PETITION TO LIST THE QUEEN CHARLOTTE GOSHAWK *Accipiter gentilis laingi* AS A FEDERALLY ENDANGERED SPECIES

May 2, 1994

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Mr. Bruce Babbitt
Secretary of the Interior
Department of the Interior
18th and "C" Street, N.W.
Washington, D.C. 20240

Dear Mr. Babbitt,

The Southwest Center for Biological Diversity, the Greater Gila Biodiversity Project, the Biodiversity Legal Foundation, Greater Ecosystem Alliance, Save the West, Save America's Forests, Native Forest Network, Native Forest Council, Peter Galvin, Eric Holle, and Don Muller hereby formally petition to list the Queen Charlotte goshawk (*Accipiter gentilis laingi*) as endangered pursuant to the Endangered Species Act, 16 U.S.C. 1531 et seg. This petition is filed under 5 U.S.C. 553(e) and 50 C.F.R 424.14(a) which grant interested parties the right to petition for issue of a rule from the Assistant Secretary of the Interior.

Petitioners also request that Critical Habitat be designated for the Queen Charlotte goshawk concurrent with the listing, pursuant to 50 C.F.R 424.12, and pursuant to the Administrative Procedures Act 5 U.S.C. 553.

Petitioners understand that this petition action sets in motion a specific process placing definite response requirements on the U.S. Fish and Wildlife Service and very specific time constraints upon those responses.

Petitioners

The *Southwest Center for Biological Diversity* is dedicated to protecting and restoring the Southwest's island forests and desert rivers by aggressively advocating for every level of biotic diversity, from butterflies to jaguars. This petition is part of the Center's ongoing efforts to conserve goshawks throughout the West.

The *Greater Gila Biodiversity Project* is dedicating to protecting and restoring the ten million acre Gila Headwaters Ecosystem and the sixty million acre Gila Watershed. It has advocated for goshawk conservation throughout the West since 1989.

The *Biodiversity Legal Foundation* is dedicated to preserving all native wild plants and animals, communities, and naturally functioning ecosystems in the United States. It co-authored a recent petition to list the Alexander Archipelago wolf, which shares habitat with the Queen Charlotte goshawk, as an Endangered Species.

The *Greater Ecosystem Alliance* works to protect wildlands and biological diversity in the Northwestern United States and British Columbia.

Save the West, publisher of *Wild Forest Review,* advocates for permanent, large-scale protection of western forests.

Save America's Forest is a nationwide campaign to protect and restore America's wild and natural forests. It has over 500 member groups.

Native Forest Network is a coalition of grassroots activists fighting to restore temperate forests in the United States, Canada and throughout the world.

Native Forest Council is based in Eugene, Oregeon. It advocates for the protection of forests throughout the United States and an end to commercial logging on public land.

Eric Holle is a self-employed field biologist working with endangered species and a fisheries technician employed by the Alaska Department of Fish and Game. He lives and travels extensively in Southeast Alaska studying wildlife. He co-authored the Alexander Archipelago wolf petition.

Don Muller lives in Sitka Alaska where he works with the Sitka Conservation Society.

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SYSTEMATICS

TAXONOMY

Eight northern goshawk (*Accipiter gentilis)* subspecies inhabit the Northern Hemisphere (Johnsgard 1990), while only three occur in North America: the Queen Charlotte goshawk (*A.g. laingi*), the Northern goshawk (*A.g. atricapillus*) and the Apache goshawk (*A.g. apache*). The subspecific validity of *A.g. laingi* is widely recognized (Taverner 1940, AOU 1957, Brown and Amadon 1968, Wattel 1973, Jones 1979, Johnson 1988, Palmer 1988, Webster 1988, Johnsgard 1990, Marshall 1992), never having been challenged in the scientific literature.

Members of the *Accipiter gentilis* species are called "northern goshawks." In Persian literature, it is Baz-Nama, the King Hawk. *A.g. laingi* is known as the "Queen Charlotte goshawk." No other common names are known. The Linnaean, *gentilis*, dates back to the "Falcon Gentle" of British mediaeval falconry. This falcon was in all probability not a goshawk, but a peregrine or gyrfalcon as goshawks are somewhat less than gentle. They are, in fact, known for being extremely fierce and aggressive. Northern goshawks will attack wolves, bears and even human which stray to close to an active nest.

EVOLUTIONARY HISTORY

Sibley, Ahlquist and Monroe (1988) place hawks, eagles and falcons within the infraorder *Falconides*, of the order *Ciconiiformes*. Falconiform raptors are likely to have evolved in the late Mesozoic or early Cenozoic eras (Feduccia 1980). Biochemical hybridization measurements suggest Accipitridae (which includes sharp shinned and Cooper's hawks as well as goshawks) and Falconidae (caracaras and falcons) probably diverged from one another about 68 million years ago (Sibley and Ahlquist 1985).

Wattel (1973) suggests that the northern goshawk is of Old World origin and may have recently colonized the New World. By contrast, fossilized hawks or eagles have been dated from the early to middle Oligocene in the America's (Feduccia 1980).
Close relatives of *gentilis* exist in Africa (*A. melanoleucus*) and Madagascar (*A. Henstii*) (Johnsgaard 1990). Primitive, ground feeding, Accipiter-like "chanting goshawks" (*Melierax*) can still be found in Africa and Arabia.

DISTRIBUTION

The geographic range of the Queen Charlotte goshawk extends from the Olympic Peninsula of Washington State to northern Southeast Alaska in the vicinity of Taku Inlet near Juneau, (Jewett *et al.* 1953, AOU 1957, Beebe 1974, Webster 1988, Johnson 1989, Flatten *in* Gustafson 1991a, Meehan-Martin in Gustafson 1991b, Campbell *et al.* 1993, see Figure 1). Jewett *et al*. (1953) believe *A.g. laingi* to be the breeding subspecies as far south as western Oregon. Though data are lacking, the subspecies appears to be largely absent from the British Columbia mainland coast.

The populations on the Olympic Peninsula, Vancouver Island, the Queen Charlotte Islands, the north coast islands of British Columbia, the southern Alexander Archipelago and the northern Alexander Archipelago show some degree of geographic and genetic distinction. Due to geographic proximity and lack of obvious barriers, we believe there is probably some

Figure 1. Geographic Range of the Queen Charlotte Goshawk (Johnsgard 1991).

mixing of the southern and northern Alexander Archipelago populations; less, possibly none between the Queen Charlotte Islands and north coast islands populations; and little or no mixing between the Olympic Peninsula and Vancouver Island populations. Each of these groups appears to be entirely isolated from the others.

The Queen Charlotte goshawk breeds on the mainland Alaska coast immediately adjacent to a relatively dense island population near Juneau. It is also known to breed on the mainland British Columbia coast north of the city of Vancouver, immediately adjacent to Vancouver Island. The breeding subspecies along the rest of the B.C. mainland coast is thought to be *A.g. atricapillus* (Beebe and Ethier pers. comm.). The northernmost Queen Charlotte goshawk population exhibits gradation with *A.g. atricapillus*, and it is likely that the Vancouver Island population is genetically swamped by *atricapillus* as it extends itself onto the mainland.

DESCRIPTION

Descriptions of the Queen Charlotte goshawk appear in Taverner (1940), AOU (1957), Beebe (1974), Webster (1988), Johnson (1989), and Crocker-Bedford (1990a, 1992). Mature adults have a black cape extending from the back of the head to nearly the mid-point of the back before lightening to a dark leaden gray. The close barring of the underside is darker and coarser than that of *A.g. atricapillus*, with the shaftline marks wider and black, rather than gray. Immatures are similarly much darker, the only real white anywhere being the eyebrow line, nape feathers, and the undertail plumes.

A.g. laingi is most distinct as a subspecies in the Queen Charlotte Islands and southern southeast Alaska. Webster (1988) determined that specimens collected north of there, on Baranof Island and Taku Inlet, were "not quite as black." Similarly, Beebe (1974) found birds south of there, on Vancouver Island, to be "almost as dark." *A.g. atricapillus* becomes progressively darker moving northward along the British Columbia coast, but never attains the darkness of *A.g. laingi* (Beebe pers. comm.).

The Queen Charlotte goshawk has been alternately described as smaller, larger and equal in size to *A.g. atricapillus* (c.f. Beebe (1974) and Johnson (1989)). Geographic discrimination, however, reveals a consistent increase in size from the Olympic Peninsula to the northern Alexander Archipelago.

Seventeen Queen Charlotte goshawks captured and radio tagged on the Olympic Peninsula were very small (Flatten pers. comm.). Queen Charlotte goshawks from Vancouver Island have been described as fully one-third smaller than Southeast Alaska birds (Beebe 1974 and pers. comm.). Tom Ethier, raptor specialist with the British Columbia Ministry of the Environment observed a dark, Cooper's hawk sized goshawk in the Nimpaish Valley on northern Vancouver Island in 1993 (pers. comm.). Beebe, who has handled 50 of these birds, believes the size difference is great enough to warrant full subspecific status to the Olympic Peninsula/Vancouver Island birds. Differences measured by morphometric skin sample analysis, however, do not appear great enough to support this claim (Lawrence pers. comm).

Queen Charlotte goshawks from the Queen Charlotte Islands and the southern Alexander Archipelago are reported to be equal in size to *A.g. atricapillus* while birds from the northern Alexander Archipelago and the adjacent mainland near Juneau are reported to be slightly larger.

Adult male and female northern goshawks are sexually dimorphic with females being larger than males. Storer (1966) believes this adaptation reduces intraspecific competition, maximizing differential prey usage between the sexes. Telemetry studies have shown surprisingly little overlap between male and female Queen Charlotte goshawk nesting and home ranges (see ADFG 1993c and references therein).

FIGURE 2. QUEEN CHARLOTTE GOSHAWK (BEEBE 1974).

NATURAL HISTORY

METHODOLOGICAL NOTE

Comparatively little field data exists on the natural history and ecology of the Queen Charlotte goshawk. When available, we base analyses on such data. When not available, we refer to the more extensive Northern goshawk literature. The assumption that the two subspecies have similar, though not necessarily equivalent, natural histories is borne out by field observations cited below. All uses of "goshawk" refer to the Northern goshawk. All references to the Queen Charlotte subspecies use the full common name or the trinomial.

REPRODUCTION

NESTING ECOLOGY. Goshawk nest building may begin up to two months before egg laying but typically occurs later (Johnsgard 1990, Marshall 1992). Nests are built of sticks and are typically 18 to 20 inches in diameter and 10 inches high (Palmer 1988). Very large nests can be three to four feet across and two feet high (Bent 1937). Active nests are topped with fresh conifer sprigs each breeding season (Schnell 1958).

Nests are placed high, at the base of the canopy of dominant trees (Crocker-Bedford and Chaney 1988) and are "typically placed on large, horizontal limbs either against the trunk or on large limbs up to 4 m from the trunk. With few exceptions, nests were located in one of the larger trees at the nest site" (Reynolds *et al.* 1982).

Along with their currently occupied nest, goshawks may maintain up to three or four alternate nests which may be used in alternate years. Reynolds and Wight (1978) found most nests at the nest site to be 200 to 300 feet apart. Crocker-Bedford (1990) reports they are usually within 1,000 feet of one another, but may be up to 3,300 feet apart. Patla (1991) found distances between nests on the Targhee National Forest to be between 100 ft and 0.7 miles. Woodbridge (1988) found the median distance between nest sites in the southern Cascades to be 778 ft with nearly a quarter of the pairs moving up to 1.7 miles between nests. They correlated distances moved with degree of forest fragmentation.

BROOD CHRONOLOGY. Nests in southern Oregon are usually initiated in early April, though a pair was found on its nest site on March 23 (Reynolds and Wight 1978). Northeast Oregon clutches were completed between April 12 and May 6 with considerable annual variation (Henny *et al.* 1988). Southern Oregon clutches were completed between April 10 and June 2 (Reynolds and Wight 1978). Eggs are laid in two to three day intervals with replacement clutches emerging 15 to 30 days after initial laying (Johnsgard 1990).

Clutch sizes of about 3.2 eggs have been found in Oregon, Alaska and Scandanavia (Marshall 1992). Incubation lasts from 30 to 32 days. One or two eggs frequently do not hatch.

Goshawk nestlings remain in the nest 42 to 47 days after hatching (Schnell 1958). While in the nest, they are fed by the female with food brought mainly by the male. Smaller males fledge before females. Fledglings use perches near the nest for 34 to 37 days and are dependent upon their parents for up to 42 additional days (Reynolds and Wight 1978). Radio-telemetry study of one pair of Queen Charlotte goshawks indicates the female stops feeding the young only a few days after fledging while the male continues to forage for them until dispersal (ADFG 1993a).

PRODUCTIVITY. Goshawk productivity has been correlated with availability of mature forests (ADGF 1993). The North Kaibab Ranger District on the north side of the Grand Canyon produced 49 successful goshawk nests in 1992 with an average of 2.16 young per nest (Reynolds *et al.* 1993). The South Kaibab Ranger District on the south side of the Grand Canyon produced only 16 successful nests with an average of 1.1 young per nest (McGuinn-Robbins and Ward 1992). The North Kaibab District has much more mature, closed canopy forest than the South Kaibab District which is dominated by younger, thinned stands.

A separate analysis of 53 territories on the North Kaibab Ranger District revealed an inverse correlation between productivity and amount of timber harvest (see Table 1).

TABLE 1. GOSHAWK PRODUCTIVITY IN RELATION TO TIMBER HARVEST ACTIVITY ON THE NORTH KAIBAB RANGER DISTRICT, ARIZONA (CROCKER-BEDFORD 1991).

No. Territories	Amount of Territory Harvested	No. Nestlings
14	O%	1.57
12	10-39%	0.75
16	40-69%	0.31
11	70-90%	0.00

REOCCUPANCY. Reynolds and Wight (1978) found nest reocuppancy in Klamath County, Oregon to be 43% at two years, 41% at three years, 29% at four years and 25% at five years. Crocker-Bedford and Chaney (1988) found that in the year nests were first located, 45% were occupied (a greater percentage due to occupied nests being easier to find); whereas 1, 2, and 3 years after, nest location occupancy rates were 32, 28, and 26%. Crocker-Bedford (1990) found that in the absence of habitat alteration, reoccupancy a decade after nest location was just as likely as reoccupancy 1 to 6 years after location. Woodbridge (1988) found high turnover, but more consistent reoccupancy rates in larger stands of trees. Patla (1991) found 51% reoccupancy of nests in undisturbed/preharvest locales but only 10% reoccupancy in harvested locales.

Reoccupancy of territories is predictably higher since occupied territories contain several alternate nests, but only one active nest. Territory reoccupancy is therefore probably a better measure of habitat usage than nest reoccupancy. Crocker-Bedford (1991) found territory reoccupancy to be inversely correlated with harvest levels (see Table 2).

Using aerial photography, Ward *et al.* (1992) correlated reocuppancy with canopy

closure. Territories active 1986-1989 were more likely to be occupied in 1991 if they were not harvested or only lightly harvested. Reoccupied territories had less forest in the 20-40% canopy closure range and more forest in the 40-60% closure range than did unoccupied territories.

TABLE 2. GOSHAWK TERRITORY REOCCUPANCY IN RELATION TO TIMBER HARVEST ACTIVITY ON THE NORTH KAIBAB RANGER DISTRICT, ARIZONA (CROCKER-BEDFORD 1991).

Percentage of Home Range Selectively Harvested	Mean Reoccupancy Rate
0%	79%
25%	42%
50%	31%
75%	9%

Queen Charlotte goshawk reoccupancy rates are very low compared to Northern goshawk reoccupancy rates (see Table 3). Only 4 of 26 (15%) territories which definitely or probably supported nesting Queen Charlotte goshawks as of 1992 were reoccupied in 1993 (see Table 12). This includes territories in which habitat remains suitable.

TABLE 3. COMPARISON OF GOSHAWK REOCCUPANCY RATES.

Location	Nest Stand Reoccupancy	Nest Reoccupancy	Source
N. California	73%	44%	Dietrich and Woodbridge 1993; Woodbridge and Dietrich 1993
N. Arizona (unlogged sites)	80%	30%	Crocker-Bedford 1990b, 1991
SE Alaska	8%	8%	See Table 8

Low reoccupancy rates, especially in suitable habitat, are indicative of a population declining in response of habitat fragmentation (Lamberson et al. 1992; Lande 1987, 1988; Levins 1969, 1970). As landscape level fragmentation increases, suitable stands are less likely to be occupied because they are more difficult to find.

MORTALITY

Seven Queen Charlotte goshawks from two families were radio-tagged and tracked in 1992 (ADFG 1993). Of the four adults, one male was killed (apparently by another raptor) and one female is also likely to have died though her remains were never recovered. Of the three juveniles, 1 was found dead and the other two disappeared from radio contact. An additional emaciated, female juvenile was rehabilitated in 1992 but was later found dead in an emaciated state. Though data are limited, it is possible that Queen Charlotte goshawks have a very high mortality rate. It is not clear whether this mortality rate is natural or an anthropogenic effect.

FORAGING HABITS

HUNTING STRATEGY. In contrast to buteos, which tend to be open-forest and forest-edge hawks, goshawks have short, rounded wings and long tails (Bent 1937, Phillips *et al.* 1964, Mavrogordato 1973, Parry and Putman 1979, Cade 1982, Fredrick II, Grossman *et al.* 1988, Brown and Amandon 1989, Reynolds 1989, Snyder and Snyder 1989, Reynolds *et al.* 1991). They also have strong, feathered eye-guards. These characteristics, well suited to its aggressive hunting strategy, suggest the goshawk has evolved to hunt among the well spaced trunks of mature canopied forests. Goshawks are extremely agile and capable of remarkable bursts of speed. Their short wings enable quick movement while their long tails acts as rudders for precise, quick turns. Eye-guards protect the goshawk's eyes as it speeds through the forest understory in pursuit of its prey (see Johnsgard 1990). Sparseness of shrubs and small trees appear to favor goshawk flight ability (Moore and Henny 1983, Speiser and Bosakowski 1987, Crocker-Bedford 1990b, Warren *et al.* 1990, Reynolds *et al.* 1991) and prey vulnerability (Reynolds and Meslow 1984, Speiser and Bosakowski 1987, Reynolds 1989, Gullion 1990, Crocker-Bedford 1990b, Warren *et al.* 1990).

Goshawks are "short sit-and-wait" predators (Beebe and Webster 1989, Brown and Amadon 1989, Grossman *et al.* 1988, Johnsgaard 1990, May 1935, Palmer 1988, Phillips *et al.* 1964, Fredrick II 1981). They perch in low hidden spots then burst out, quickly traveling a short distance to take their unsuspecting prey. Perches are only occupied for a short time, allowing goshawks to hunt over a large area.

Captured prey are taken to one of a number of plucking posts or sites where they are eaten. Plucking posts are typically stumps, fallen trees, rocks, or large horizontal branches (Schnell 1958, Reynolds and Meslow 1984).

PREY BASE. Goshawks select relatively large prey. Half the biomass of goshawks studied in Oregon came from birds larger than 200 grams (large woodpeckers, owls, pigeons, quail, grouse and ducks) and from mammals larger than 450 grams (large squirrels, rabbits and

hares) (Reynolds and Meslow 1984). Small squirrels, flickers, jays, thrushes and ptarmigans are also important prey items (Reynolds and Meslow 1984, Johnsgard 1990).

The Queen Charlotte Goshawk, inhabiting wetter forests than other goshawks, has a much more limited prey base (see Table 4). In the Queen Charlotte Islands, it takes many Northwestern crows (*Corvis caurinus*), while feeding predominantely on Steller's jays (*Cyanocitta stelleri*) and varied thrushes (*Ixoreus naevius*) on Vancouver Island (Beebe 1974). Crows are a major part of the Queen Charlotte's diet near Juneau, while on Sumez Island they are known to eat Steller's jays, greater yellowlegs (*Tringa melanoleuca*) and Franklin's spruce grouse (*Dendragapus canadensis franklinii*) (Crocker-Bedford 1992, ADFG 1993c). Major prey items are closely associated with old growth forests or coastal forest edges (see Table 4).

Just as goshawk population densities appear to be considerably lower in Southeast Alaska than elsewhere, prey base densities are lower as well, especially in Winter. Many mammals which are common elsewhere and important components of goshawk diets are absent from Southeast Alaska's temperate rainforest. These include the snowshoe hare (*Lepus americanus*), the mantled ground squirrel (*Citellus lateralis*), chipmunks (*Tamias* sp.) and cottontail rabbits (*Sylvilagus* sp.) (ADFG 1993c).

Grouse species may be a particularly important prey items for the Queen Charlotte goshawk. Grouse remains were found at five of six nest sites examined in 1990-1992. Falconers on Vancouver Island report that about 95% of observed goshawk prey remains are grouse (Ethier pers. comm.). Johnsgard (1990) suggests gallinaceous species such as grouse are generally the most important avian component of goshawk diets. Other authors (Beebe 1974, McGowan 1975, Reynolds *et al.* 1992) concur that grouse are very important goshawk prey items. Grouse are non-migratory and closely associated with old-growth habitats in southern Southeast Alaska. Mature and old-growth forests, especially those with large amounts of downed woody material and closed canopies, tend to support greater prey productivity (Goodwin and Hungerford 1979, Patton 1975, 1984; Vahle and Patton 1983, Patton *et al.* 1985, Crocker-Bedford and Chaney 1988, Siegel 1989, Crocker-Bedford 1990b, Warren *et al.* 1990, Reynolds *et al.* 1991).

Prey availability may help explain the distribution of goshawks in Southeast Alaska. Queen Charlotte goshawks appear to nest in greater densities in northern Southeast, generally on or near the mainland coast. They also appear to have smaller home ranges (Flatten pers. comm.). The forests of northern Southeast are much more contiguous and support a more diverse prey base. Blue grouse and rock ptarmigan are relatively common there but are absent from southern Southeast. The grouse species available in southern Southeast (Franklin's spruce grouse) is rare.

Many bird species which serve as non-winter prey items migrate out of the Queen Charlotte goshawk's winter range including varied thrushes, greater yellowlegs, and sharp-shinned hawks. Other birds (*Alcid* sp., cavity nesting ducks, etc.) are year-round residents of Southeast Alaska but may be unavailable in the winter because they do not use forest habitats outside their breeding season

TABLE 4. PREY REMAINS COLLECTED AT SIX QUEEN CHARLOTTE GOSHAWK NESTS 1990-1992 (ADFG 1993C).

PREY SPECIES	P.O.W. Island	Suemez Island	Etolin Island	Kupreanof Island	Douglas Island	Point Bridget

Alcid sp.						X						
Waterfowl sp.	X											
Greater Yellowlegs			X									
Shorebird sp.									X			
Franklin's Grouse	X		X									
Blue Grouse						X			X		X	
Sharp-shinned Hawk		X										X
Belted Kingfisher	X											
Red Breasted Sapsucker		X										
Woodpecker sp.	X					X						
Northwestern Crow	X											
Steller's Jay	X		X		X		X		X		X	
Varied Thrush	X		X			X						
Unidentified Bird	X		X		X		X		X		X	
Red Squirrel				X								
Unidentified Mammal	X		X		X		X		X		X	

TABLE 5. QUEEN CHARLOTTE GOSHAWK PREY ITEMS.

SPECIES	HABITAT	IMPORTANCE	RANGE
Blue Grouse	Open conditions during breeding season, closed during winter Johnsgard (1983); in SE Alaska, old-growth forests throughout the year (Doerr *et al.* 1984 in Winter 1993); eliminated by clearcutting on Vancouver Island (Zwickel and Bendell 1984).	Important; large (≈kilogram); available year-round in Southeast Alaska.	Low densities on Revilla Island, mainland coast and the northern Alexander Archipelago; absent from southwestern Alexander Archipelago; much more common on Vancouver Island (Bendell 1955).
Franklin's Spruce Grouse	More closely associated with old growth forests Blue grouse (Johnsgard 1983); dependent upon mature spruce forests in SE Alaska (ADFG 1993e).	Important; large (≈kilogram); available year-round in Southeast Alaska.	Rare endemics; found on Prince of Wales (Gabrielson and Lincoln 1959), Mitkof and Sumez islands (ADFG 1993e).
Northern Flickers	Use variety of forests but prefer mature forests (Reynolds *et al.* 1992); dependent upon snags which are most prevalent in old growth forest (USFS 1993c).	Less important; medium (≈200 grams); may be less available in winter	Rare in SE Alaska.
Red-breasted Sapsucker		Less important; medium sized; may be less available in winter	Common in SE Alaska.
Sea Birds	Open water.	Not important; large but available only at forest edge.	Common throughout range.
Northwestern Crow	Marine shore and adjacent forests.	Important; relatively large; available year-round.	Common in SE Alaska
Steller's Jay	Variety of forest structures (Franzreb and Ohmart 1978, Reynolds *et al.* 1992).	Important; small (100 grams); abundant in summer; available in winter	Common throughout range.
Rock Ptarmigan	Skree fields and avalanche chutes	May be important; large; available year-round	Found only in northern SE Alaska
Varied Thrush		Less important; small; abundant in summer; available in winter	Abundant in SE Alaska
Red Squirrel	Mature forests (Patton and Green 1970, Patton 1975, 1984; Sullivan and Moses 1986).	Important; large (≈300 grams)	Introduced on some SE Alaska islands.

HABITAT USE

GENERAL. Being a rare subspecies, the Queen Charlotte goshawk has infrequently been observed. Reports, however, generally concur with Crocker-Bedford's (1990a) assertion that its habitat needs are similar to *A.g. atricapillus*. Goshawk literature is relatively consistent in strongly associating goshawk nesting in the United States with extensive forests or large stands of mature and old-growth trees:

> (Bent 1937, Bartelt 1977, Hennessy 1978, Shuster 1980, Jones 1981, Reynolds *et al.* 1982, Saunders 1982, Moore and Henny 1983, Reynolds 1983, 1989; Mannan and Meslow 1984, Hall 1984, Bloom *et al.* 1985, Herron *et al.* 1985, Crocker-Bedford 1987, 1990a, 1990b, 1991, 1992; Speiser and Bosakowski 1987, Woodbridge 1988, Fowler 1988, Kennedy 1988, 1989; Hayward and Escano 1989, Falk 1990, Warren *et al.* 1990, Patla 1990, 1991; Zinn and Tibbitts 1990, Ward *et al.* 1992).

These forests provide ample perches, hiding cover, prey, protected nests sites, sparse understories, and well spaced tree trunks.

NESTING HABITAT. "Preferred habitat during the breeding season is older, tall forests---deciduous, coniferous and mixed---where goshawks can maneuver in and below the canopy while foraging and where they can find large trees in which to nest" (Reynolds 1989). Crocker-Bedford and Chaney (1988) similarly found a nesting preference for large trees with dense canopies. Goshawks in Connecticut show a significant preference for nest sites far from forest clearings (average distance to clearing = 6 miles)-- farther than any other hawks (Falk 1990). Extent of forest was also found to be important in New York (Speiser and Bosakowski 1987). In Pennsylvania, goshawks selected heavily forested landscapes (Kimmel and Yuhner 1993).

In contrast, goshawk nests in northern Idaho and Montana were found to average only .25 miles from forest openings larger than 3 acres (Hayward and Escano 1989). The authors noted, however, that their results were probably skewed by the fact that many of the nests were found during logging operations.

Non-quantitative descriptions of Queen Charlotte goshawk nest sites and/or areas where Queen Charlotte goshawks have been observed generally support the thesis that the subspecies is closely associated with contiguous, high volume old growth stands (see Table 6).

Table 6. DESCRIPTIONS OF QUEEN CHARLOTTE GOSHAWK NESTING AREAS.

Port Refugio	"The [perch] tree was about 80 feet tall, and was the tallest tree standing for about 100 feet in any direction. The [western hemlock] tree was defoliated from the top down 15-20 feet"[6]. Canopy cover at both nests is 90%[11]
Sarkar Lake	Nest stand "dense"[11]. One of the most important old-growth areas remaining on Prince of Wales. "Much of the Sarkar drainage is uncut, but some of the best quality forested areas in the Sarkar have already been logged, and much of the remaining unroaded area is muskeg"[7]. Fifty acres of old-growth between the Lake and the coast were recently and illegally logged, "what remains are two fragmented tracts of old-growth which clearly have reduced wildlife values and are in turn subject to more wind throw"[8].
Sarheen	"unfragmented habitat"[2].
Hatchery Lake	"Honker Divide, though long and narrow in configuration, also has suitable habitat for hawks and owls and is another area important for maintaining viable levels of species diversity"[7].
Thorne River	"Honker Divide, though long and narrow in configuration, also has suitable habitat for hawks and owls and is another area important for maintaining viable levels of species diversity"[7].
Starfish	nest stand surrounded by muskeg and low volume timber[11].
Kake	"The entire area is densely forested old-growth, consisting of a mixture of Sitka spruce, hemlock, and yellow cedar"[4]. Nest 30-50 ft up in 26" dbh hemlock[4].
Big John Creek	nest in high volume timber stand[11].
Dewey Lake Trail	"Apparently, cottonwood and other deciduous trees are mixed with conifers in this area"[5].
Admiralty Island (Ward & Florence Creeks)	"(T)he nests are in spruce corridors along stream buffer areas or along boundary adjacent to clearcut"[9].
Douglas Sale Area	"...nest in a 35 dbh hemlock, 50 feet up, and in the forest"[10]- presumably a description of Ready Bullion, Blueberry Hill or Eagle Creek.
Ready Bullion	nest stand in high volume second growth[11].
Blueberry Hill	nest stand in high volume second growth[11].
Eagle Creek	nest stand in high volume second growth[11].

Sources: [1]ADFG 1993d, [2]ADFG 1991,[4]Gustafson 1990, [5]Gustafson 1990c, [6]Gustafson 1991d, [7]Gustafson 1989; [8]ADFG 1989; [9]Schenck 1993; [10]Blatt 1993; [11]Winter 197

FORAGING HABITAT. Radio telemetry studies in Utah (Fisher 1986) and California (Austin 1991, Austin 1993, Hargis *et al.* 1993) found goshawks selecting tall, mature and overmature trees as foraging substrates. Whether this is primarily a preference for arboreal structure or for prey abundance has been a matter of some contention. The Forest Service's Goshawk Scientific Committee (Reynolds *et al.* 1991) argued that goshawks are habitat generalists and prey specialists, selecting habitats with numerous prey species and individuals. A field study by Fischer and Murphy (1992), however, suggests that goshawks select for foraging areas where they are able to maneuver deftly beneath a dense canopy in conditions where prey are vulnerable. Such selection is for forest structure (= prey vulnerability), not prey abundance. Crocker-Bedford and Chaney (1988) also believe foraging preference is primarily for large trees with dense canopies. This conclusion is supported by literature suggesting that the incursion of smaller trees after timber harvesting, which create a thickety understory, may reduce goshawk ability to hunt successfully (Reynolds 1989, Gullion 1990, Crocker-Bedford 1990b). Fischer and Murphy's (1986) radio-telemetry study found Utah goshawks to be selecting for mature forest structure rather than prey abundance.

The methods and interpretations used by the Goshawk Scientific Committee (Reynolds *et al.* 1991) to conclude that goshawks are habitat generalists and prey species specialists have been rigorously challenged by the U.S. Fish and Wildlife Service and the Arizona Game and Fish Department (USFWS 1992d, AGFD 1992, 1993). Their major point is that the committee confuses habitat *structure* with habitat *type*. While goshawks are known to use a variety of habitat types, they consistently choose for a habitat structure characterized by large trees, dense canopies, and relatively open understories. It should also be noted that the Scientific committee's prey base conclusions were based upon field studies in managed forests.

Openings near old-growth forests may be used for foraging if they support high densities of prey species. The location of some nest sites suggest that the Queen Charlotte goshawk may prey upon dense seabird concentrations on the outer islands, waterfowl in estuaries, and in muskegs (Crocker-Bedford 1990a). Prey found in open areas, however, are unlikely to contribute the majority of the bird's diet due to ecological niche separation and known adverse effects of competition with raptors favoring open situations (Crocker-Bedford 1990a, 1990b). The Queen Charlotte goshawk is better adapted to forest situations.

A radio-telemetry study of two adult, nesting Queen Charlotte goshawks found a significant preference for productive old growth (ADFG 1993). Of 94 independent relocations within their home ranges, 100% of the male's and 91% of the female's relocations were in productive old growth with at least 8,000 board feet/acre (volume class 4, 5, 6 or 7). This shows a significant preference since only 54.6% and 40.2% respectively of the male and female's home ranges contained such productive old growth. A significant preference was also found for volume class 5 forests (20-30,000 board feet/acre). Fifty six percent of the male's and fifty two percent of the female's independent relocations were in class 5 forests though these comprised only twenty one and thirteen percent of their respective home ranges. Both birds generally avoided unforested areas and stands with less than 8,000 board feet/acre.

Thirty Queen Charlotte goshawks, including seven breeding pairs were radio-tagged and tracked in 1993 (Flatten pers. comm.). Eighty nine percent of 667 relocations were in old growth stands, ninety two percent of those were in commercial timber stands with greater than

eight thousand board feet per acre. Goshawks in northern Southeast Alaska were also relocated in alpine areas and on rock faces, where they were probably hunting rock ptarmigan.

HOME RANGE AND TERRITORY

Northern goshawks defend a 20-25 acre area around active nests against human intrusion (Reynolds 1983), and a larger area surrounding alternate nests against other raptors. The territory defended against conspecifics may be larger than that defended against humans (Crocker-Bedford 1992). All of 34 territories found on the Targhee National Forest were located at least two miles from known neighboring territories; most were at greater distances (Patla 1991).

Home ranges appear be larger than defended territories. Literature as of 1983 showed goshawk home ranges to cover 5,000 and 8,000 acres (Reynolds 1983). In a fragmented forest, home range sizes as large as 17,000 acres have been recorded (Austin 1991, 1993). In high quality, contiguous habitat, home ranges may be smaller and show a high degree of overlap between pairs. Pair density in uncut and very lightly cut forests in northern Arizona was one pair per 1,100 acres (Crocker-Bedford 1990b).

In 1992, the Alaska Department of Fish and Game radio tagged a pair of adult nesting Queen Charlotte goshawks at Sarkar Lake on Prince of Wales Island (ADFG 1993a). The results indicate that *A.g. laingi* in southern Southeast Alaska has very large nesting and home ranges (see Table 7), much larger than those recorded for *A.g. atricapillus*. Telemetry results from 30 birds tracked in 1993 showed geographical differences (Flatten pers. comm.). Home ranges varied from 4,700 to 288,000 acres. Home ranges were much larger in severely fragmented southern Southeast than in northern Southeast which contains much more wilderness and roadless acres.

TABLE 7. NESTING AND TOTAL HOME RANGE AREA (ACRES) OF SARKAR LAKE GOSHAWKS (ADFG 1992b).

	FEMALE	MALE	COMBINED
Nesting Home Range			
Land and Water	59,309	46,736	101,596
Land only	25,737	26,541	50,798
Total Home Range			
Land and Water	243,783	169,153	390,042
Land only	174,675	75,734	195,021

Large Queen Charlotte goshawk home ranges are not unexpected. Marshall (1992) cites research showing goshawk densities to be higher in southern areas and lower in northern areas

such as Alaska and Finland. Prey are more abundant and vulnerable in southern latitudes, so goshawk home ranges would be expected to be smaller in these locals.

At Sarkar Lake, the adult female began movements away from the nest into the northern portion of her range when the young fledged, whereas the adult male did not begin movements away from the nest until the juveniles dispersed. The area of overlap between the two birds was very small: 4.4% in the nesting home range and 5.9% in the total home range.

Though comparative data from adjacent radio-tagged home ranges is not available, researchers noted that the Sarkar Lake birds did not venture into the Sarheen Creek drainage which is suspected of supporting an adjacent pair of nesting goshawks (ADFG 1993c).

MOVEMENT

MIGRATION. Goshawks are not generally migratory (Brown and Amadon 1968, Reynolds 1989, Johnsgard 1990). Taverner (1940) and Gabrielson and Lincoln (1959) reported that Queen Charlotte goshawks are not migratory. Their conclusions were confirmed by a 1992 radio-telemetry study by the Alaska Department of Fish and Game (ADFG 1993a, 1993c). None of three Queen Charlotte goshawks successfully radio-tracked through the Fall and Winter of 1992 migrated from Southeast Alaska. The farthest distance traveled was 34 miles from the nest site.

ADULT MOVEMENT. Adult goshawks do not move their breeding locations and when non-migratory, are usually year-round residents on their territories, even in the northern limits of their range (McGowan 1975, Widen 1985). Goshawks mate for life and when migratory, return to the same territory year after year (Brown and Amadon 1968, Palmer 1988, Johnsgard 1990). Non-breeding, adult Northern goshawks without territories are also usually year-round residents (Widen 1985).

Though not migratory, goshawks in interior Canada may travel hundreds of miles south in search of food during some winters (Crocker-Bedford 1992). Goshawks in south-central Sweden, on the other hand, typically travel 60 miles or less under the same conditions (Widen 1985). Queen Charlotte goshawks do not appear to travel very far during winter food shortages (Beebe 1974 as cited in Johnsgard 1990).

A radio-telemetry study of a pair of Queen Charlotte goshawks found the birds to expand their home ranges after the nesting period (ADFG 1993a). Between the end of the nesting period (August 10, 1992) and the end of the post-nesting/winter residency period (March 10, 1993), the female expanded her range 411% and the male expanded his 362%. The greatest distance recorded from the nest was 34 miles for the female (December 3) and 19 miles for the male (October 13). Because the male continued to forage the fledglings, his range expansion occurred later than his mate's who did not appear to tend to the fledglings. This is consistent with female accipiter-like raptors in Central American who also expand their ranges early, leaving fledglings care to their mates (Craig Flatten pers. comm.).

Radio-tagged Queen Charlotte goshawks crossing from Prince of Wales Island to Heceta Island may have "island hopped," while another bird crossed two miles of open water over the

Gastineau Channel (ADFG 1993a).

JUVENILE DISPERSAL. Six of eight juvenile goshawks in Sweden dispersed over 30 miles (Widen 1985). Another, larger study in northern Sweden found only 44% of juveniles dispersed over 30 miles (Hoglund 1964 as cited in Widen 1985). Only 4% of juveniles in Germany dispersed more than 30 miles (Glutz *et al.* in Widen 1985). Average dispersal distances of 8 central Alaska juveniles was 12 miles (McGowan 1975). The majority of these records are based on winter sightings. If juveniles return to their general fledging area in the spring, actual dispersal distances may be much smaller.

Queen Charlotte goshawk dispersal is consistent with this pattern. One coastal southeast Alaska juvenile goshawk dispersed 11 miles prior to its death (probably on or before November 22, 1992, ADFG 1993a). Two other juveniles were not relocated despite an aerial search of 20,000 mi^2. It is not known if the birds dispersed outside the search area or were not relocated for other reasons (equipment failure, topography, mortality, etc.). A juvenile from Prince of Wales Island crossed Sumner Straight (5 miles) in 1993 to travel a total distance of 60 miles (Craig Flatten pers. comm.). Another juvenile on Petersburg Island dispersed 30 miles (ibid.)

POPULATION ESTIMATE

INTRODUCTION

The low density and numbers of Queen Charlotte goshawks reflects the impact of habitat loss on a subspecies which was apparently always rare. Southeast Alaska, even in a pristine state, probably never supported dense goshawk populations. The quality and distribution of its forests and prey base were always limiting factors (Winter 1993).

Goshawk populations across North America display a pattern of distribution evident on a smaller scale within both Mexican and Northern Spotted Owl populations (Thomas *et al.* 1990, McDonald *et al.* 1991) Densities in the southern portion of the respective ranges are greater than within the northern portions. This is probably a reflection of reduced prey bases and vulnerability. Goshawk populations in Arizona and Colorado, for example, were likely always denser than Alaskan populations. Conditions in the rainforests of southeast Alaska add to this effect. Goshawks prefer large prey items: half the biomass consumed by goshawks in Oregon came from birds larger than 200 grams and from mammals larger than 450 grams (Reynolds and Meslow 1984). Such large prey are less common in southeast Alaska than in the forests of the western United States (Winter 1993). Goshawks in Washington State are similarly scarcer on the wet Olympic Peninsula than on the drier east side of the Cascades (Lowell *in* Gustafson 1991a, Meehan-Martin *in* Gustafson 1991c).

Southeast Alaska's young forests and scrubby old-growth (less than 8 thousand board feet per acre) are not suitable Queen Charlotte goshawk habitat (ADFG 1993a). Even many of the acres of unharvested old-growth which naturally have too much dense shrub growth and too much canopy at low levels, provide poor habitat (Crocker-Bedford 1990a).

Based on densities of Northern goshawks in locales with varying levels of forest fragmentation (see Table 8), Crocker-Bedford (1990a) suggested that Queen Charlotte goshawk habitat capability varied with percentage of productive (> 8,000 bf/acre) old growth in a 10,000 acre landscape. He estimated 0.1 goshawks at 20% old growth, 0.7 at 50%, and 2.5 goshawks at 84%. The 1988 range-wide habitat capacity estimate was:

Tongass National Forest	< 716
Southeast Alaska	< 810
British Columbia (islands & mainland coast, both subspecies)	< 1,750
Total (excluding Olympic Peninsula)	"well below 2,560"

This estimate is certainly too high since the vast majority of the British Columbia habitat is not within the range of the Queen Charlotte goshawk. The addition of the Olympic Peninsula would add a few more pairs but not nearly enough to offset the British Columbia figure.

TABLE 8. DENSITIES OF PAIRS OF BREEDING GOSHAWKS IN CONIFEROUS FORESTS, AS COMPARED TO THE DEGREE OF TIMBER HARVEST (FROM CROCKER-BEDFORD 1990A).

Number of Pairs/ 10,000 Acres	Location	Timber Harvest	Source
0.0	N.W. Oregon	Much	Reynolds and Meslow 1984
0.1	Black Hills, South Dakota	Much	Bartelt 1977
0.4	California	Fragmented	Bloom *et al.* 1985
0.5[1]	N. Arizona	Selection 30% Volume	Crocker-Bedford 1990
0.6	N. Sweden	?	Nilsson 1981 in Widen 1985
0.8	Central Alaska	Little logging- but much fire	McGowan 1975
1.2	South-central Sweden	Limited	Widen 1985
1.3	California	Limited	Bloom *et al.* 1985
1.5	Oregon	Limited	Reynolds and Wright 1978
3.0	Colorado	Little	Shuster 1976
4.4	N. Arizona	Salvage selection	Crocker-Bedford and Chaney 1988
9.0	N. Arizona	None	Crocker-Bedford and Chaney 1988

[1] Though with little successful reproduction.

Iverson (1990) has suggested that even within Southeast Alaska, Crocker-Bedford's habitat capability estimates where too high. He noted that low volume, commercial forests were classified as suitable habitat, while such stands preclude goshawk use because their density leaves little flight room. Crocker-Bedford himself (1990a, 1992), noted that his model did not account for 1) the greater habitat value of high volume old-growth for prey production and flight room; 2) the fact that logging has almost exclusively been concentrated in higher volume timber stands; and 3) that logging of large trees near beaches has induced greater understory vegetation. Crocker-Bedford's (1992) revised density estimate for the total landscape of southeast Alaska, excluding water, is between 0.1 and 0.3 pairs per 10,000 acres, or between 0.2 and 0.5 per 10,000 acres of potentially forested land, and between 0.4 and 0.9 pairs per 10,000 acres of forest supporting greater than 8 thousand board feet of sawtimber per acre.

A 1992 radio-telemetry study (ADFG 1993), supports Crocker-Bedford's revised density and population estimate. A single pair of Queen Charlotte goshawks on Prince of Wales Island used 390,042 total acres and 195,021 land acres for their combined home range. They used 101,596 total acres and 50,798 land acres during nesting season.

Survey efforts and the scarcity of recent sightings also suggest that Queen Charlotte goshawk breeding densities are much lower than initially estimated. A 1991 survey effort by the Alaska Department of Fish and Game yielded only seven sightings at four locations over a 36,000 acre area of southern southeast Alaska which was previously known to support goshawks (ADFG 1991). The survey effort entailed 57.5 person days. An additional 54.5 persons days surveying apparently suitable habitat on 37,000 acres where goshawks had not previously been reported resulted in no detections. An expanded survey effort of 139,730 acres in 1992 produced only 12 confirmed and 3 probable detections (ADFG 1993b). Only 4 of the 12 confirmed detections represented new goshawk locations. Survey efforts on the Olympic Peninsula produced similar results (Lowell *in* Gustafson 1991b).

The following record of recent sightings was presented in Crocker-Bedford (1990a):

> - Despite the aggressiveness with which goshawks defend the 25 acres around their nest for 6 to 10 weeks each summer, 20 birders and forest workers who hike extensively and know goshawks, knew of only 6 stands where aggressive goshawks or their nests were found.
> - Paul Coffey, Craig Ranger District Forester, located only 2 Queen Charlotte goshawk pairs on the Craig and Thorne Bay Ranger Districts during 10 years of field work there.
> - Twenty nine observations were made on Mitkof Island between 1980 and 1990, none of nests or aggressive/defensive behavior.

Extreme rarity appears to be the case throughout the Queen Charlotte goshawk's range. The last known sighting on the Queen Charlotte Islands is from over 40 years ago (Beebe pers. comm.). Despite intensive survey efforts, very few nesting Queen Charlotte goshawks have been found on the Olympic Peninsula (Flatten *in* Gustafson 1991a, Meehan-Martin in Gustafson 1991b).

Crocker-Bedford's (1992) latest estimate of the actual Queen Charlotte goshawk population in Southeast Alaska is 200-500 pairs, possibly less. Assuming an original habitat capability of 1,160 pairs (Crocker-Bedford 1990a), the historic population has declined by 57-83% in southeast Alaska. Neither Crocker-Bedford's original analysis (1990a), nor his revision (1992), take into account that historic habitat loss in British Columbia far exceeds that of Southeast Alaska, or that the Queen Charlotte goshawk is not the breeding subspecies on the mainland coast. Based on habitat estimates presented in the following chapter, we suggest the following population estimate:

Southeast Alaska	200-500
Queen Charlotte Islands	25
Vancouver Island	50
Olympic Peninsula	50
Total	**325-625**

CRITERIA FOR ENDANGERED SPECIES ACT PROTECTION

PRESENT OR THREATENED DESTRUCTION, MODIFICATION, OR CURTAILMENT OF HABITAT OR RANGE

LOGGING IS THE MAJOR CAUSE OF GOSHAWK HABITAT LOSS

Logging in mature and old growth forests diminishes the habitat elements necessary for successful nesting and foraging. Studies have consistently shown that goshawks almost always nest in mature or old growth stands which have dense overstory canopies:

> (Bent 1937, Bartelt 1977, Hennessy 1978, Schuster 1980, Jones 1981, Reynolds 1983, 1989; Saunders 1982, Moore and Henny 1983, Hall 1984, Mannan and Meslow 1984, Bloom *et al.* 1985, Herron *et al.* 1985, Crocker-Bedford 1987, 1990b, 1991, 1992; Crocker-Bedford and Chaney 1988, Speiser and Bosakowski 1987, Fowler 1988, Kennedy 1988, 1989; Woodbridge 1988, Hayward and Escano 1989, Falk 1990, Patla 1990, 1991; Warren *et al.* 1990, Zinn and Tibbits 1990, Reynolds *et al.* 1992, Siders and Kennedy 1993, Patla and Trost 1993, Hargis *et al.* 1993, Smith and Mannan 1993, Kimmel and Yahner 1993).

Radio-telemetry studies have demonstrated that most foraging occurs in mature or old growth stands:

> (Widen 1985, Fischer 1986, Austin 1991, 1993; Hargis *et al.* 1993, ADFG 1993a).

Other studies found that occupied home ranges contained more forest cover than unoccupied home ranges (Ward *et al.* 1992, Woodbridge and Detrich 1993). Home range sized areas around nests contained more forest cover than random sites (Falk 1990, Kimmel and Yahner 1993). While many authors have shown or suggested that timber harvesting in the nest stand is adverse, others have found negative effects from harvesting beyond the nest stand as well:

> (Woodbridge 1988, Crocker-Bedford 1990b, 1991; Patla 1991, Ward *et al.* 1992).

Crocker-Bedford (1990a) summarizes adverse effects of logging on goshawks:

> "Goshawk breeding density varies with the volume of forest canopy (for prey production), tree size (for prey production, nesting sites, perches, and the goshawk's ability to fly beneath canopy and between tree trunks), openness beneath canopy (to facilitate goshawk flight and reduce prey escape cover), and continuity of forest (to maintain prime foraging habitat and to reduce competition and predation on goshawks by open-forest raptors)... Logging's depressing effect on goshawk density...probably relates to a loss of canopy volume, reduction in average tree size, a lower canopy level, an

increase in the total density of low woody vegetation, and fine-grained and course grained forest fragmentation."

In northern Arizona, Crocker-Bedford (1990b) compared large tracts (12,000 and 35,000 acres) of unharvested and harvested breeding habitat. He found a 94% decline in reproduction following the partial harvesting of one-third of the timber volume from 80% of the stands surrounding unharvested nest buffers which averaged 95 acres (range = 3 to 500 acres). Most of the abandoned goshawk territories were taken over by raptors associated with edge effects and open canopies. A comparison of goshawk densities in relation to logging levels supports Crocker-Bedford's Arizona study (see Tables 6 and 7).

Logging fragments contiguous forest tracts, making them unsuitable for goshawk use. A fragmented landscape is one in which habitat "islands" are separated from one another by marginal or unsuitable habitat. Fragmentation may be caused by biogeographical influences (muskegs, grasslands, coastlines), natural disturbances (fires, tornados), or by human intrusion (logging, agriculture, urban development). Where suitable habitat patches abut non-suitable areas, an edge is formed. The ratio of patch-to-edge size is an important indicator of suitability and is determined by the size and shape of the patch (see Giles (1978), Thomas (1979), Forman and Gordon (1981)).

Many studies have shown avian diversity and richness to be positively correlated with greater island sizes (Bond 1957, Moore and Hooper 1975, Forman *et al.* 1976, Galli *et al.* 1976, Whitcomb 1977, Whitcomb *et al.* 1981, Ambuel and Temple 1983, Howe 1984, Lynch and Whigham 1984, Opdam *et al.* 1985, Pettersson 1985, Freemark and Merriam 1986, Rosenburg and Raphael 1986, Vaisanen *et al.* 1986, Keller 1987). Primarily focussed on forest songbird assemblages, these studies have shown that forest fragmentation most adversely affects territorial species with large home range sizes, and species which prefer large patches of contiguous forest.

Forman *et al.* (1976) and Galli *et al.* (1976) found that raptors were more likely to be present in forest patches greater than 40 ha. Like other North American goshawks, the Queen Charlotte is a forest interior dweller. Goshawks require large tracts of contiguous habitat to inhibit competition and predation by open-forest and forest-edge raptors (Crocker-Bedford 1990b). Forest fragmentation was found to adversely affect goshawks in California (Woodbridge 1988). Goshawks in Connecticut show a significant preference for nest sites far from forest clearings (average distance to clearing = 6 miles)- farther than any other hawk (Falk 1990). Extent of forest was also found to be important in New York (Speiser and Bosakowski 1987) and Pennsylvania (Kimmel and Yahner 1983). Widen (1989) found goshawk to prefer forest tracts larger than 100 acres by a factor of ten over 50 acre patches. Austin (1993) found 10 radio-tagged goshawks to avoid openings and select forest tracts with greater than 40% canopy cover.

Contrary to these findings is a study which found goshawk nests in northern Idaho and Montana to average only .25 miles from forest openings larger than 3 acres (Hayward and Escano 1989). The authors noted, however, that their results were probably skewed by the fact that many of the nests were found during logging operations.

The fragmenting effect of logging exacerbates a very high natural degree of habitat

fragmentation and population isolation. The range of the Queen Charlotte goshawk is naturally highly fragmented by muskegs, glaciers, snowfields, lakes, fjords, sounds, and ocean water. Queen Charlotte goshawk populations are isolated from one another throughout their range. Individuals and subpopulations within each population are separated from one another by natural and human induced habitat fragmentation.

Rangewide, the subspecies is divided into three disjunct populations. The Southeast Alaska population is limited to the thousand plus islands of the Alexander Archipelago and a narrow mainland strip below the Coastal Mountains. It is separated from continental North America by The Saint Elias Mountains to the north and the Coastal Mountains to the East. Both ranges are capped by immense glaciers and snowfields. The Pacific Ocean extends to the west and also separates the population from the Queen Charlotte Islands which are about 150 miles to the southwest. The Queen Charlotte Islands are completely surrounded by the Pacific Ocean. Vancouver Island lies approximately 400 miles south of the Queen Charlotte Islands. Though this population could possibly interact with Northern goshawks on the mainland, there is not record of overlapping ranges or interbreeding between the two subspecies.

Habitat fragmentation is also naturally high within each of the three island formations. The 17 million acre Tongass National Forest comprises 77% of Southeast Alaska and contains most of the region's Queen Charlotte goshawk habitat. Seven million of its acres are unforested and another 4.3 million acres are sparsely forests with less than 8,000 board feet/acre (USFS 1991a). A large portion of the remaining 5.7 million acres of forest contain less than 20,000 board feet/acre, the lower limit of preferred Queen Charlotte goshawk use. The suitable forest stands are separated from one another by lakes, bays, channels, sounds, tidal flats, muskegs, glaciers and icefields. Southeast Alaska high volume old growth stands occur in smaller more fragmented patches than in the Pacific Northwest (Alaback and Juday 1989).

The landscape of the nearby Queen Charlotte Islands is similarly fragmented though it contains no glaciers or ice fields. Far to the south, Vancouver Island is more similar to Pacific Northwest forests (pers. obser.). Muskegs, lakes, bays and open sea water do fragment the forest landscape, but not as highly as in the northern regions.

Artificial fragmentation has been introduced at the stand level as well. The most contiguous, highest volume stands of old growth formerly occurred in the lower parts of watersheds. Clearcutting has traditionally focused on just these areas, fragmenting the most biologically productive old growth stands (Crocker-Bedford 1990a). Being smaller , and having suffered more intense logging pressure, Vancouver Island and the Queen Charlotte Islands are almost completely logged over. They now support very few large, unfragmented stands of old growth. Though Southeast Alaska has also been heavily impacted by logging, its contains the most extensive tracts of Queen Charlotte goshawk habitat.

Possibly due to prey base issues discussed elsewhere, goshawks inhabiting wet forests west of the North Cascade Mountains in northern Washington are less tolerant of habitat fragmentation than goshawks inhabiting drier forests east of the Cascades and Northern spotted owls east of the Cascades (Flatten *in* Gustafson 1991a, Meehan-Martin *in* Gustafson 1991b).

Intra/inter-specific competition for nest sites and prey items is increased by forest fragmentation. Modification of the Queen Charlotte goshawk's preferred old-growth habitat

which reduces canopy cover and/or decreases interior-to-edge ratios, may give a competitive advantage to other raptors which thrive in these situations. Excessive competition may reduce the Queen Charlotte goshawk's chances of successful hunting and nesting. This general assessment is supported by numerous studies and observations.

Bendire (1892) suggested that goshawks drive all other raptors off their hunting territories and usually nest a "considerable distance" from red-tailed hawks. He also cites competition between goshawks and great horned owls. Crocker-Bedford (1990b) similarly found that in unlogged control locales in northern Arizona, that nests of other raptors were no closer than 0.6 miles from goshawk nests. After logging, however, most goshawk territories were usurped by raptors better adapted to forest edges and open canopies.

Red-tailed hawks, Long-eared owls, Great horned owls, and Great gray owls are better adapted to hunting in sparse forests and forest openings. Numerous researchers have commented that they benefit from logging operations (Franzreb and Ohmart 1977, Moore and Henny 1983, McCarthy *et al.* 1989). Patla (1991) found four former goshawk nests in a highly modified forest were occupied by Great gray owls. Mikkola (1983 in Patla 1991) reports 56.6% of Great gray owl nests in Finland to be in former goshawk nests. Bull *et al.* (1988) found 50% of all Great gray owl nests in a logged locale in Oregon to be in former goshawk nests. Bryan and Forsmann (1987) found 6 of 11 central Oregon Great gray owl nests to be in abandoned goshawk nests. Mikkola has noted that the two species are highly competitive and that Great grays often take over occupied goshawk nests. Goshawk presence in northern Europe despite significant forest fragmentation has been attributed to lack of a European counter-part to the red-tailed hawk (Beebe 1984).

Predation on goshawks may be increased by forest fragmentation. Logging increases the likelihood of predation on goshawks by introducing open areas near goshawk nests and PFAs, and by forcing goshawks to pass through open areas which hunting or dispersing (Crocker-Bedford 1992). Nestlings and juveniles are most likely to be taken, though adult goshawks may be taken as well.

HISTORIC AND PROPOSED LOGGING OF OLD GROWTH FORESTS IN SOUTHEAST ALASKA

TONGASS NATIONAL FOREST. A large percentage of the Tongass' best Queen Charlotte goshawk habitat has already been cut or fragmented. That so few the currently known birds are in the southern Alexander Archipelago which formerly supported the best habitat is a testimony to the level of destruction that has occurred there. Heceta, Kosciusko, Tuxekan, Prince of Wales, Zarembo, Dall, Bushy, Marble, Revilla, and Annette Islands have all suffered extreme logging pressure and are barely capable of supporting goshawks if at all.

Heceta Island is a large, heavily fragmented island in Sea Otter Sound. An active Queen Charlotte goshawk nest was found there in 1982 but the nest tree and the forest around it were cut down in 1987 or 1988. The island is probably no longer capable of supporting goshawks.

Prince of Wales is the largest island in southern Southeast Alaska. Known as the

"garden of the Tongass," its limestone bedrock provides excellent drainage and supports the Forest's largest and fastest growing trees. It contains a high percentage of the Tongass's remaining old growth. Unfortunately, nearly 50% of the Alaska Region's timber target comes from the Thorne Bay Ranger District which comprises the central and northern portion of the island (Crocker-Bedford 1992). The Craig Ranger District on the southern portion of the island, formerly supported vast tracts of high quality old growth. Little remains, however. These tracts have either been logged by the Forest or conveyed to Native American Corporations via ANCSA to be eventually clearcut.

From the north coast as far south as Moria Sound the Island has been devastated. Staney and Logjam Creeks are typical examples. With the exception of the Karta River Valley (a designated wilderness area), Honker Divide and Salmon Bay, all old growth on the northern portion of the island has been fragmented. The latter two partially included in the 1989-1994 Ketchikan Pulp Corporation Long-Term Sale (KPC LTS). The Alaska Department of Fish and Game has repeatedly asked that these drainages be preserved but the Forest Service has refused their recommendations (Lunn 1990). In a 1989 memo, ADFG warned that the

> "only way to assure the maintenance of likely existing low density breeding populations of (goshawks and other old-growth associated raptors) may be to leave drainages such as Salmon Bay and Honker Divide in their present condition, even though such action could even eventually prove to be too late, or these areas too small" (Gustafson 1989).

The Ketchikan area habitat biologist recommended that ADFG initiate mediation if necessary to prevent roading and logging of Salmon Bay and Honker Divide until raptor research is conducted which could prove the Forest is maintaining minimum viable population levels (Gustafson 1989).

Salmon Bay consists of about 10,000 acres of unfragmented habitat, "it comprises the largest of the last unaffected forests in (North Central Prince of Wales) and is the most likely to continue to provide habitat for breeding pairs of old-growth dependent raptors...Honker Divide, though long and narrow in configuration, also has suitable habitat for hawks and owls and is another area important for maintaining viable levels of species diversity" (Gustafson 1989). Honker Bay supports one probable and one possible goshawk territory (ADFG 1993c). A potential nest tree was cut down there in 1990.

Though smaller, the Sarkar drainage is also one the few "large" forest areas left on Prince of Wale. Though some of the best old growth has been logged, much of it remains uncut. The drainage supported a pair of nesting Queen Charlotte goshawks in 1992.

The U.S. Forest Service began promoting large-scale pulp production in southeast Alaska in the 1920's (Brooks 1992). In 1951, the Service negotiated a 50-year contract with the Ketchikan Pulp Company (KPC) guaranteeing the company up to 8.25 billion board feet of timber with a maximum cut of 192.5 million board feet/year. In return, KPC built a pulp mill in Ketchikan. Several years later a second 50 year contract was negotiated with the Japanese owned Alaska Lumber and Pulp company guaranteeing 5.5 billion board feet of timber in return for building a pulp mill in Sitka. These contracts caused timber harvests on the Tongass to jump from about 55 million board feet in the early 1950's to about 350 million board feet in the early

1960's, and then to well over 500 million board feet by the 1970's (see Table 9).

The Alaska Native Claims Settlement Act of 1980 (ANCSA) legislated continued high levels of timber harvest in southeast Alaska regardless of market conditions. While setting aside only 5 million acres of wilderness (most of it rock and ice), it guaranteed the Tongass National Forest $40 million annually to produce 4.5 billion board feet of timber per decade. It simultaneously conveyed over 500 thousand acres of the very best old growth from the Tongass to Alaska Native Corporations. These lands were promptly clearcut. The loss of these high volume forests through, coupled with the need to reach its 4.5 billion board foot timber target, encouraged the Tongass to highgrade its remaining high volumes stands.

Highgrading has always been the preferred logging method on the Tongass. The 2.1 billion board feet harvested on the Tongass between 1909-1953 disturbed only 41,000 acres (Crocker-Bedford 1990a). Between 1954 (when the long-term contracts began) and 1991 another 14.4 billion board feet were cut. Although only 10% of the Forest's productive old-growth was cut between 1954 and 1988, goshawk capability was decreased by greater than 26%, because logging was concentrated in the highest volume stands, in the least fragmented landscapes (Crocker-Bedford 1990a). Few of the 4,593,600 acres of coniferous old-growth containing low volume (8 to 30 MBF/acre) old growth were harvested between 1954-1988, while 37% of the 912,000 acres of coniferous old-growth containing 30 to 70 MBF/acre were harvested in the same period (TLMP Revision DEIS Table 3-41, see also Table 10).

By 1988, over 40% of the Tongass's highest quality old growth had been cut (Crocker-Bedford 1990a). Between 1988 and 1991, an additional 238.5 million board feet of timber were sold (Chelstad 1992).

TABLE 9. TIMBER VOLUME HARVESTED, TONGASS NATIONAL FOREST, CALENDAR YEARS 1909-1993, MMBF (USFS 1991a, USFS 1992b).[1]

CALENDAR YEAR	VOLUME	CALENDAR YEAR	VOLUME
1906-1916	234.5	1954	109.2
1917	41.0	1955	213.8
1918	43.1	1956	230.2
1919	37.4	1957	226.4
1920	45.6	1958	167.5
1921	11.7	1959	266.6
1922	20.6	1960	347.5
1923	40.5	1961	338.2
1924	48.6	1962	366.3
1925	53.7	1963	395.1
1926	51.0	1964	443.7
1927	52.0	1965	397.6
1928	33.8	1966	474.3
1929	42.0	1967	474.3
1930	38.5	1968	529.5
1931	18.2	1969	519.3
1932	14.7	1970	560.1
1933	14.7	1971	527.7
1934	8.2	1972	547.5
1935	30.5	1973	588.5
1936	40.0	1974	544.0
1937	35.3	1975	408.4
1938	25.6	1976	462.8
1939	26.5	1977	447.3
1940	30.9	1978	398.7
1941	35.8	1979	453.2
1942	38.5	1980	452.1
1943	73.6	1981	385.7
1944	86.8	1982	344.9
1945	58.3	1983	251.2
1946	48.6	1984	249.8
1947	83.4	1985	265.3
1948	81.0	1986	271.6
1949	49.2	1987	351.5
1950	54.4	1988	407.7
1951	52.9	1989	408.0
1952	63.4	1990	472.6
1953	59.2	1991	325.5
		1992	331.4
		1993	372.1

Total Harvest, Calendar Years 1909-1993: 17,171.0 MMBF

[1]1909-1951 volumes include sawlog only. 1952-1993 volumes include sawlog and utility (i.e. pulp).

TABLE 10. OLD GROWTH FOREST (>8 mbf/acre) IN THREE CLASSES OF LANDSCAPE FRAGMENTATION, TONGASS NATIONAL FOREST, 1954, 1988 (from Crocker-Bedford 1990a).

Class Landscape Fragmentation	Number of Stands 1954	1988	Acres of Old Growth 1954	1988
0-32% Old Growth	273	298	5,805	1,067,754
33-66% Old Growth	436	503	3,267,502	3,578,616
67-100% Old Growth	173	81	1,555,183	538,566

In 1990, Congress passed the Tongass Timber Reform Act (TTRA) in an attempt to reduce overcutting and high-grading. The Forest, however, has and continues to resist reform efforts (Brooks 1992, SEAC 1992, Katz 1992). During the formulation of the TTRA, the Forest issued a Draft Tongass Land Management Plan Revision. Intended to head off the TTRA, it called for the retention of 24% of the remaining old growth in each Wildlife Analysis Area. After the TTRA's passage, however, the Forest supplemented the draft TLMP, deleting all Wildlife Analysis Area old growth retention standards (Brooks 1992).

Further evidence of the Forest's unwillingness to establish reasonable long-term habitat protection measures is it's response to the interagency Viable Populations Committee which was charged with developing a strategy to protect old growth associated species (Suring *et al.* 1993). Their report, A Strategy for Maintaining Well-Distributed, Viable Populations of Wildlife Associated With Old-Growth Forests in Southeast Alaska, May 1993, stated that the Forest's planned timber and old growth strategy has "a very low likelihood of maintaining viability and distribution" for old growth obligates including the Queen Charlotte goshawk. The Forest attempted to suppress the report, but failed due to public outcry (Brooks 1993).

STATE AND PRIVATE LANDS. As result of the Alaska Statehood Act and the Alaska Native Claims Settlement Act, some 886,600 acres of public land were transferred to the State of Alaska and Alaska (USFS 1991a). About 81% were commercial forest land, most of it old growth. Sixty-one percent of of the old growth was clearcut by 1990. Though logging on the Tongass far surpasses sustainable levels, logging on State and Alaska Native Corporation lands is far worse. Queen Charlotte goshawk capability on these lands will probably decline to zero (Crocker-Bedford 1990a).

While the Alaska Native Claims Settlement Act (ANCSA) of 1980 appears to address historic wrongs by returning (some) lands back to their original inhabitants, it in fact turned over public land to corporate interests, not traditional people. The result has been wholesale clearcutting of Queen Charlotte goshawk habitat and the destruction the traditional people's inheritance. Also dominated by corporate interests, Alaska State lands are being clearcut at a phenomenal rate.

ANCSA conveyed over 500,00 acres of land from the National Forest to Native Corporations. The Corporations primarily selected very high volume stands, largely from the Thorne Bay and Craig Ranger Districts (i.e. Prince of Wales and the surrounding islands) which contained a large percentage of the Tongass's best old growth. These old growth stands were promptly liquidated. Long Island is a tragic example. About 14 miles long and 7 miles wide, almost all of it was conveyed to Klukwan, Inc. which virtually denuded the island within a period of 7 years. It is one the largest continuous clearcuts in Southeast Alaska and is no longer capable of supporting Queen Charlotte goshawks.

During the early eighties, the Tongass produced 78% of Southeast Alaska's lumber, while the Native Corporations produced 21%. After the conveyance, timber harvest in the region increased dramatically, with the Native Corporations producing 51% of the volume (see Table 11.).

TABLE 11. TIMBER SUPPLY FROM NATIVE CORPORATIONS IN SOUTHEAST ALASKA, FY 1980-1990 (MILLION BOARD FEET, LOG SCALE) (from USFS 1991a).

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Sawlog	83.0	31.6	137.0	249.3	202.3	225.3	295.9	286.1	286.4	419.8	441.7
Pulplogs	61.8	35.4	22.3	42.6	56.0	46.6	-0.4	110.0	121.3	192.9	44.6

SOUTHEAST ALASKA. As of 1992, a total of approximately 822,000 acres of old growth forest have been logged in Southeast Alaska: 464,000 acres on State and private land, 358,000 acres on Federal land. Cutting levels, especially on private lands, increased dramatically in the last decade. Logging in Southeast Alaska consumed an average of 685.8 mmbf/year between 1980 and 1990.

Planned timber harvesting on the Tongass National Forest is concentrated in best remaining Queen Charlotte goshawk habitat. It will directly effect a large percentage of recently occupied nests. The Supplemental Draft Environmental Impact Statement for the Tongass National Forest Land Management Plan identifies a *preferred alternative* which would harvest approximately 418 million board ft on 16,000 acres each year. Seventy-four percent of planned logging will be concentrated south of Fredrick Sound in southern Southeast Alaska. Northern Prince of Wales and Kupreanof islands will bear the brunt of much of the logging. These islands have been heavily fragmented by historic logging, yet contain much of the

Tongass National Forest's remaining high quality, contiguous old growth. Planned logging will severely impact these remaining stands.

Of the 4 areas where goshawks were seen in 1991, three are within proposed timber sales (ADFG 1993c). Of the 17 Queen Charlotte goshawk nests known to be active since 1980:

11 are in areas on the Tongass National Forest planned for harvest or recently harvested
2 are on state lands available for harvest
1 is on reserved land
3 are on lands with previous or planned cutting
3 have had their nest trees cut down
(See Table 12).

Of the 39 areas where goshawks probably nest or once nested, 31 are in areas proposed for logging (see Table 13).

The Draft Environmental Impact Statement for the Ketchikan Pulp Corporation Long-Term Timber Sale on Central Prince of Wales Island proposes to harvest 22 units within the Sarkar Lake males home range and 75 units within the females home range (USFS 1992e, ADFG 1993c). Only 6% of the commercial forest base within the 321,866 acre planning area is reserved from timber harvest.

Harvest on State and Private land is expected to continue at unsustainable levels. In 1990, harvest from State lands was expected to remain at approximately 30 mmbf/year through 2010 (USFS 1991a). Recently introduced Senate Bill 310, however, would likely increase the projected levels as it would make timber production the priority management goals on state lands. Logging on private lands, most of which are Alaska Native Corporation Lands, is expected to reach 105 mmbf/year by 2000 and continue at 100 mmbf/year through 2010 (USFS 1991a).

TABLE 12. STATUS OF CONFIRMED/PROBABLE/POSSIBLE QUEEN CHARLOTTE GOSHAWK NEST SITES (ADFG 1993C, 1993D; IVERSON 1993, 1993B; USFS 1992D; CROCKER-BEDFORD 1990A; GUSTAFSON 1990C, 1990D, WINTER 1993).

Nest Site	1986	1987	1988	1989	1990	1991	1992	1993
KETCHICAN AREA								
Port Refugio, Suemez Island				active/ inactive nests found during timber sale layout	inactive	inactive; adult or immature in nesting season	inactive; adult or immature in nesting season	inactive; adults observed; new inactive nest found
Logjam Creek, Prince of Wales Island								one young fledged; adult male radio-tagged
Sarheen, Prince of Wales Island						adults and fledglings observed	goshawks observed	inactive; adults observed
Sarkar Lake, Prince of Wales Island							nest located; adults and two juveniles radio-tagged	inactive; radio-tagged adult male died; female found w/male on Heceta Island but did not renest
Hatchery Lake, Prince of Wales Island					nest site discovered; nest site logged	adult or immature in nesting season	no evidence of nesting	
Niblack Anchorage, Prince of Wales Island								
Thorne River, Prince of Wales Island	unconfirmed historical sighting						vocal response	
Ketchikan Lakes, Revilla Island							sightings	

Naha/Leask, Revilla Island	unconfirmed historical nest				sighting			adult
Nest Site	1986	1987	1988	1989	1990	1991	1992	1993
Hassler Pass, Revilla Island							unconfirmed	adult
Cannery Creek, Cleveland Peninsula	possible active nest	possible active nest	probable	probable	active nest		inactive	inactive
Vixon Inlet, Cleveland Peninsula						adult or immature in nesting season	no evidence of nesting	
Chickamin River, Misty Fiords NM								
Grant Creek, Misty Fiords NM						probable active nest	probable active nest	inactive
Tonowek Creek, Heceta Island	nest found in 1982	nest cut in mid 1980's				no evidence of nesting		
STIKINE AREA								
Anita Bay, Etolin Island	goshawks seen in 1986 or 1987					active nest found during timber sale layout	inactive	inactive
Marble Point, Etolin Island	probable active nest						inactive	inactive
Mossman Inlet, Etolin Island							old nest located	inactive
Falls Creek, Mitkof Island							well developed fledgling found	goshawks responded to call in spring
Cabin Creek, Mitkof Island	probable active nest	nest tree or stand logged						inactive
Pan Creek, Mitkof Island					probable active nest		probable active nest	inactive

Woodpecker, Mitkof Island					adult or immature in nesting season	probable active nest	adult or immature in nesting season	
Nest Site	1986	1987	1988	1989	1990	1991	1992	1993
Upper Totem Creek, Kupreanof Island							probable active nest (discovered in 1993)	two inactive nests discovered during presale; one may have been visited by goshawks
Big John Creek, Kupreanof Island							active; 2 young fledged	active; 1 male, 1 female fledged; adults and nestlings radio-tagged; juvenile male died
Kake, Kupreanof Island				2 fledged; nest tree cut; tribal lands	1 bird seen	inactive		inactive
Rowan Creek, Kuiu Island								active; 2 females fledged; both radio-tagged
Salamander Creek, Wrangell Island						probable active nest	adult or immature in nesting season	inactive
Nemo Road, Wrangell Island							active	inactive
Thomas Bay, Mainland							adult or immature in nesting season	
CHATHAM AREA								

Ready Bullion Creek, Douglas Island						active; two fledged	active;one fledged	inactive; no signals from male and female radio-tagged in 1992; female probably dead
Nest Site	1986	1987	1988	1989	1990	1991	1992	1993
Blueberry Hill, Douglas Island							nest discovered	nest discovered 6 km away; 2 young fledged; adults and 1 female fledgling radio-tagged
Eagle Creek, Douglas Island								2 males fledged; adults and fledglings radio-tagged nest 3.6 km nw of 1993 Blueberry Hill nest
Nugget Creek, Mendenhall Glacier							active	3 young fledged; adults and 2 female fledglings radio-tagged
Echo Cove, Point Bridget State Park						active	active; two fledged	active; 2 young fledged; adults and fledglings radio-tagged
Eagle Glacier, Juneau Mainland						probable active nest	probable active nest	
Thayer Lake, Admiralty Island	active	active	active				inactive	inactive

Mud Bay River, Chichagof Island								active; three fledged
Dewey Lake Trail, Skagway	active (1985)	active	inactive	inactive			inactive	inactive

TABLE 13. CONFIRMED/PROBABLE/POSSIBLE QUEEN CHARLOTTE GOSHAWK NESTS AND TIMBER SALES (USFS 1992A,1993b,1994; ADFG 1993C,1993D, IVERSON 1993B; CROCKER-BEDFORD 1990A; GUSTAFSON 1990C, 1990D).

Nest Site	Status	Timber Sale
Ketchikan Area		
Port Refugio, Suemez Island	active 1989 inactive 1990-1993	Santa Cruz Sale
Logjam Creek, Prince of Wales Island	active 1993	CPOW 1994 Control Lake 1995
Sarheen, Prince of Wales Island	active 1991 inactive 1993	KPC 1989-1994 CPOW 1994
Sarkar Lake, Prince of Wales Island	active 1992 male died 1993	CPOW 1994
Hatchery Lake, Prince of Wales Island	active potential nest tree cut 1990	KPC 1989-1984
Thorne River, Prince of Wales Island	possible 1992; unconfirmed historical	KPC 1989-1984
Niblack Anchorage, Prince of Wales Island	probable	Moira Sound 1999
Cannery Creek, Cleveland Peninsula	probable	KPC 1996
Vixon Inlet, Cleveland Peninsula	probable 1991	KPC 1996 Vixen Inlet 1996
Ketchikan Lakes, Revilla Island	possible 1992	no
Naha/Leask, Revilla Island	possible 1992, unconfirmed nest	Three Creeks 1994-1995
Hassler Pass, Revilla Island	possible	North Revilla 1994
Chickamin River, Misty Fiords NM	probable	reserved
Grant Creek, Misty Fiords NM	probable 1991-1992	reserved
Tonowek Creek, Heceta Island	probable 1982 nest cut 1987-1988	Hecata 1994
Stikine Area		
Anita Bay, Etolin Island	active 1991 inactive 1992-1993	Starfish Sale
Marble Point, Etolin Island	probable 1986 inactive 1993	
Mossman Inlet, Etolin Island	probable	yes

Falls Creek, Mitkof Island	probable	Falls Creek 1960-1980
Nest Site	Status	Timber Sale
Cabin Creek, Mitkof Island	active 1980; nest tree cut, adjacent nest uncut; inactive 1993	Cabin Creek late 1980's
Pan Creek, Mitkof Island	probable 1990, 1992	potential MHT sale
Woodpecker, Mitkof Island	probable 1990-1992	
Kake Tribal, Kupreanof Island	active 1989; nest tree cut 1989 inactive 1990, 1991, 1993	Tribal sale
Big John Creek, Kupreanof Island	active 1992-1993	North Irish Creek Reoffer
Upper Totem Creek, Kupreanof Island	probable 1992; inactive 1993	yes
Rowan Creek, Kuiu Island	active 1993	North Kuiu; East Kuiu
Salamander Creek, Wrangell Island	probable 1991, 1992	Wrangel late 1980's early 1990's
Nemo Road, Wrangell Island	probable historical; recently logged	Pacific Northern 1960's Currently active
Thomas Bay, Mainland	probable 1992	early 1960's
Chatham Area		
Ready Bullion Creek, Douglas Island	active 1991-1992; inactive 1993	yes; state land
Blueberry Hill, Douglas Island	active 1992-1993	state land
Eagle Creek, Douglas Island	active 1993	
Shelter Island, Shelter Island	probable 1984	
Nugget Creek, Mendenhall Glacier	active 1992-1993	no
Echo Cove, Point Bridget State Park	active 1991-1993	reserved
Eagle Glacier, Juneau Mainland	probable 1991-1992	
Thayer Lake, Admiralty Island	probable 1986-1988	no
Mud Bay River, Chichagof Island	active 1993	Eight Fathom

Dewey Lake Trail, Skagway	active 1985, 1987 inactive 1988-1989	

HISTORIC AND PROJECTED HABITAT LOSS IN BRITISH COLUMBIA.

GENERAL. Past and current logging impacts on the Queen Charlotte Islands and coastal British Columbia are even greater than in the Tongass National Forest. British Columbia produces nearly one half of Canada's timber (Cooperman 1993a). The annual timber volume cut in British Columbia averages 17 billion board feet- nearly double the annual cut in the entire U.S. National Forest system (Frost and Friedman 1992). At least 75% of the volume is extracted from old growth forests which are being logged at a rate of 300,000 acres per year (Frost and Friedman 1992, Sherrod and Copeland 1993). Thirty five percent of coastal British Columbia's original productive old growth has already been cut (Imre Spandli, Ministry of Forestry in Crocker-Bedford 1990a), ninety percent of it by clearcut (Cooperman 1993b).

Logging pressure in British Columbia has increased dramatically in the past two decades and shows no sign of decreasing. One half of all trees cut in British Columbia since 1914 were cut in the last 14 years (Cooperman 1993b). The yearly cut has jumped from 32 million cubic meters to in 1961 to 78 million cubic meters in 1989 (Cooperman 1993). The Federal Government of Canada's "State of the Environment Report, 1991" concluded B.C.'s annual allowable cut is 40% above sustainable levels (FGC 1991). Nearly all of B.C.'s remaining old growth Sitka spruce-western hemlock forests are slatted for logging (Beebe, 1991).

Queen Charlotte Islands. The total land area (excluding water) of the Queen Charlotte Islands is 2.4 million acres.[2] Ninety five percent is Crown land, 22.5% is reserved from logging, and 25% is classed as merchantable timber. Much of the reserved land is not suitable goshawk habitat. There are 569 acres in small, widely scattered reserves; 174,648 acres in Provincial Parks concentrated in the low volume and non-forested, northeast section of the Islands; 346,320 acres of medium to low volume forest in the South Morseby Island Park Reserve; and 24,000 acres of old growth in three Ecological Preserves concentrated on the west coast of Graham Island. The merchantable timber lands, on the other hand, contain the best high volume goshawk habitat. There is very little high volume old growth outside the merchantable timber base.

Logging on the Islands began in the late 1800s but really took off in the early 1940s as part of the war effort to build Mosquito Bombers. Harvest levels at that point averaged 240 mmbf/year. Beginning in the 1960s, the annual cut steadily increased, reaching 600 mmbf 1975. Cutting over the last decade averaged 535 million board feet per year. The current annual cut is 450 mmbf. The projected cutting rate in the near future is 430 mmbf. Acres cut range between 6,000 and 9,600 per year. Logging has concentrated in high volume old growth stands and currently averages 57,000 bf/acre. Ninety five percent of logging on the Islands is by clearcut.

We estimate 21.5 billion board feet of high volume old growth (averaging 60,000 bf/acre) on 358,333 acres to have been clearcut as of 1993, most of it along the very high volume coastal forests. Most of the coastal forests are managed as Tree Farm Licenses while the interior forests are managed as Timber Supply Areas.

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[2] The following profile is based on personal communication with Terry Dyer, Ministry of Forests District Manager for the Queen Charlotte Islands, and Ben Hansen, Operations Manager. All volumes and acreages have been converted according to the following: 214.3bf/m^3, 6bf/f^3, 2.4ac/ha.

Reserved lands on the Queen Charlotte Islands total 545,537 acres. Much of this is unforested. Very little of the forested areas support high volume old growth. Queen Charlotte goshawk habitat capability outside reserved areas can be expected to drop to zero, and may be so already. We estimate the maximum habitat capacity of the reserved lands to be 5 breeding goshawk pairs. The Queen Charlotte Islands represent an isolated, non-viable population. The only known nesting Queen Charlotte goshawk is a record from Slate Chuck Creek on Haida land over 40 years ago (Beebe pers. comm.). It is possible that the subspecies is already extirpated.

Mainland Coast. Logging impacts on the mainland coast have been tremendous. According to a recent government report: "At the current rate of logging, it is estimated that there will be no substantial ancient forest left on the coast of British Columbia by the year 2008. Currently...about 2.6% of the original old growth forests are protected" (FGC 1991).

Vancouver Island. Vancouver Island is heavily cut over. Of the 89 watersheds larger than 5,000 hectares on Vancouver Island, only 5 have not been logged. One is protected, the other four are slated for cutting within five years (Frost and Friedman 1992). Satellite imagery indicates that one-half of the old growth existing in 1954 was cut by 1993 (Cooperman 1993c). Much of the cutting has taken place in the southern portion of the island which retains only one-quarter of the 1954 old growth. This may well serve to isolated the Olympic Peninsula population from the northern Vancouver Island population which must already contend with the Straits of Jaun de Fuca.

It is estimated that all unprotected old growth on Vancouver Island will be cut by 2004 (Cooperman 1993c).

HISTORIC AND PROJECTED HABITAT LOSS ON THE OLYMPIC PENINSULA[3]

Old growth forests once covered at least 2 million acres of the Olympic Peninsula. On federal lands, old growth remained relatively intact until the post-World War II era. In 1940, the Olympic National Forest maintained 390,000 acres of old growth, by 1988 only 94,400 acres remained- a decline of 76% (see Figure 3). As virtually all the private land on the Peninsula has been clearcut, the total decline in old growth is even larger. Less than 20% of the Peninsula's original old growth is still standing, almost all of it in Olympic National Park.

The lower elevations of the Peninsula were once blanketed in over a million acres of Sitka spruce and western hemlock- prime Queen Charlotte goshawk habitat. Only 3% (36,700 acres) were left as of 1988, primarily in the National Park. Most of the remaining old growth is in the Pacific silver fir zone.

What old growth is left, is severely fragmented. The National Forest contains only one old growth tract larger than 10,000 acres (see Figure 4).

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[3]All information in this section is taken from *Ancient Forests on the Olympic National Forest: Analysis from a Historical and Landscape Perspective*, by Peter H. Morrison for The Wilderness Society (Morrison 1990).

Figure 3. Old Growth on the Olympic National Forest, 1940-1968 (Morrison 1990).

Figure 4. Old Growth Patch Distribution Trends, Olympic National Forest (Morrison 1990).

OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

It is not known if Queen Charlotte goshawks are actually suffering from excessive collection or harassment. Due to their extreme rarity, the collection of even a single species could jeapordize the Queen Charlotte goshawk..

Goshawks are the most highly prized hunting birds among Asian falconers from Turkey to Japan (Beebe 1974). It is known as Baz-Nama, the King Hawk of Persian literature. Goshawks sell so quickly and for such good money in Turkey and Pakistan that they do not even appear on export price lists. There is not much of a goshawk market in Europe or North America where the species is not highly prized. Because of its greater abundance and more accessible habitat, *A.g. atricapillus* is more commonly captured by North American falconers than *A.g. laingi* (Ethier, pers. comm.).

DISEASE AND PREDATION

DISEASE. Goshawks are subject to frounce, a lethal blood disease acquired through predation on pigeons infected with *trichomonas*. According to Beebe (1974), all feral and most non-commercial domestic pigeon flocks carry *trichomonas*. Bandtailed pigeons and mourning doves, which occur throughout the goshawk's range south of extreme southwestern British Columbia, may also carry the micro-organism. Southern goshawks have developed some resistance to the disease, therefore, while northern populations have not. According to Beebe (1974):

> "...almost every goshawk of northern origin, fed the least bit of fresh pigeon, develops the characteristic mouth lesions of classic frounce about 10 days later. Unless treated, the infection proves fatal in another 10 day...the implication that this disease is a major cause of death to goshawks of northern origin invading environments where domestic or feral pigeons have been introduced is most convincing. Goshawks are greatly attracted to pigeons and catch them rather easily."

Frounce is treatable in goshawks by drugs developed to cure domestic poultry. Once contacted and cured, the disease rarely recurs. Treating wild Queen Charlotte goshawks, however, is not technically feasible. They reside deep within old growth rain forests on widely scattered islands, and are very difficult to locate.

NATURAL PREDATION. Logging increases the likelihood of predation on goshawks by introducing open areas near goshawk nests and PFAs, and by forcing goshawks to pass through open areas which hunting or dispersing (Crocker-Bedford 1992). Nestlings and juveniles are most likely to be taken, though adult goshawks may be taken as well.

HUMAN PREDATION. Goshawks are known to prey on domestic animals and forage

in urban/suburban areas during the winter months. This, combined with a general dislike of predators among some humans, may subject the Queen Charlotte goshawk to human predation. Retaliation against, or removal of goshawks, by those who shortsightedly perceive the species as an economic threat, is also a potential hazard.

INADEQUACY OF EXISTING REGULATORY MECHANISMS

USFS SENSITIVE SPECIES PROTECTION.

The Tongass National Forest has stubbornly resisted efforts to list the goshawk as a sensitive or even a management indicator species. By failing to take pro-active measures early on, the Forest has forced itself into a crisis whereby full protection under the Endangered Species Act has become necessary.

There have been ample opportunities and warnings. The history of the Tongass Forest Plan Revision process is replete with missed opportunities, denial and outright hostility toward the goshawk. The first indication of a problem, and the first opportunity to solve it, came in 1986 when a Forest Service working group proposed to make the Queen Charlotte goshawk a management indicator species. The proposal was shelved by the Forest Plan Revision team. In 1990 the Forest Supervisor of the Ketchikan Area resurrected the proposal, warning that if pro-active steps were not taken, the Tongass would eventually face a spotted owl situation. That recommendation was ignored as well. So was a recommendation by the Alaska Department of Game and Fish to list the goshawk as a *sensitive* species. Rejecting a *sensitive* listing, the absolute minimum level of protection, the Forest displayed its intent to ignore every warning signal and plunge directly into a forest crisis.

The stage for the crisis was set later that year by the Draft Environmental Impact Statement for the revised Forest Plan which did not even mention the Queen Charlotte goshawk. The Forest Supervisor's warning almost came true- the Alaska Department of Game and Fish responded to the DEIS by drafting a letter requesting the Fish & Wildlife Service to list the Queen Charlotte goshawk as *threatened*. The Forest Service, however, managed to suppress the request by promising to have its Wildlife Interagency Wildlife Technical Committee review the Queen Charlotte goshawk for possible *sensitive* species status. The Committee, made up of biologists from the U.S. Forest Service, National Park Service, National Marine Fisheries Service, and the Alaska Department of Fish and Game unanimously recommended that the goshawk be listed as *sensitive* in March, 1991. This recommendation was squelched several months later by the Director of Timber Management who complained to the Regional Forester that:

> "the goshawk may be such a rare species in Southeast Alaska that its designation as a *sensitive* species would lead to numerous inappropriate land management prescriptions"

In the face of escalating public and agency pressure, and realizing that Endangered Species Act protection was very likely to occur, the Tongass finally listed the Queen Charlotte goshawk as a sensitive species in January of 1994.

USFS INTERIM GOSHAWK GUIDELINES.

Guidelines. In response to intense pressure, the Region issued Interim Habitat Management Recommendations for the Northern Goshawk (Guidelines) in August of 1992 (USFS 1992). The Guidelines are based on the Interim Guidelines established for the Northern goshawk in the Southwestern Region of the U.S. Forest Service in 1991. The latter were eventually replaced because of their inadequacy The Alaska Region reissued the original guidelines in August of 1993 (USFWS 1993a) without change. Because of their "interim" status, the guidelines have never be subject to citizen review in the Southwest or Alaska.

The Guidelines establish a **Nest Area** including "the nest, nest tree, and approximately 20-30 forested acres surrounding the nest tree that includes prey handling areas, perches, and roosts." The Nest Area should be a continuous band of "single-storied trees of uniform size (usually 20+ inches DB), a closed canopy (60% or greater), and low ground vegetation." No timber harvesting or other habitat disturbance is permitted in the Nest Area. Nest Areas are to be established around active nests, and may be established around inactive nests or where there is evidence of nesting.

Surrounding the Nest Area, the Guidelines establish a 600 acre **Post Fledging Area (PFA)**. The PFA is to designed to protect an area where young hawks can hide and develop hunting skills prior to dispersal. It should be forested and resemble the Nest Area as much as possible. Muskegs may be included if 600 ft. or less across. Up to 5% of the PFA may have a height structure of 15 ft or less. "Timber harvest can occur, but harvest should be planned in less important habitat types where possible...Opening size resulting from timber harvest should not exceed 20 acres. However exceptions to this can occur if harvest unit design provides for a configuration that does not exceed 600 feet in width."

Surrounding the PFA, the Guidelines establish a 6,000 acre Foraging Area. Because the goshawk is an "opportunistic forager," the foraging area may contain a "mosaic of habitat types." Habitat manipulation is permitted without restriction in the foraging area.

Inadequacies. The U.S. Fish and Wildlife Service has consistently voiced concerns about the effects of logging on northern goshawks in the Stikine Area of the Tongass National Forest (USFWS 1992a, 1992b, 1993a, 1993b). In June of 1993 (USFWS 1993c), the Service summarized these concerns in a letter to the Forest Supervisor of the Stikine Area, stating that "implementing the existing Forest Service interim goshawk management guidelines are inadequate to protect the species." In April of 1993, the Fish and Wildlife Service wrote the Forest Supervisor of the Ketchikan Area stating:

> "We do not believe that the current interim guidelines are adequate to protect either a particular goshawk territory or a viable, well distributed goshawk population. For example, where current or historic goshawk nests have been documented, no cutting should be permitted within the nest area, post fledging areas or foraging area. Even if adequately modified, site specific management efforts will likely fail to assure the maintenance of populations or population segments at the ecosystem level" (USFWS 1993d).

Though they have not been implemented widely, or for long enough to allow for

meaningful data collection and analysis, principles of conservation biology and experience with goshawk and raptors elsewhere strongly suggest that the Guidelines will not ensure the viability of the Queen Charlotte goshawk. They focus on much too small an area, do not fully protect the Post Fledging Area, do not give any protection to the Foraging Area, and institute of policy of island habitat management.

Numerous studies have show that logging in areas well beyond the nest stand can have negative impacts on nesting goshawks (Woodbridge 1988, Crocker-Bedford 1990b, 1991; Patla 1991, Ward *et al.* 1992). Goshawks in northern Arizona suffered a 94% reproduction decline following the partial harvest of one-third of the timber volume from 80% of the stands surrounding unharvested nest buffers (Crocker-Bedford 1990b). His nest buffers averaged 95 acres (range = 3 to 500 acres) while the surrounding stands ranged from 12,000 to 35,000 acres.

This inadequacy is compounded by the small size of the designated Nest, Post Fledging and Foraging Areas. A 1992 radio-telemetry study has shown that a pair of Queen Charlotte goshawks used a 51,000 acre nesting home range and a 195,000 total home range (ADFG 1993a). This is more than eight times the area specified for goshawk management under the current guidelines.

The Guidelines also fail to protect active goshawk territories found within timber sales already released or under contract. Five of nine territories within timber sale boundaries in 1992 were not eligible for protection under the Guidelines (see Table ??).

THE VIABLE POPULATION COMMITTEE REPORT.

Background. In 1990, as part of the Tongass National Forest Land Management Plan revision process, an interagency committee was established to develop a scientifically credible plan for maintaining well distributed, viable populations of native vertebrates. The Viable Population Committee's research has been documented in a series of draft reports entitled *A Strategy for Maintaining Well-Distributed, Viable Populations of Wildlife Associated with Old-Growth Forests in Southeast Alaska*. The *Strategy* was to be Southeast Alaska's first comprehensive, scientifically based conservation strategy.

The *Strategy* draws heavily upon island biogeography and metapopulation theory. The theory of island biogeography (MacArthur and Wilson 1967) was developed to explain and predict patterns of local extinction and colonization on isolated oceanic islands. According to the theory, isolated populations are prone to extinction due to a variety of stochastic (i.e. random, natural) events. Small populations become extinct sooner than large populations. Very large population may persist indefinitely, while very small populations are likely to become extinct over a short period of time. Local extinctions can be offset by recolonization if populations are not entirely isolated from one another. Patterns of extinction and colonization are determined by population sizes and the distance between populations relative to dispersal capabilities. Completely isolated populations are more likely to become extinct than connected populations.

The MacArthur/Wilson model has been modified and extended into metapopulation theory (Levins 1970, Slatkin 1977, Hanksi 1981, Shaffer 1985, Harrison *et al.* 1988, Hanski 1989). The latter treats populations as consisting of smaller metapopulations. Metapopulations exist on terrestrial "islands" of suitable habitat separated from one another by unsuitable areas. The total population is maintained in a dynamic balance whereby metapopulations are

periodically subject to local extinction and recolonization.

Metapopulations can be as small as one breeding pair, allowing for very localized analysis. This is particularly useful for developing conservation strategies for rare or fragmented plant and animal communities (Brown 1971, Diamond 1975, Gilpin and Diamond 1980, Harris 1984, Lande 1987, 1988a, 1988b; Mace and Lande 1990, Lamberson *et al.* 1992).

Analyzing population dynamics in terms of metapopulation interaction, Levins (1969, 1970) has shown why species may not occupy all available suitable habitat, and why populations may become extinct even though suitable habitat patches are available. Lande (1987) has extended the analysis to territorial species by treating individual territories as the metapopulations subject to extinction and colonization. Assuming that patches of suitable habitat are randomly or evenly distributed across a large region but separated from one another by unsuitable areas, his model predicts the equilibrium occupancy of suitable habitat by females as a function of the proportion of the landscape which is suitable, and the demographic potential of the species (i.e. life history and dispersal behavior).

Lande (1988) has pointed out several limitations of his model which are applicable to the Queen Charlotte goshawk. The model "depends strongly" on the assumption that suitable habitat patches are randomly or even distributed across a region, that suitable habitat is at equilibrium, that initial populations are large enough to be immune from extinction due to demographic or environmental stochasticity, and that there is no loss of fitness due to inbreeding depression. Lamberson *et al.* (1992) have extended Lande's analyses by developing a model which accounts for environmental stochasticity and habitat conditions which continually declining.

Using a mathematical model to predict long-term population dynamics of northern spotted owls in fragmented landscapes, Lamberson *et al.* (1992) determined that populations tend toward stable equilibrium when initial populations are sufficiently large and territory search efficiency is relatively high. "If search efficiency was low, however, even very large initial populations crashed." This is known as the Allee effect-: as populations become smaller and more scattered, or as the habitat becomes more fragmented, dispersing males become less successful at finding suitable territories and females become less successful at finding potential mates.

Strategy. The highly fragmented natural biogeographic condition of Southeast Alaska poses a particular management challenge:

> "Island systems are very prone to extinctions. Because the amount of suitable habitat for a species is almost always far less than for its counterpart on a continent, the island species usually exist closer to its minimum viable population, even under natural conditions. Furthermore, endemic species and subspecies on the Tongass tend to be divided into separate metapopulations by straits, fiords and glaciers. If any one metapopulation on the Tongass gets so low that it becomes extinct, it takes longer to be recolonized from a nearby metapopulation because of the great barriers to dispersal. In contrast, if on a continent a species winks out locally owing to habitat destruction, the location may be recolonized after the habitat recovers" (VPC 1993).

The Viable Population Committee proposed a system of Core Reserves and Habitat

Conservation Areas of such sizes and distribution that while goshawks may occasional be extirpated from entire Subprovinces, they would be likely to recolonize and maintain themselves at viable population levels throughout the Forest (VPC 1993). The Committee's definition of "well-distributed" works at two levels- it provides for habitat well distributed across Provinces/Subprovinces and across Wildlife Analysis Areas (WAA's) within each Subprovince (Iverson 1991).

Each Subprovince (or undivided Province) would have one Old Growth Core Reserve capable of supporting eight pairs of breeding goshawks. Logging would not be allowed in the Core Reserve, though minimal roading would. Core Reserves would be at least 40,000 acres in extent with at least 20,000 of those acres having 20,000 board feet or more per acre. Core Reserves may be up to 35 miles (center to center) from each other.

Surrounding the Core Reserve would be smaller Habitat Conservation Areas (HCA's) capable of supporting 3 pairs of breeding goshawks. The HCA's would be at least 16,000 acres in extent with at least 8,000 of those acres having at least 20,000 board feet or more per acre. HCA's would be less than 8 miles apart, edge to edge.

If habitat conditions do not allow for full size Core Reserves, more HCAs would be established. If habitat conditions do not allow for full size HCA's, then smaller 8,000 acres HCA's would be established. These would be capable of supporting 2 pairs of breeding goshawks with at least 4,000 acres having at least 20,000 board feet per acre.

Every location on the Forest which was once capable of supporting wintering martens or breeding goshawks must be within a Core Reserve or HCA, or be within 8 miles of a Core Reserve or HCA, or be within 4 miles of a small HCA.

The Committee specifically identified the Cleveland Peninsula Subprovince as "being critical to perpetuate the Queen Charlotte goshawk." In addition to supporting "unusually healthy goshawk populations," it is thought to be a "critical biological corridor for interactions between subpopulations of goshawks." They recommended that no timber harvest be allowed on the Peninsula until research indicates it is not critical habitat or that timber harvesting will not harm the species.

Inadequacies. The largest proposed goshawk reserves would support only 8 pairs of breeding birds. Cole-Crocker Bedford, the lead goshawk researcher for the Committee has questioned the adequacy of such small habitat blocks (Crocker-Bedford 1990b). He notes that the Queen Charlotte goshawk may require additional conservation measures as he did not consider some factors which led Thomas *et al.* (1990) to recommend the preservation of blocks large enough for 20 pairs of Northern spotted owls. Other researchers suggest blocks supporting even greater numbers. Samson *et al.* (1989) suggests that a habitat island capable of supporting a viable population must be large enough to support the net effective breeding population size. He considered 50 adults as essential for short-term viability and 500 adults as necessary for long-term viability.

The small size of proposed Core Reserves and HCA's is compounded by the fact not enough habitat remains to establish them in each Province/Subprovince: "the quality of old-growth forest in some Subprovinces is so fragmented that objectives will not be met for either Core Reserves or for HCA's" (VPC 1993).

The greatest problem, however, is that the Committee's recommendations are based on an

assumed minimum home range of 5,000 acres. This figure was derived from goshawk studies in the continental U.S. Radio-telemetry studies of Queen Charlotte goshawks conducted after the *Strategy* was written revealed nesting home ranges of 195,000 acres excluding water. This is 39 times larger than the Committee's assumption. It was for fear of such a discrepancy that Bruce Marcot, in his technical review of the *Strategy* recommended that home range sizes be based on telemetry results wherever possible (Marcot 1992). Use of the telemetry results would result in vast areas reserved from logging (see Table 14).

TABLE 14. CORE RESERVE SIZES BASED ON 195,000 ACRE HOME RANGE AT THREE DIFFERENT VIABLE POPULATION SIZE ASSUMPTIONS.

SOURCE	MINIMUM NO. OF PAIRS/CORE RESERVE	CORE RESERVE SIZE (acres)
Viable Population Committee	8	1.6 million
Thomas *et al.* (1990)	20	3.9 million
Samson *et al.* (1989)	50	9.8 million

THE SUPPLEMENTAL DRAFT TONGASS NATIONAL FOREST LAND MANAGEMENT PLAN.

Plan. The Tongass National Forest is currently preparing a Land Management Plan which will set long term conservation and logging directions for the Forest. As discussed above, the original Draft called for the retention of 24% of each Wildlife Analysis Area (WAA) in an old growth state. When this failed to prevent the passage of the Tongass Timber Reform Act, the Forest prepared the current Supplemental Draft Tongass Land Management Plan (*Plan*) which removed all old growth retention standards.

The *Plan*, with no attempt at biological justification, ignores the recommendations of the Viable Population Committee and concludes that legislated wilderness and LUDII (i.e. roadless) areas are sufficient to maintain well distributed, viable populations of Queen Charlotte goshawks.

Inadequacies. The Viable Population Committee has already expressed grave concerns about the *Plan*:

> "Well-distributed" is a concept open to interpretation and conjecture and has been used to suggest that LUDII and Wilderness in existence in the Tongass provides for viable populations. Our committee agrees that these populations would not be well-distributed and capable of interchange/interaction...[The *Plan]* does not now assure this level of well-distributed...[it] could allow goshawks and marten to be extirpated from Mitkof...because there is a Core Deme on Kupreanof - essentially isolated from Mitkof for Marten - but within the same Province" (VPC 1993).

The Committee has argued that existing wilderness and LUDII areas are too narrow, isolated and poorly distributed to maintain viable populations (AFSEEE 1993).

Because the Committee's recommendations and critique of the proposed *Plan* were so damaging, the Planning Team asked wildlife biologist Duane Fisher to reassess the *Plan's* impact on old growth dependent species. In a draft Final Environmental Impact Statement, Fisher concluded that over a 150 year period, the *Plan* carried a high risk of jeopardizing Queen Charlotte goshawks and other old growth dependent species in 3 of the Forest's 21 Ecological Provinces (AFSEEE 1993, Brink 1993). Fisher was subsequently reprimanded and removed from the task. The section was rewritten by Team Leader Steve Brink who concluded that the risk was low due to existing wilderness and LUDII areas. Brink is a road engineer by training.

Because of great public controversy, the *Plan* was recently reviewed yet again in light of the Viable Population Committee's concerns. This time, 6 of the 21 Ecological Provinces were projected to be in danger of losing the ability to support Queen Charlotte goshawks and other species in the next 150 years: Northern Prince of Wales Island, Kupreanof/Mitkof Islands, Rangle/Etolin Islands, Revilla Island/Cleveland Peninsula, Dall Island, and Southern Prince of Wales Island (Bruce Rene, Planning Team NEPA Leader, pers. comm.).

North Central Prince of Wales (NCPOW), the site of the most recent Ketchican Pulp Corporation (KPC) long-term timber sale, is the most seriously threatened- it also supports a large percentage of the Tongass National Forests remaining high quality old growth. Alaska Department of Fish & Game singled NCPOW out in its comments on the proposed *Plan*:

> "Forest raptors with large home ranges (i.e. barred owls, goshawks, great-gray owls, etc.), appear to face potential consequences which will not be reflected by the MIS analysis provided in the upcoming TLMP revision. Both the short-term and long-term population viabilities of some of these species in some geographic provinces on the Tongass is in question. Viable population levels in...(North Central Prince of Wales Island) may be in particular jeopardy and are even more immanently threatened by the proposed [KPC] 1989-1994 Operating Plan" (Gustafson 1989).

Three of the Tongass' twenty-one Ecological Provinces (Yukatat Forlands, Yukatat Uplands, and Lynn Canal) occur north of Taku Inlet, entirely outside the Queen Charlotte goshawk's geographic range. A fourth (Ice Fields) is largely outside the goshawk's range and,

being recently glaciated, supports very little old growth habitat. The *Plan*, therefore may compromise 6 of 17 provinces with the Queen Charlotte goshawk's range within 150 years.

There are 4.7 million acres of old growth within the 17 ecological provinces comprising the Queen Charlotte goshawk's geographic range on the Tongass National Forest (see table 9). The distribution of these forests is highly fragmented, however. Only 11 of the provinces support over 200,000 acres of old growth. Four of them are "jeopardy" provinces. Only three (Admiralty Island, North Central Prince of Wales Island, and Revilla Island/Cleveland Peninsula) support over 500,000 acres of old growth. Two of these are "jeopardy" provinces.

Within the provinces, there is a high degree of habitat fragmentation as the provinces average only 39% old growth cover (see Table 15.).

Yet a third level of fragmentation occurs within the old growth stands themselves. Old growth stands with less than 30,000 board feet/acre (Stratas A and B) are marginal Queen Charlotte goshawk habitat (Iverson 1990). Yet 90% of all old growth in the 17 provinces is classed as either Strata A or B (see Table 15). Only two percent is classed as Strata D.

Only 39% percent of the Tongass National Forest's old growth within the geographic range of the Queen Charlotte goshawk is protected in designated Wilderness Areas, National Monuments and LUD II roadless areas (see Table 16). That which is protected is disproportionately skewed toward lower volume stratas.

TABLE 15. TOTAL AREA AND OLD GROWTH IN TONGASS NATIONAL FOREST BY ECOLOGICAL PROVINCE AND STRATA, 1990 (USFS 1991).

PROVINCE	TOTAL AREA	STRATA A OLD GROWTH	STRATA B OLD GROWTH	STRATA C OLD GROWTH	STRATA D OLD GROWTH	TOTAL OLD GROWTH
East Chichagof	1,057,583	219,723	154,005	34,036	720	408,484
West Chichagof	280,485	49,788	17,525	2,159	0	69,472
East Baranoff	391,980	58,336	34,747	2,204	0	95,287
West Baranoff	772,623	152,078	60,018	4,186	60	216,342
Admiralty	1,045,114	243,269	245,348	90,981	7,195	586,793
North Coast Range	1,012,506	159,978	138,950	22,602	415	321,945
Kupreanof/Mitkof	760,648	183,583	110,058	18,385	1,420	313,446
Kuiu	483,651	102,758	157,389	31,373	5,802	297,322
Central Coast Range	721,158	127,224	96,408	17,934	481	242,047
Etolin/vicinity	500,119	130,289	85,153	12,020	661	228,123
North Central Prince of Wales	1,260,553	208,083	213,364	93,072	33,071	547,590
Revilla/Cleveland Peninsula	1,169,559	221,939	267,613	32,368	1,780	523,700
Southern Outer Islands	213,964	56,957	45,602	11,279	2,124	115,962
Dall/vicinity	109,899	27,552	29,078	6,747	1,576	64,953
South Prince of Wales	370,594	70,850	48,002	25,227	23,754	167,833
North Misty Fiords	971,413	119,962	64,347	10,677	3,219	198,205
South Misty Fiords	904,304	200,773	96,887	11,365	2,640	311,665
All Provinces	12,026,153	2,333,142	1,864,494	426,615	84,918	4,709,169

Strata A old growth = 8,000-20,000 board feet/acre
Strata B old growth = 20,000-30,000 board feet/acre
Strata C old growth = 30,000-50,000 board feet/acre
Strata D old growth = over 50,000 board feet/acre

TABLE 16. PERCENT OF OLD GROWTH ON TONGASS NATIONAL FOREST BY PROVINCE AND STRATA, 1990.

PROVINCE	PERCENT OF PROVINCE IN OLD GROWTH STATE	PERCENT OF OLD GROWTH IN STRATA A	PERCENT OF OLD GROWTH IN STRATA B	PERCENT OF OLD GROWTH IN STRATA C	PERCENT OF OLD GROWTH IN STRATA D C
East Chichagof	39	54	38	8	0
West Chichagof	25	72	25	3	0
East Baranoff	24	61	36	2	0
West Baranoff	28	70	28	2	0
Admiralty	56	41	42	16	1
North Coast Range	32	50	43	7	0
Kupreanof/Mitkof	41	59	35	6	0
Kuiu	61	35	53	11	2
Central Coast Range	34	53	40	7	0
Etolin/vicinity	46	57	37	5	0
North Central Prince of Wales	43	38	39	17	6
Revilla/Cleveland Peninsula	45	42	51	6	0
Southern Outer Islands	54	49	39	10	2
Dall/vicinity	59	42	45	10	2
South Prince of Wales	45	42	29	15	14
North Misty Fiords	20	61	32	5	2
South Misty Fiords	34	64	31	4	1
All Provinces	39	50	40	9	2

Strata A old growth = 8,000-20,000 board feet/acre
Strata B old growth = 20,000-30,000 board feet/acre
Strata C old growth = 30,000-50,000 board feet/acre
Strata D old growth = over 50,000 board feet/acre

TABLE 17. TOTAL AND PROTECTED OLD GROWTH ON THE TONGASS NATIONAL FOREST BY STRATA, 1990 (ACRES) (USFS 1991A).

OLD GROWTH STRATA	TOTAL OLD GROWTH	PROTECTED OLD GROWTH	PERCENT OLD GROWTH PROTECTED
STRATA A	2,333,142	931,216	40
STRATA B	1,864,494	732,397	39
STRATA C	426,615	168,090	39
STRATA D	84,918	21,515	25
TOTAL	4,709,169	1,853,218	39

The *Plan* calls for the logging of an additional 1.2 million acres of old growth by 2150 (see Table 18). This represents a 31% decline in old growth between 1954 and 2150. Old growth will decline by at least 40% on seven provinces (North Coast Range, Central Coast Range, Kupreanof/Mitkof Islands, Etolin Island, Dall Island, North Central Prince of Wales Island, and South Prince of Wales Island). Six of the seven are "jeopardy" provinces. North Central Prince of Wales is slated to lose 68% of its old growth.

These figures represent the combined impact on all old growth stratas. Because the Tongass National Forest continues to highgrade, however, the higher volume stratas will bear a disproportionate logging burden (see Table 19). These provide the optimal Queen Charlotte goshawk habitat. While the lowest volume old growth (Strata A) will decline by 21%, the highest volume old growth (Strata D) will decline by 48%. Five of the provinces (Kuiu, Central Coast Range, North Central Prince of Wales, Southern Outer Islands, and Dall) will lose more than 50% of their Strata D old growth.

Historic habitat loss on state, private and federal lands in southeast Alaska has been tremendous. Habitat capacity in the region is currently estimated at 200-500 pairs (Crocker-Bedford 1992). Future logging on state and private lands is expected to preclude their use by Queen Charlotte goshawks (Crocker-Bedford 1990a). The Tongass National Forest will be the only reservoir of Queen Charlotte goshawk habitat. Only 39% of the Forest's current old growth is reserved from logging. Much of this is in the lower volume stratas, and will provide only marginal Queen Charlotte goshawk habitat. Logging outside the reserves will be concentrated in optimal Queen Charlotte goshawk habitat- high volume old growth. Old

TABLE 18. ACRES OF OLD GROWTH ON THE TONGASS NATIONAL FOREST: 1954-2150 (projected under preferred Forest Plan alternative).

PROVINCE	1954	1990	2000	2010	2040	2150	PERCENT DECLINE 1990-2140	PERCENT DECLINE 1954-2140
East Chichagof	443,446	408,484	389,823	371,822	340,869	312,000	24	30
West Chichagof	69,472	69,472	69,472	69,472	69,472	69,472	0	0
East Baranoff	105,852	95,287	91,811	87,348	83,168	80,405	16	24
West Baranoff	232,437	216,342	215,251	214,509	213,402	207,988	4	11
Admiralty	586,793	586,793	586,793	586,793	581,973	572,635	2	2
North Coast Range	321,965	321,945	316,490	311,079	279,383	269,676	16	16
Kupreanof/Mitkof	341,378	313,446	304,092	289,909	238,201	175,069	44	49
Kuiu	317,152	297,322	278,126	267,788	244,697	226,576	24	29
Central Coast Range	247,243	242,047	236,221	234,425	209,090	171,061	29	31
Etolin/vicinity	255,118	228,123	214,687	190,416	145,686	116,583	49	54
North Central Prince of Wales	707,754	547,590	487,933	438,276	277,440	225,586	59	68
Revilla/Cleveland Peninsula	548,889	523,700	509,614	497,610	469,365	342,165	35	38
Southern Outer Islands	130,061	115,962	114,161	105,159	89,597	86,307	26	34
Dall/vicinity	65,313	64,953	63,625	60,991	42,393	31,433	52	52
South Prince of Wales	170,570	167,833	166,360	156,601	120,035	102,875	39	40
North Misty Fiords	199,065	198,205	198,205	198,105	195,526	194,526	2	2
South Misty Fiords	311,665	311,665	311,665	311,665	311,665	311,665	0	0
All Provinces	5,056,127	4,709,169	4,554,329	4,391,968	3,911,962	3,496,022	26	31

TABLE 19. EXPECTED LOSS OF OLD GROWTH (ACRES) ON THE TONGASS NATIONAL FOREST 1990-2150 BY ECOLOGICAL PROVINCE AND STRATA TYPE (USFS 1991a).

PROVINCE	ACRES LOST 1990-2150 STRATA A	ACRES LOST 1990-2150 STRATA B	ACRES LOST 1990-2150 STRATA C	ACRES LOST 1990-2150 STRATA D	PERCENT DECLINE 1990-2150 STRATA A	PERCENT DECLINE 1990-2150 STRATA B	PERCENT DECLINE 1990-2150 STRATA C	PERCENT DECLINE 1990-2150 STRATA D
East Chichagof	27,055	59,232	9,878	319	12	38	29	44
West Chichagof	10	0	0	0	0	0	0	0
East Baranoff	3,014	11,289	579	0	5	32	26	0
West Baranoff	5,203	2,942	209	0	3	5	5	0
Admiralty	4,678	7,320	2,020	140	2	3	2	2
North Coast Range	8,986	35,802	6,986	195	6	33	31	47
Kupreanof/Mitkof	77,339	51,793	8,985	260	42	47	49	18
Kuiu	19,043	36,665	11,118	3,920	19	23	35	68
Central Coast Range	36,953	28,359	5,414	260	29	29	30	54
Etolin/vicinity	62,101	42,280	6,979	180	48	50	58	27
North Central Prince of Wales	120,699	122,304	54,895	24,106	58	57	59	73
Revilla/Cleveland Peninsula	71,666	97,110	12,059	700	32	36	37	39
Southern Outer Islands	10,343	12,713	5,096	1,503	18	28	45	71
Dall/vicinity	12,339	16,233	3,892	1,056	45	56	58	67
South Prince of Wales	27,381	19,906	9,646	8,025	39	41	38	34
North Misty Fiords	2,399	880	300	100	2	1	3	3
South Misty Fiords	0	0	0	0	0	0	0	0
All Provinces	489,209	544,828	138,056	40,764	21	29	32	48

growth Stratas C and D are expected to decline 32% and 48% respectively. Queen Charlotte goshawk habitat capability will decline even more due to fragmentation effects.habitat capability will decline even more due to fragmentation effects.

Under the current *Plan* we expect habitat capability in southeast Alaska to drop to 50-125 pairs by 2150. Southeast Alaska Queen Charlotte goshawks are almost certainly an isolated population as dispersal capability precludes genetic interchange with birds on the Queen Charlotte Islands. One hundred and twenty five breeding pairs is not a viable large raptor population (Thomas *et al.* 1990).

THE PEER REVIEW ANALYSIS

To obtain independant analysis of the adequacy of the Draft Forest Plan EIS and the Viable Population Strategy, the Tongass asked the U.S. Forest Service's Pacific Northwest Research Station to review wildlife management proposals and assessments on the Tongass National Forest. Eighteen independent reviewers, all from outside Alaska, were asked to analyze Appendix M of the Draft Land Management Plan, Fish and Wildlife: A Viability Risk Assessment; the Viable Population Committee's' *Strategy* for maintaining viable populations; and Habitat Capability Models for Wildlife in Southeast Alaska. The reviewers found the *Appendix M* to be severely lacking. The editors summarized their comments: "(n)one of the planning alternatives currently considered is adequate to ensure viability of all species considered" (Kiester and Eckhart 1994). The *Strategy*, on the other hand, was well received. The reviewers felt it represented solid conservation biology but was not ambitious enough: "(t)he particular pattern of Habitat Conservation Areas that it suggests will not ensure viability of all species."

The reviewers were particularly concerned about the continued existence of the Northern goshawk on the Tongass (=Queen Charlotte goshawk):

> "This species is likely to become protected under the Endangered Species Act. Thus, management planning with regard to the northern goshawk will need to be especially conservative. Because goshawks require large territories to thrive, several reviewers are of the opinion that even large HCAs were not adequate to meet its needs."

We exerpt from pertinent reviewer's comments below:

Craig W. Benkman, Assistant Professor, Department of Biology, New Mexico State University.

"This subspecies (Queen Charlotte goshawk) is endangered based on the information given by the author...Thus, the conservation strategy needs to be very effective in protecting the remaining goshawks. Yet, the recommended HCA sizes and distances between them inadequately protect goshawks. Large HCAs need to support eight pairs of goshawks, but based on the authors earlier work large HCAs will support at most three pairs of goshawks. Similarly, medium HCAs will usually support no goshawk pairs, not two pairs...."

"What I find potentially troublesome about the proposed management plans is the effect on the percent of the productive old growth remaining in each of the ecological provinces. By

2110, many ecological provinces will have only about 75% of their productive old-growth left. By 2140, most will have less than 75% left. Is 75% enough?

Eric Forsman, Supervisory Research Wildlife Biologist, USDA Forest Service, Pacific Northwest Research Station.

"Based on the preliminary data from the telemetry study in SE Alaska, it also appears to me that you may be totally underestimating the amount of habitat and area being used by Goshawks in your model. After reading your report I am left with one dominant conclusion - all we can say about goshawks in SE Alaska at this point is that they are relatively rare, and that they are probably declining as a result of habitat loss...

It appears to me that you have a couple of really serious problems with developing a plan for this species. First, your survey data, albeit limited, suggests a relatively limited population, and lots of site turnover. That is, even if they are not harvested, many sites are unoccupied at any one time.

Second, the recent telemetry data collected by ADF&G suggests that goshawks on the Tongass may utilize home ranges and amounts of habitat that are much larger than in other parts of the range. If the Sarkar Lake pair are representative, then it is likely that the conservation areas you propose may contain fewer pairs than the 15-20 pair target.

In light of the uncertainty regarding population size, spacing of pairs, overlap of territories, and site tenacity in SE Alaska, I don't think you have much choice but to adopt a fairly conservative approach to managing the species, while proceeding as rapidly as possible to collect better data on the distribution and abundance of the species. Although not without risk, I think your proposed network of conservation areas is a reasonable start in combination with protection of known nest areas with the matrix. Without more data, I don't know what more you could do at this point, short of shutting down all harvest. Even that would not be without risk to the goshawk, since you appear to be dealing with a small relatively isolated population at the edge of the range."

Andrew James Hansen, Assistant Professor, Department of Biology, Montana State University.

The *Strategy* "tends to ignore the matrix of forest lands outside of the specified forest reserves and corridors. There are perhaps two shortcomings to this. First, it assumes that activities in the matrix will not reduce the quality of habitat within the reserves and corridors. What is the likelihood that clear-cutting adjacent to corridors or HCAs will result in substantial blowdown within those corridors or HCAs? Second, it assumes that corridors will be sufficient to allow animals to disperse among HCAs. The current spotted owl plan, in contrast, specifies managing the matrix to maintain a certain level of canopy cover to allow dispersal."

The "Species Review" section of *Appendix M* "is very confusing and hints at major problems in the forest plan....(Paragraph 2 pg M-10) says that there are "no current viability concerns" and suggests that the forest standards and guidelines are too weak to prevent species from becoming viability concerns. This bit of doublespeak indicates that the forest plan does not offer sufficient protection to prevent species from becoming inviable, as is called for by the National Forest Management Act...all the management alternatives fail to have a high likelihood of maintaining well-distributed viable populations of vertebrates."

Russell Lande, Professor, Department of Biology, University of Oregon.

"In the *Strategy*, large HCAs composed of 20,000 contiguous acres of old-growth (containing at least one class I anadromous fish stream) are state to be capable of supporting 8 pairs of goshawks, 5 female brown bears, and 25 female marten...There is no observational evidence or modelling cited for any of these species to suggest that these numbers will adequately reduce local extinction rates. Such small populations of brown bear...and goshawk would be subject to strong effects of demographic stochasticity and possible inbreeding depression...In addition, for the species long dispersal distances, dispersing individuals may spend considerable time wandering through unsuitable habitat searching for suitable unoccupied habitat in which to establish their home range. This effect of fragmentation may cause a substantially increased juvenile mortality, thereby lowering population viability."

Roger A. Powell, Professor, Department of Zoology, North Carolina State University.

Appendix M- "I found this document also to be generally negative. It seemed to me to outline a plan that guarantees that wildlife populations on the Tongass National Forest will be lost in the future."

STATE OF ALASKA

Although the Alaska Department of Fish and Game has consistently pressed the U.S. Forest Service for increased goshawk protection, it has not placed the goshawk on its own list of protected species. Two bills before the State Senate have the potential to virtually eliminate Queen Charlotte goshawk on state lands (Edwards, pers. comm.). State Bill 310 would make timber harvest the priority management goal of State Lands. A second bill would deduct more than acre-for-acre from other state parks, the 45,000 acres being put into a state park on Afognak Island.

NATIVE AMERICAN TRIBES

The Queen Charlotte goshawk is not protected by Native American Tribes in Canada or Alaska.

CANADIAN GOVERNMENT

The Queen Charlotte goshawk is listed or protected as a *vulnerable* species by federal or state Canadian governments.

OTHER NATURAL OR ANTHROPOGENIC FACTORS

Northern goshawks have a low pesticide burden (Snyder et al. 1972, Reynolds and Wight 1978)

We know of no other known natural or anthropogenic factors threatening the continued existence of the Queen Charlotte goshawk.

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APPENDIX B
BRITISH COLUMBIA SIGHTINGS[1]

SPRING RECORDS

Comox	1958	3
Cranberry	1977	2 adults
Quatse River	1951	1 immature
Masset Inlet	1981	3

SUMMER RECORDS

VANCOUVER ISLAND

Campbell Lake	1953	3
Tree Point, Alert Bay	1976	1 adult
Hope Island	1939	1 female (MCZ 281613)

QUEEN CHARLOTTE ISLANDS

Skidegate	1895	1 male (RBCM 406)
Langara Island and northern Graham Island	1927	Observed daily

1. All records from Campbell *et al.* (1993).