% Confidence limits; range in parentheses)

Location	Nest-tree height (m)	Nest height (m)	Nest tree dbh (cm)	Source
Alaska (n = 41)	9.1 ± 2.2		28.3 ± 6.1	McGowan (1975)
NE. Oregon (n = 34)		14.5 ± 4.4	51.6 ± 14.9	Moore and Henny (1983)
E. Oregon (n = 62)	33.5 ± 12.0 (6.1-54.9) (n=62)	16.2 ± 5.5 (4.6-27.4) (n=22)	82.3 ± 28.3 (30.5-161.5) (n=61)	Reynolds et al. (1982)
Rocky Mountain Forest, W. Montana, N. Idaho (n = 9)	22.0 ± 4.96[b] (12-32)	10.0 ± 1.75[b] (7-14)	42.0 ± 14.31[b] (25-79)	Hayward and Escano (1989)
Columbia Highlands, W Montana, N. Idaho (n = 8)	31.0 ± 8.73[b] (23-48)	14.0 ± 1.83[b] (12-17)	58 ± 18.93[b] (25-97)	Hayward and Escano (1989)
N. California (n =		17	74	Saunders (1982)
NW. California (n = 10)	43 ± 3 (24-55)	21 ± 2 (9-28)	91 ± 6 (70-160)	Hall (1984)
Utah/Idaho (n = 10)		12.6 ± 3.0	33.5 ± 15.3	Hennessey (1978)
Colorado (n = 20)	19.2 (13.7-24.1)	(7.0-18.0)	(20.6-50)	Shuster (1980)
New Mexico (n = 12)	25.9 ± 6.8	16.9 ± 4.5	57.2 (27.9-101.6)	Kennedy (1988)
Arizona (n = 21)		19.5 ± 2.8		Crocker-Bedford and Chaney (1988)
Northern New Jersey/ southeastern New York (n = 19)	22.9 ± 5.33 (14.3-35.5)	12.0 ± 2.09 (8.6-18.0)	38.3 ± 9.96 (23-63)	Speiser and Bosakowski (1987)*
Northern New Jersey/ southeastern New York (n = 29)	23.6 ± 6.02 (14.3-41.6)	12.6 ± 2.84 (7.4-20.4)	39.7 ± 10.78 (19-63)	Speiser and Bosakowski (1989)
Ontario (n = 29)		(7.5-23)		Peck and James (1983)
British Columbia (n = 17)		(6-18)		Campbell et al. (1990)

* Note that these data are a subset of Speiser and Bosakowski (1989)

Table 2 Characteristics of nesting stands used by goshawk for (numbers show mean ± 1SD or range for each variable; [1] = 95% Confidence limits)

Location	Forest type	Height (m) or age (yrs)	Canopy cover %	Density trees/ha	Total basal area (m^2/ha)	Mean tree diameter (cm)	Slope	Aspect	Distance to forest edge (m)	Distance to water (m)	Distance to human disturbance (m)
Alaska[a] (n = 41)	Boreal (Po,Bw, Sw,Sb)	-	-	-	-	-	-	26 S, 15 N	-	-	-
Montana[b] (n = 12)	Old growth Douglas-fir	- (203 yrs)	72	475	-	31	-	-	-	-	-
W Montana / N Idaho[c] (n = 17)	Douglas-fir, grama-needlegrass wheatgrass cedar/hemlock	-	80 ± 3[1]	1,135 ± 94[1]	41 ± 4[1]		6 31-40% 4 21-30% 4 11-20% 2 > 40% 1 0-10%	7 N (315° - 45°)	< 1,000	< 500	-
E Oregon[d] (n = 62)	Old growth ponderosa pine, Douglas-fir, white fir, lodgepole pine, larch, aspen, hemlock	15 ± 9 (n=7) (180+ yrs)	60 ± 21 (n=7)	482 ± 146 (n=7)	-	27 ± 18 (n=7)	9 ± 12 % (n=59)	61% N, 17% E, 14% W, 8% S	-	119 ± 171 (n=50)	-
E Oregon[e] (n = 34)	Old growth Douglas-fir, ponderosa pine	-	-	1,007 ± 422	52 ± 17	22 ± 6	14 ± 10%	NP[2]	-	199	-
Nevada[f] (n = 14	Aspen	8	-	-	-	-	21 %	-	45-90	49	-
NE Utah / SE Idaho[g] (n = 10)	-	-	63	-	-	-	29 %	-	57	400	254
N Colorado[h] (n = 20)	-	-	-	-	99-152 (aspen) 52-88 (pine)	-	12 %	-	-	0-275	-
N California[i]	-	-	-	749	-	27	12 %	NE	-	0-665	15-310

Continued on next page

Table 2 - continued

Location	Forest type	Height (m) or age (yrs)	Canopy cover %	Density trees/ha	Total basal area (m^2/ha)	Mean tree diameter (cm)	Slope	Aspect	Distance to forest edge (m)	Distance to water (m)	Distance to human disturbance (m)
NW California[i] (n = 10)	*Pseudotsuga* hardwood	(100-120 yrs)	94	427	90	46	41 %	18°	-	153	279
New Mexico[k] (n =11)	Pinyon - juniper with mixed chaparral,	-	-	960	21.1	21.5	17 %	NP[2]	-	292	-
N Arizona[l] (n = 36)	Ponderosa pine / mixed conifer	28	76	-	-	-	-	-	-	-	-
N New Jersey / SE New York[m] (n = 48)	Hemlock-white pine-northern hardwoods/ oak chestnut	-	-	662 ± 310	37 ± 9	-	9 ± 11°	-	119 ± 183	172 ± 115	1335 ± 568
N New Jersey / SE New York[n] (n = 16)	Hemlock-white pine-northern hardwoods/ oak chestnut	-	89 ± 7	707 ± 257	37 ± 6	-	9 ± 7°	-	264 ± 117	-	1052 ± 635

[a] McGowan (1975)
[b] Whitford (1991)
[c] Hayward and Escano (1989)
[d] Reynolds et al. (1982)
[e] Moore and Henny (1983)
[f] McAdoo and Bokich (1991)
[g] Hennessy (1978)
[h] Shuster (1980)
[i] Saunders (1982)
[j] Hall (1984)
[k] Kennedy (1988)
[l] Crocker-Bedford and Chaney (1988)
[m] Speiser and Bosakowski (1987)
[n] Bosakowski et al. (1992) - subset of Speiser and Bosakowksi (1987)
[2] No preference for aspect

Table 3 Number of young fledged per nest attempt of goshawks in various states and two countries in Europe. (studies ranked in order of productivity).

Location	Years	[Productivity] Number fledged	Number of nests	Source
Utah	1979-85	3.0	10	D. Fischer et al. unpubl. data
Idaho	1990	2.2	12	Patla (1991)
Nevada	1976-81	2.2	88	Herron et al. 1985
Alaska	1971-73	2.0	33	McGowan (1975)
California	1981-83	1.7	127	Bloom et al. 1986
Oregon	1969-74	1.7	48	Reynolds and Wight (1978)
Utah/Idaho	1973-74	1.4	10	Hennessy 1978
New Mexico	1984-85	0.69	11	P. Kennedy unpubl. data
Denmark	1937-40	1.8	9	Holstein 1942
Finland	1955-58	1.5	28	Hakila 1968

Table 4 Representative prey species of the goshawk (*Accipiter gentilis*) in North America[1] (Table from Jones 1979, with additions from Duncan and Kirk 1995; * denotes most important prey species).

BIRDS
Mallard *Anas platyrhynchos*
Blue-winged Teal *Anas discors*
American Kestrel *Falco sparverius*
Blue Grouse *Dendragapus obscurus*
* Ruffed Grouse *Bonasa umbellus*
* Spruce Grouse *Dendragapus canadensis*
Willow Ptarmigan *Lagopus lagopus*
* Northern Bobwhite *Colinus virginianus*
Mountain Quail *Oreortyx pictus*
* Ring-necked Pheasant *Phasianus colchicus*
Band-tailed Pigeon *Columba fasciata*
Rock Dove *Columba livia*
Common Nighthawk *Chordeiles minor*
Northern Flicker *Colaptes auratus*
Pileated Woodpecker *Dryocopus pileatus*
Blue Jay *Cyanocitta cristata*
* Steller's Jay *Cyanocitta stelleri*
* American Crow *Corvus brachyrhynchos*
* American Robin *Turdus migratorius*
Yellow-rumped Warbler *Dendroica coronata*
* Blackbirds *Agelaius* spp., *Euphagus* sp., *Quiscala* sp.
Savannah Sparrow *Passerculus sandwichensis*

MAMMALS
California Mole *Scapana latimanus*
Belding Ground Squirrel *Citellus beldingi*
* Arctic Ground Squirrel *Citellus undulatus*
* Golden-mantled Ground Squirrel *Spermophilus lateralis*
Thirteen-lined Ground Squirrel *S. tridecemlineatus*
* Richardson's Ground Squirrel *S. richardsonii*
Eastern Chipmunk *Tamias striatus*
* Townsend Chipmunk Eutamias townsendi
Eastern Gray Squirrel *Sciurus carolinensis*
* Western Gray Squirrel *Sciurus griseus*
* Red Squirrel *Tamiasciurus hudsonicus*
* Chickaree *Tamiasciurus douglasi*
Northern Flying Squirrel *Glaucomys sabrinus*
Boreal Redback Vole *Clethrionomys gapperi*
* Snowshoe Hare *Lepus americana*
* Eastern Cottontail *Sylvilagus floridanus*
Mountain Cottontail *Sylvilagus nuttali*

[1] Not all prey species reported in literature are listed. Sources for food habits are: Clabaugh (1932), Bent (1937), Bloom et al. (1986), Bond (1940), Ingles (1945), Alexander (1947), Schnell (1958), Ammann (1959), Meng (1959), Eng and Gullion (1962), Shuster (1980), Storer (1966), Snyder et al. (1973), Snyder and Wiley (1976) and Woodbridge et al. (1988).